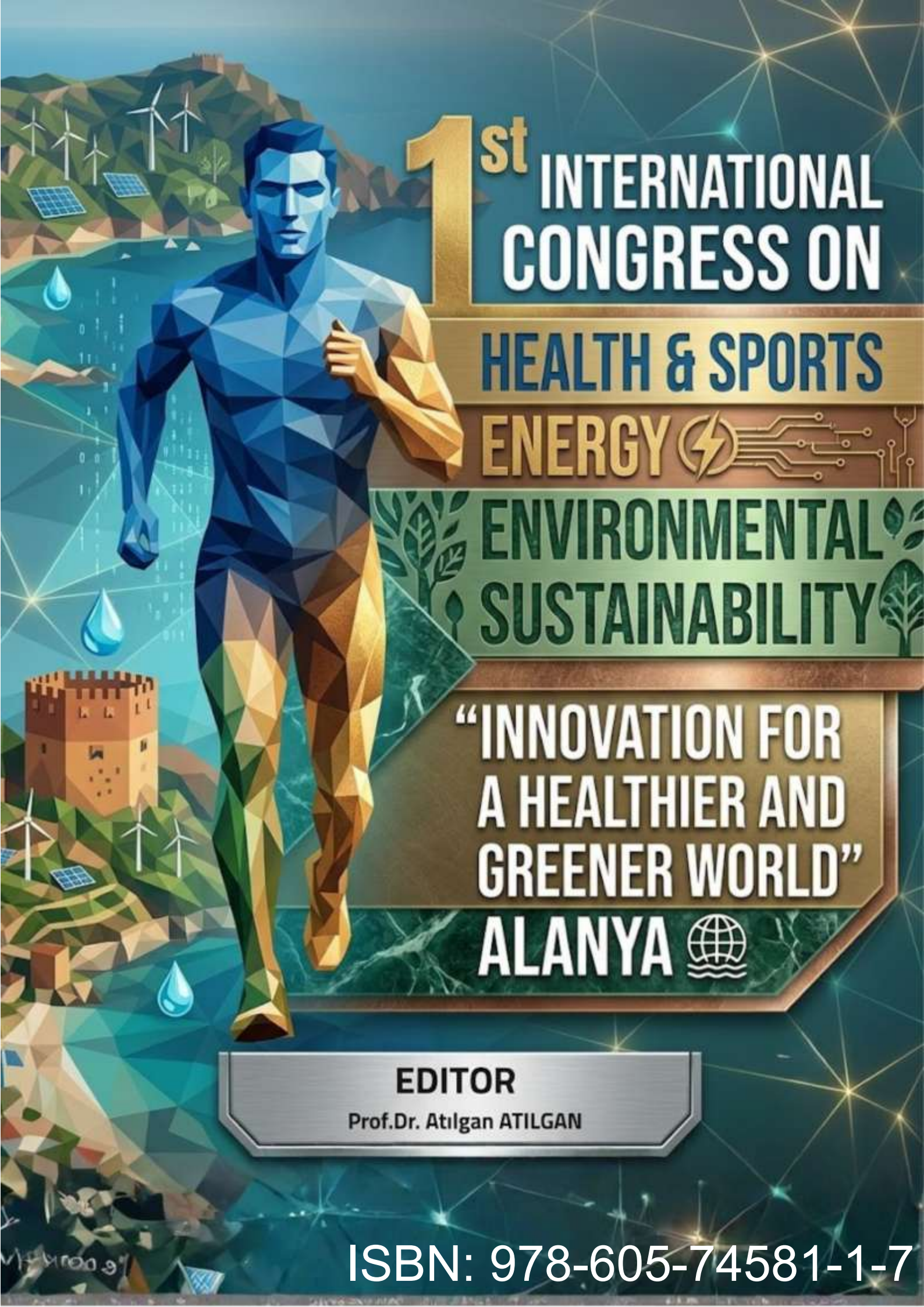




**1<sup>st</sup> INTERNATIONAL  
CONGRESS ON**

**HEALTH & SPORTS**

**ENERGY** 

**ENVIRONMENTAL  
SUSTAINABILITY** 

**“INNOVATION FOR  
A HEALTHIER AND  
GREENER WORLD”**

**ALANYA** 

**EDITOR**

Prof.Dr. Atilgan ATILGAN

ISBN: 978-605-74581-1-7

Bu kitapta yer alan yazıların içerięi yazarların sorumluluęunda olup 5846 sayılı yasaya g re eserin b t n yayın,  eviri ve alıntı hakları ALK  Yayınlarına aittir.

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Alanya Alaaddin Keykubat  niversitesi Yayınları: 010  
(Alanya Alaaddin Keykubat University Publications: 010)

ISBN: 978-605-74581-1-7



## PREFACE

Scientific progress and sustainable development increasingly depend on interdisciplinary research and international collaboration. In response to this need, the 1st International Congress on Health, Sport, Energy and Environmental Sustainability (IHSEC 2026) was successfully organized in a hybrid format on 23–25 April 2026, hosted by Alanya Alaaddin Keykubat University (ALKÜ), Türkiye.

IHSEC 2026 was established as an international scientific platform dedicated to fostering interdisciplinary dialogue, promoting the exchange of innovative ideas, and strengthening global academic partnerships. The congress brought together researchers, academics, practitioners, and graduate students from diverse scientific disciplines to discuss current challenges and emerging opportunities in health, sport, energy, and environmental sustainability. By encouraging the integration of knowledge across disciplines, the congress sought to contribute to scientific advancement and to support the development of sustainable solutions for contemporary global challenges.

The scientific program covered a broad range of topics, including Health Sciences, Sport Sciences, Energy Systems and Sustainability, Environmental Sustainability, Public Health and Sustainable Development, and Technology and Innovation for Sustainable Societies. These thematic areas provided an inclusive framework for presenting original research, exchanging scientific perspectives, and establishing new collaborations among participants from different academic backgrounds.

The participation of scholars from Türkiye, the United States, Bangladesh, Poland, and Iraq further enhanced the international character of the congress and created valuable opportunities for expanding global research networks. The hybrid format ensured broad accessibility, enabling active participation and scientific interaction regardless of geographical location.

The Organizing Committee extends its sincere appreciation to all authors, keynote speakers, reviewers, session chairs, members of the Scientific and Organizing Committees, and all participants whose dedication and contributions ensured the success of IHSEC 2026. We also gratefully acknowledge the support and collaboration of our international partner institutions: Noakhali Science and Technology University, ISRAA University, SPIRU HARET University, Zagreb School of Business, and Al-Mustaqbal University.

We sincerely hope that these conference proceedings will serve as a valuable reference for researchers, contribute to the dissemination of scientific knowledge, and inspire future interdisciplinary research and international collaborations addressing the challenges of a more sustainable world.

IHSEC 2026 Organizing Committee



[ihsec2026.alanya.edu.tr](http://ihsec2026.alanya.edu.tr)

## 1st INTERNATIONAL HEALTH SPORTS ENERGY ENVIRONMENTAL SUSTAINABILITY CONGRESS

APRIL 23-25, 2026, ALANYA/TÜRKİYE

Meeting ID: 912 6818 1944

Join Zoom Meeting

<https://zoom.us/j/91268181944>

Ankara Local Time: 10:00-12:00

**HEAD OF SESSION : Prof.Dr. Sedat BOYACI**

| Authors                                                                                        | Affiliation                                                                                                                                                                                                                                       | Presentation Title                                                                                                                                                  |
|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Katarzyna GRADECKA-JAKUBOWSKA<br>Marek GANCARZ                                                 | University of Agriculture in Krakow<br>University of Agriculture in Krakow                                                                                                                                                                        | Determination of The Mechanical Strength of Coffee Beans with Different Roasting Degrees                                                                            |
| Rahma Mukhlis ADE<br>Firas Kadhim ALJUBOORI                                                    | University of Mosul<br>University of Mosul                                                                                                                                                                                                        | Root Knot Nematodes infect Oleander Plants in Iraq                                                                                                                  |
| Ekaterina ARABSKA<br>Dimitar YAKIMOV<br>Svetla DIMITROVA<br>Rezear KOLAJ<br>Valentina MARINOVA | University of Agribusiness and Rural Development<br>University of Agribusiness and Rural Development<br>University of Agribusiness and Rural Development<br>Agricultural University of Tirana<br>University of Agribusiness and Rural Development | The Future of Organic Farming and Its Potential Impact on Sustainable Development                                                                                   |
| Marwa K. El-Din Abdel SALAM<br>Dr. Bassam Y. IBRAHIM                                           | University of Mosul<br>University of Mosul                                                                                                                                                                                                        | Molecular Diagnosis and Pathological Characterization of Fusarium Species associated with Dry Rot Disease in Stored Potatoes                                        |
| SALAH MAAROOF<br>MAHMOOD MAROOF                                                                | Ministry of OIL/OPDC/Western Directorate/MOSUL                                                                                                                                                                                                    | Employing Corrosion Treatments in Oil Pipeline Maintenance and Their Role in Achieving Environmental and Economic Sustainability                                    |
| Asma BATOOL                                                                                    | Institute of Business Administration, Karachi, Pakistan                                                                                                                                                                                           | A Comparative Machine Learning Framework for Cross-City Air Quality Prediction: Evidence from Karachi and Lahore Using Energy-Aware Climate AI Principles           |
| Ferhat DEMİRALP                                                                                | Dicle University                                                                                                                                                                                                                                  | Administrative Water Loss Management Maturity Model for Water and Sewerage Administrations (WSA) in Turkey: An Evaluation of institutional Capacity and Performance |
| Sedat BOYACI<br>Misra SEZER<br>Atılğan ATILGAN                                                 | Kırşehir Ahi Evran University<br>Kırşehir Ahi Evran University<br>Alanya Alaaddin Keykubat University                                                                                                                                             | The Effect of insulation Thickness on Energy Saving in Laying Hen House Walls                                                                                       |
| Sedat BOYACI<br>Misra SEZER<br>Atılğan ATILGAN                                                 | Kırşehir Ahi Evran University<br>Kırşehir Ahi Evran University<br>Alanya Alaaddin Keykubat University                                                                                                                                             | investigation of The Utilization of Biogas Potential Produced from Animal Manure for Greenhouse Heating                                                             |
| Mehmet BUCAKLI<br>Leyla AKBULUT<br>Sena Zeliha TAŞKAN<br>Ahmet ÇOŞGUN<br>Afşin GÜNGÖR          | Akdeniz University<br>Alanya Alaaddin Keykubat University<br>Akdeniz University<br>Akdeniz University                                                                                                                                             | Use of Geographic Information Systems (Gis) in Photovoltaic Potential Estimation: A Field Application for Antalya Province                                          |
| Mehmet BUCAKLI<br>Leyla AKBULUT<br>Sena Zeliha TAŞKAN<br>Ahmet ÇOŞGUN<br>Afşin GÜNGÖR          | Akdeniz University<br>Alanya Alaaddin Keykubat University<br>Akdeniz University<br>Akdeniz University                                                                                                                                             | European-Based Carbon Reduction Methods for The Cement Sector in Achieving 2050 Net Zero Emission Targets: A Compilation of Scenarios and Cases                     |

**(All speakers required to be connected to the session 10 min before the session starts)**

**Moderator is responsible for ensuring the smooth running of the presentation, managing the group discussion and dynamics.**

## 23.04.2026 / Online / SESSION-2

Meeting ID: 951 5930 0242

Join Zoom Meeting

<https://zoom.us/j/95159300242>

Time: 10:00-12:00

**HEAD OF SESSION : Prof.Dr. Tariq J. Al-Musawi**

| Authors                                                                                | Affiliation                                                                                                                             | Presentation Title                                                                                                   |
|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Ahmed Rawdhan<br>SALMAN<br>Munther Fadhel<br>HASAN<br>Aseel H. Al SABARY               | Al-Mustaqbal University<br>Al-Mustaqbal University<br>Al-Mustaqbal University                                                           | Digital Sustainability and Inclusivity: The Future Algorithm for Epistemic Justice                                   |
| Mahmoud Daoud AL-<br>RUBAIE                                                            | Al-Mustaqbal University                                                                                                                 | Requirements for Achieving Digital Transformation in Higher Education Institutions                                   |
| Majid, MOHAMMED<br>SH<br>Ali ALKHARSAN                                                 | Al-Mustaqbal University<br>Iraqi Media Network                                                                                          | Dual-Channel LLM-Guided Semantic Feature Extraction with Zero-Shot Classification for Zero-Day Malware Detection     |
| Majid, MOHAMMED<br>SH<br>Ali ALKHARSAN                                                 | Al-Mustaqbal University<br>Iraqi Media Network                                                                                          | Dual-Channel LLM-Guided Semantic Feature Extraction with Zero-Shot Classification for Zero-Day Malware Detection     |
| Musaddak Maher<br>Abdul ZAHRA                                                          | Al-Mustaqbal University                                                                                                                 | Deep Reinforcement Learning–Based Adaptive Modulation and Coding for Wireless Communication Systems                  |
| Deniz ÇETİN<br>Levent KAYA                                                             | Alanya Alaaddin Keykubat<br>University<br>Alanya Alaaddin Keykubat<br>University                                                        | Being A Woman in Aviation: Wings Hitting the Glass Ceiling                                                           |
| Irem Öykü KARTAL<br>Levent KAYA                                                        | Alanya Alaaddin Keykubat<br>University<br>Alanya Alaaddin Keykubat<br>University                                                        | Environmental Impacts of Airport Operations and Sustainability Practices: The Case of Gazipaşa-Alanya Airport        |
| Ahmed Adnan HADİ                                                                       | Al-Mustaqbal University                                                                                                                 | A Proposed Model for AI-Driven Smart Learning Environments to Enhance Green Education Concepts in Iraqi Universities |
| Dhurgham A.A.Al-<br>Sultany, Ahmed<br>Jasim<br>Mohammed Alaa K.<br>H.<br>Al-Khalaf     | Al-Mustaqbal University<br>Al-Mustaqbal University<br>Al-Mustaqbal University                                                           | Bioaccumulation of Heavy Metals and Associated Histopathological Alterations in Cyprinus Carpio                      |
| Zahraa N.Hussain<br>Jamal M. Ali<br>Hasan S.Majdi<br>Bashar J.Kadhim<br>Abbas J.Sultan | University of Technology<br>University of Technology<br>Al-Mustaqbal University<br>University of Technology<br>University of Technology | Enhanced Convective Heat Transfer in Copper Tubes Using TiO <sub>2</sub> -GNP/Water Hybrid Nanofluids                |
| Mohammed Hasan<br>Aldulaimi                                                            | Al-Mustaqbal University                                                                                                                 | An Effective Framework for Predicting Air Quality Using Artificial Intelligence Techniques                           |
| Athraa Y.Al-Hijazi<br>Hasan K.Alammar<br>Ali H Al-Ogaili                               | Al-Mustaqbal University<br>Al-Mustaqbal University<br>Al-Mustaqbal University                                                           | Molecular Changes in Diabetic Rat Dental Pulp: Upregulation of RANKL, OPG, and VEGF.                                 |
| Mohammed M.<br>Obeid                                                                   | Al-Mustaqbal University                                                                                                                 | Computational Strategies for Designing 3D Porous Carbon Anodes for Sodium-Ion Batteries: A Mini Review               |

**(All speakers required to be connected to the session 10 min before the session starts)**  
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## 23.04.2026 /Online/ SESSION-3

Meeting ID: 954 1709 5569

Join Zoom Meeting

<https://zoom.us/j/95417095569>

Ankara Local Time: 12:00 - 14:00

**HEAD OF SESSION: Dr.Ali Hamid Jasim KHEKAN - Assist.Prof.Dr. Levent KAYA**

| Authors                                                   | Affiliation                                                                                  | Presentation Title                                                                                                                          |
|-----------------------------------------------------------|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Ali Hamid Jasim KHEKAN                                    | Al-Mustaqbal University                                                                      | Evaluation and Investigation of Antibiotic Resistance in Immunocompromised Patients with Chronic Periodontal Diseases: A Systematic Review  |
| Saja Jawad Obaid Al-Sailawi                               | Al-Mustaqbal University                                                                      | Hepcidin-25 as A Central Mediator of Iron Dysregulation in Chronic Kidney Disease                                                           |
| Mahmood Dawood SALMAN                                     | Al-Mustaqbal University                                                                      | Study of Variables in The Ratio of Creatine in the Blood of Short, Medium and Long Distance for Runners                                     |
| Çiğdem ERDEM Bilgen ARIKAN                                | Suleyman Demirel University Usak University                                                  | Mobilization After Cardiac Surgery: A Bibliometric Analysis                                                                                 |
| Zahraa Hamza Merza Ghadeer Talib Khlaif Athemar MR. ALWAN | Al-Mustaqbal University<br>Al-Mustaqbal University<br>Al-Mustaqbal University                | The Rising Incidence of Multidrug-Resistant S. Aureus in Abscess Infections and Assesses Volatile Oils as A Possible Supplemental Treatment |
| Aleyna YILMAZ Raif ZILELI                                 | Bilecik Şeyh Edebali University<br>Bilecik Şeyh Edebali University                           | A Bibliometric Analysis of Visual-Motor Integration Studies Conducted Using the Beery-Buktenica Test Between 2000-2026                      |
| Özlem ÖZDEMİR Edanur MARAŞ Özge BAŞAR                     | Recep Tayyip Erdoğan University<br>Recep Tayyip Erdoğan University<br>Turkuaz Dental Clinics | Ultrasonic-Assisted Root Canal Retreatment in A C-Shaped Mandibular First Molar                                                             |
| Özge BAŞAR Özlem ÖZDEMİR                                  | Turkuaz Dental Clinics<br>Recep Tayyip Erdoğan University                                    | Endodontic Treatment of a Mandibular Molar Tooth with A Broken File                                                                         |
| Fatma Özlem ÜNER Figen ALP YILMAZ                         | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                   | Psychometric Properties of The Turkish Version of The Sexual Communication Scale                                                            |
| Fadime TORU                                               | Alanya Alaaddin Keykubat University                                                          | Presentation of Technological Methods Used in Teaching Patient Care in Nursing and Current Research                                         |
| Fatma Özlem ÜNER Figen ALP YILMAZ                         | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                   | Awareness-Based Interventions in Cancer: Global Trends and A Thematic Analysis                                                              |
| Candan TERZİOĞLU Eda KES                                  | Alanya Alaaddin Keykubat University<br>Bartın University                                     | Confidentiality, Therapeutic Relationship, and Sustainability in Digital Psychiatry: a Current Literature Review                            |
| Büşra BAŞ Raif ZILELI                                     | Bilecik Şeyh Edebali University<br>Bilecik Şeyh Edebali University                           | A Review of Master's Theses in The Field of Life Kinematics in Türkiye?                                                                     |

**(All speakers required to be connected to the session 10 min before the session starts)**

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## 23.04.2026 / Online/ SESSION-4

Meeting ID: 996 9199 8848

Join Zoom Meeting

<https://zoom.us/j/99691998848>

Ankara Local Time: 14:00 - 16:00

**HEAD OF SESSION : Prof.Dr. Tariq J. Al-Musawi**

| Authors                                                                                        | Affiliation                                                                                              | Presentation Title                                                                                                                        |
|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Mustafa Adnan Madlool<br>Al-BAKRY<br>Abdulahdi Raheem<br>HAMZA                                 | Al-Mustaqbal University<br>Al-Mustaqbal University                                                       | Digital Transformation in Management Methods: A Case Study of The University of Babylon and Al-Mustaqbal Private University               |
| Qusay Rasheed Al-amir<br>Ali Baqer Hussein<br>Hiba Mohsen abd Ali                              | Al-Mustaqbal University<br>Al-Mustaqbal University<br>Al-Mustaqbal University                            | Experimental Heat Transfer Study in Cylindrical System of Different Arrangement Immersed in Porous Media                                  |
| Tariq J. Al-Musawi<br>Noor Ahmad Rasim                                                         | Al-Mustaqbal University<br>Al-Mustaqbal University                                                       | Psychological Pressures Causing School Dropout Among Female Secondary School Students in Light of Sdg 4 (Quality Education)               |
| Merve AYTAÇ<br>Leyla AKBULUT<br>Afşin GÜNGÖR                                                   | Süleyman Demirel University<br>Alanya Alaaddin Keykubat University<br>Akdeniz University                 | From Infrastructure to Power Instrument: Digital Twin Technology and the Transformation of Energy Diplomacy                               |
| Merve AYTAÇ<br>Leyla AKBULUT<br>Afşin GÜNGÖR                                                   | Süleyman Demirel University<br>Alanya Alaaddin Keykubat University<br>Akdeniz University                 | Energy Storage Systems and State Security in Fragile States: the Resilience–Vulnerability Paradox                                         |
| Eman ARIF                                                                                      | Dawood University of Engineering and Technology Karachi                                                  | Enhancing Smart Irrigation through AI: Comparative Analysis of Classical Models and ConvLSTM for Spatio-Temporal Soil Moisture Prediction |
| Ali MAJDİ                                                                                      | Al-Mustaqbal University                                                                                  | Structural Development and Construction Practices of University Buildings: A Reflective Assessment of Al-Mustaqbal University (2010–2026) |
| Mazin Hadi KAZAR<br>Mohammed Asim GHAZI                                                        | Al-Mustaqbal University<br>Hilla University                                                              | Sustainable Smart Sports Cities as an Innovative Solution To Combat Climate Change And Enhance Energy Efficiency In Urban Environments    |
| Qusay Rasheed AL-AMİR<br>Ali Ajmi FALEH<br>Salwan Obaid WAHEED<br>Khafaji<br>Mohammed M. OBEİD | Al-Mustaqbal University<br>Al-Mustaqbal University<br>Al-Mustaqbal University<br>Al-Mustaqbal University | From Nature to Lab: A Sunflower-Inspired Solar Toolkit for Teaching Renewable Energy Fundamentals through Applied Research Activities"    |

**(All speakers required to be connected to the session 10 min before the session starts)**

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## 23.04.2026 / Online/ SESSION-5

Meeting ID: 972 3624 3137

Join Zoom Meeting

<https://zoom.us/j/97236243137>

Ankara Local Time: 14:00 - 16:00

HEAD OF SESSION: Prof. Dr. Feyza Meryem Kara-Dr. Öğr. Üyesi Elvan Deniz Yumuk

| Authors                                                                                                                               | Affiliation                                                                                                                                              | Presentation Title                                                                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Grzegorz KONIECZNY                                                                                                                    | Witelon Collegium State University                                                                                                                       | What Is New in Cryotherapy?                                                                                                                                |
| Magdalena BOJARSKA                                                                                                                    | State University of Applied Sciences in Jarosław                                                                                                         | The Role of Social Media in Building an Athlete's Image                                                                                                    |
| Ertan BEKİROĞLU<br>Melis KEKÜLLÜOĞLU TAN<br>Ayça YAĞCIOĞLU SÜDOR<br>Güler Aleyna YILDIRIM<br>Irem KAYA CEBİOĞLU<br>Gözde DUMLU BİLGİN | Yeditepe University<br>Yeditepe University<br>Yeditepe University<br>Yeditepe University<br>Yeditepe University<br>Yeditepe University                   | The Association of Dietary Intake, Nutrition Knowledge, and Anthropometric Measurements with Sports Performance Among Collegiate American Football Players |
| Rozelin BİLMEZ<br>Hilal ŞAHİN                                                                                                         | Erzincan Binali Yildirim University<br>Erzincan Binali Yildirim University                                                                               | Sustainability in Community Feeding Systems                                                                                                                |
| Anil Çilem ÇELİK<br>Salih ERDOĞAN                                                                                                     | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                               | The Importance of Service Quality and Accreditation in International Health Tourism                                                                        |
| Hamdi Alper GÜNGÖRMÜŞ<br>Feyza Meryem KARA<br>Elvan Deniz YUMUK<br>Onur CEYHAN                                                        | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University | Predicting Psychological Flow in Recreational Dart Participants: A Multidimensional Analysis of Leisure Involvement                                        |
| Hamdi Alper GÜNGÖRMÜŞ<br>Feyza Meryem KARA<br>Elvan Deniz YUMUK<br>Onur CEYHAN                                                        | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University | A Systematic Review of Postgraduate Theses on Adventure Recreation in Türkiye: Trends, Methodological Approaches, and Thematic Distribution                |
| Emirhan YALÇIN<br>Duran AKBAŞ<br>Işık BAYRAKTAR                                                                                       | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                        | A Bibliometric Analysis of Research on Racket Sports                                                                                                       |
| Utku DUMAN<br>Işık BAYRAKTAR                                                                                                          | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                               | Bibliometric Analysis of Circadian Rhythm Research in Sports Science: An Approach Based on Web of Science Data                                             |

(All speakers required to be connected to the session 10 min before the session starts)

Moderator is responsible for ensuring the smooth running of the presentation, managing the group discussion and dynamics.

# OPENING CEREMONY

| INTERNATIONAL HEALTH SPORTS ENERGY ENVIRONMENTAL SUSTAINABILITY CONGRESS<br>Program April 23-25, 2026 Alanya (Türkiye) |                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| April 24 2026 (Friday) Alev Alatlı Conference Hall (Rectorate Building)                                                |                                                                                                                               |
| 9:00-12:00                                                                                                             | Arrival and Registration                                                                                                      |
| 11:00-11:10                                                                                                            | Opening Remarks<br><b>Prof. Dr. Atif BAYRAMOĞLU</b> (Vice Rector)<br>Alanya Alaaddin Keykubat University, Alanya-Turkey       |
| 11:10-11:20                                                                                                            | <b>Prof. Dr. Kenan Ahmet TÜRKDOĞAN</b> (Rector)<br>Alanya Alaaddin Keykubat University, Alanya-Turkey                         |
| 11:20-11:40                                                                                                            | Keynote Speech I<br><b>Prof.Dr.Mary HOLZ-CLAUSE</b><br>Chancellor at the University of Minnesota Crookston, USA               |
| 11:40-12:00                                                                                                            | Keynote Speech II<br><b>Assist.Prof.Dr. Joanna KOCIĘCKA</b><br>Poznan University of Life Sciences, POLAND                     |
| 12:00-12:20                                                                                                            | Keynote Speech III (Online)<br><b>Professor Dr. Mohammad ISMAIL</b><br>Noakhali Science and Technology University, BANGLADESH |
| 12:20-12:30                                                                                                            | Photo Session                                                                                                                 |
| 12:30-13:30                                                                                                            | LUNCH                                                                                                                         |

24.04.2026 / Face to face / SESSION-1 / Alev Alatlı Conference Hall

Time: 13:30 - 15:30

HEAD OF SESSION: Prof. Dr. Ali Kemal ERENLER

| Authors                                                                          | Affiliation                                                                                                                                                              | Presentation Title                                                                                                                                               |
|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ceren ÇALIK<br>Ayfer YILMAZ<br>Doğa TÜRKKAHRAMAN                                 | Kepez State Hospital<br>Kepez State Hospital<br>Antalya Training and Research Hospital                                                                                   | Current Approaches to Obesity Awareness in Children: A Literature                                                                                                |
| Ceren ÇALIK<br>Seher TOPKAÇ<br>Özlem GÖMEÇ<br>Ayşegül İŞLER<br>Doğa TÜRKKAHRAMAN | Kepez State Hospital<br>Antalya Training and Research Hospital<br>Antalya Training and Research Hospital<br>Akdeniz University<br>Antalya Training and Research Hospital | How Aware are Adolescents of Obesity?                                                                                                                            |
| Meryem UÇKAYA<br>Fatih UÇKAYA                                                    | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                                               | in Silico Investigation of Volatile Compounds from Citrus Blossoms<br>Targeting Serotonergic And Dopaminergic Receptors: Molecular Docking<br>and Admet Analysis |
| Emine Hilal YILDIRIM<br>Ayça ARACI                                               | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                                               | Toward Sustainable Physiotherapy: Clinical Utility,<br>Limitations, and Future Perspectives of Wearable<br>Technologies in Rehabilitation                        |
| İrem DOĞUKAYA<br>İsmail SARIKAN                                                  | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                                               | Investigation of The<br>Relationship Between Chronotype and Night Eating Syndrome, Fasting<br>Blood Glucose, and HbA1C In Patients With Type 2 Diabetes Mellitus |
| Ceren ŞARAHMAN<br>KAHRAMAN<br>Eda ERKMEN<br>Duygu AKIL                           | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                        | Do Yoga Practices Affect Yogis' Level of Nutritional Knowledge and Their<br>Adherence to the Mediterranean Diet?                                                 |
| Elif ÖZDEMİR<br>Seda ARSLAN                                                      | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                                               | The Integration of 3D Anatomy<br>Platforms and AI-Based Image Analysis Systems in the Digital<br>Renaissance Era                                                 |

(All speakers required to be connected to the session 10 min before the session starts)

Moderator is responsible for ensuring the smooth running of the presentation, managing the group discussion and dynamics.



# 24.04.2026 / Face to Face / SESSION-2 / T3(Tömer Classroom)

Time: 13:30 - 15:30

**HEAD OF SESSION: Prof. Dr. Osman GÖKDOĞAN**

| Authors                                                     | Affiliation                                                                                                                                              | Presentation Title                                                                                    |
|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Durmuş Ali AKILLI<br>Fırat ARSLAN                           | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                               | Analysis of Gazipaşa Irrigation Scheme Using Fao-Rap Performance Indicators                           |
| Atılğan ATILGAN<br>Alper YENİALP                            | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                               | Possibilities of Using Tropical Fruit Waste as Organic Mulch                                          |
| Cansu KAHVECİOĞLU<br>Fırat ARSLAN                           | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                               | Coffee (Coffea spp.) Production in the Gazipaşa Ecosystem                                             |
| Meltem AKÇA                                                 | Alanya Alaaddin Keykubat University                                                                                                                      | Employee Perceptions of Green Logistics Practices in Airports: Implications for Sustainable Aviation  |
| Meltem AKÇA                                                 | Alanya Alaaddin Keykubat University                                                                                                                      | The Impact of Climate Change on The Aviation Industry: An Analysis of The Current Situation in Turkey |
| Karolina JÓZEFOWICZ<br>Barbara KĘSICKA                      | Poznan University of Life Sciences<br>Poznan University of Life Sciences                                                                                 | Between City and Countryside: Land Use Change in The Suburban Zone – a case Study From Poland         |
| Seda SARI<br>Fatma Hüda TAN<br>Burak SALTUK<br>Fırat ARSLAN | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University | An Examination of Sufficiently Profitable Agricultural Land Size: The Alanya Example                  |
| Derya Deniz ŞİRİNYILDIZ                                     | Alanya Alaaddin Keykubat University                                                                                                                      | The Importance of Sustainable Food Systems                                                            |
| Osman GÖKDOĞAN<br>Cihan DEMİR                               | Isparta University of Applied Science<br>Kırklareli University                                                                                           | Agricultural Mechanization Level of Alanya District of Türkiye                                        |

**(All speakers required to be connected to the session 10 min before the session starts)**

**Moderator is responsible for ensuring the smooth running of the presentation, managing the group discussion and dynamics.**

## 24.04.2026 / Face to Face / SESSION-3 / Alev Alatlı Conference Hall

Local Time: 15:45 - 17:30

HEAD OF SESSION : Prof. Dr. Atıf Bayramoğlu

| Authors                                                                                                                                           | Affiliation                                                                                                                                                                                                                                                                                                          | Presentation Title                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Rumeysa DIKICI<br>Funda ARIKAN<br>Ceyhun SAYMAN                                                                                                   | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                                                                                                                                                    | C2–C3 Cross-Sectional Area<br>Morphological Evaluation; Biomarker Search in Multiple Sclerosis?                                                 |
| Bariş ASLANOĞLU<br>Kadir Timuçin TURGUTOĞLU<br>Toprak HACIOĞLU<br>Yalçın GÜNEY<br>Hakan ÖZÇELİK<br>Müge Elif YAŞIN<br>Bırol ÖZKAL<br>Mehmet SEÇER | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University | Minimally Invasive Management of Pediatric T5 Vertebra Plana Due To<br>Langerhans Cell Histiocytosis: A Case Report                             |
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| Halil Orbay ÇOBANOĞLU<br>Derya ÖZ                                                                                                                 | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                                                                                                                                                                                                           | Bibliometric Analysis of<br>Studies on Football and Analytics Between 2006-2025                                                                 |
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24.04.2026 / Face to Face/SESSION-4/T3(Tömer Classroom)

Time: 15:45 - 17:30

HEAD OF SESSION : Assist.Prof.Dr. Tuğçe ÇOPUR

| Authors                                                                               | Affiliation                                                                                                                 | Presentation Title                                                                                                                                           |
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| Sena Zeliha TAŞKAN<br>Leyla AKBULUT<br>Mehmet BUCAKLI<br>Ahmet ÇOŞGUN<br>Afşin GÜNGÖR | Akdeniz University<br>Alanya Alaaddin Keykubat University<br>Akdeniz University<br>Akdeniz University<br>Akdeniz University | Technical and Economic Assessment of Renewable Energy And Sustainable Water Management Systems in Public Buildings Located in the Mediterranean Climate Zone |
| Eren KARATAŞLI<br>Tuğçe ÇOPUR                                                         | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                  | Environmental Sustainability in Airport Layout Planning: a Case Study of Gazipaşa-Alanya Airport                                                             |
| Gürkan ORTAMEVZİ<br>Kubra Elcin KARAKUS                                               | Alanya Alaaddin Keykubat University<br>Alanya Alaaddin Keykubat University                                                  | Safety of Transporting Hazardous Gases in Pressurized Cylinders                                                                                              |

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## THE RISING INCIDENCE OF MULTIDRUG-RESISTANT *S. AUREUS* IN ABSCESS INFECTIONS AND ASSESSES VOLATILE OILS AS A POSSIBLE SUPPLEMENTAL TREATMENT

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### ABSTRACT

An abscess is an accumulation of pus in any part of the body that usually causes inflammation and edema around it. Volatile oils having antibacterial activity against bacteria were used to treat abscess infections. The third sustainable development goal (Good Health and Well-Being) is aided by this study. 144 swabs from samples of clinical abscesses. *S. aureus* accounts for 72.3% of abscess isolates, whereas *P. vulgaris*, *P. aeruginosae*, and *E. coli* account for 27.7% of Gram-negative isolates. Ofloxacin has a 50.0% sensitivity to *S. aureus* isolates followed by amikacin and erythromycin. However, *S. aureus* isolates are completely resistant to cefoperazone and penicillin. Significant difference was observed between MIC and MBC of ofloxacin ( $p < 0.05$ ). The most potent antibacterial activity was shown by peppermint oil, followed by fennel oil. With a statistically high significant difference in MIC values ( $p < 0.01$ ), peppermint demonstrated better antibacterial action than fennel. Clinical *S. aureus* isolates are synergistically suppressed when peppermint oil and ofloxacin are combined, When paired with peppermint oil MICs, both the ofloxacin MIC inhibition zone and the ofloxacin MIC inhibition zone show significant modifications ( $p < 0.05$ ). In an effort to prevent drug resistance and suggest methods for the production of antibiotics in the future through structural clarity.

**Keywords:** Antibiotic resistance, abscess infections, *Staphylococcus aureus*, Volatile oils

APSELİ ENFEKSİYONLARDA ÇOK İLACA DİRENÇLİ *S. AUREUS*'UN ARTAN  
GÖRÜLME SIKLIĞINI VE UÇUCU YAĞLARI OLASI EK TEDAVİ OLARAK  
DEĞERLENDİRMEKTEDİR

ÖZET

Apse, vücudun herhangi bir yerinde irin birikmesi olup genellikle çevresinde iltihap ve ödem oluşturur. Bakterilere karşı antibakteriyel aktiviteye sahip uçucu yağlar, apse enfeksiyonlarını tedavi etmek için kullanılmıştır. Bu çalışma, üçüncü sürdürülebilir kalkınma hedefine (İyi Sağlık ve Refah) katkıda bulunmaktadır. Klinik apse örneklerinden 144 sürüntü alınmıştır. Apsel izolatlarının %72,3'ü *S. aureus* iken, *P. vulgaris*, *P. aeruginosa* ve *E. coli* Gram-negatif izolatların %27,7'sini oluşturmaktadır. Ofloksasin, *S. aureus* izolatlarına %50,0 duyarlılığa sahiptir; bunu amikasin ve eritromisin izlemektedir. Ancak *S. aureus* izolatları sefoperazon ve penisiline tamamen dirençlidir. Ofloksasin'in MİK ve MBK değerleri arasında anlamlı bir fark gözlemlendi ( $p < 0,05$ ). En güçlü antibakteriyel aktivite nane yağı tarafından gösterildi, ardından rezene yağı geldi. MIC değerlerinde istatistiksel olarak yüksek anlamlı bir farkla ( $p < 0,01$ ), nane yağı rezene yağına göre daha iyi antibakteriyel etki gösterdi. Klinik *S. aureus* izolatları, nane yağı ve ofloksasin kombinasyonu ile sinerjik olarak baskılanmaktadır. Nane yağı ile eşleştirildiğinde hem ofloksasin MIC inhibitör zonu hem de ofloksasin MIC inhibitör zonu anlamlı değişiklikler göstermektedir ( $p < 0,05$ ). İlaç direncini önlemeye ve gelecekte antibiyotik üretimi için yapısal açıklık yoluyla yöntemler önermeye yönelik bir çabadır.

**Anahtar kelimeler:** Antibiyotik direnci, apseli enfeksiyonlar, *Staphylococcus aureus*, Uçucu yağlar

INTRODUCTION

In a few years, Alexander Fleming, who went back to his laboratory in London, will have discovered penicillin. Antibiotics have since shown themselves to be quite beneficial for both physical and emotional well-being. But along with the antibiotic era came a new issue called antimicrobial resistance, which currently prevents the antibiotic era from reaching its full centennial [1,2]. Second only to cardiovascular diseases, antibiotic-resistant bacteria are listed by the World Health Organization as one of the top three dangers to global health [3].

The skin, the biggest organ in the human body, serves as the body's first line of defense against illnesses caused by bacteria. It supplies a broad biological niche for a variety of microorganisms and keeps foreign illnesses out of the body [4]. A microbial invasion of the skin layers and underlying soft tissues is the hallmark of skin and soft tissue infections (SSTIs), a significant cause of morbidity and mortality. The infections can range in intensity from mild to fatal, and manifest as anything from simple cellulitis to abscesses, deep tissue necrosis, and necrotizing fasciitis [5,6].

Gram-positive and coagulase-negative bacteria, including *Staphylococcus aureus* and  $\beta$ -hemolytic streptococci, are the main causes of bacterial SSTIs. Additionally, non-fermentative bacteria like *Pseudomonas* species and *Acinetobacter baumannii*, as well as Gram-negative Enterobacteriaceae and *Staphylococcus* species [6,7]. Bacterial skin infections have been linked to necrotizing fasciitis, scarlet fever, erysipelas, erythrasma, abscesses, folliculitis, furunculosis, and impetigo [8]. *Pseudomonas aeruginosa*, Enterobacteriaceae, *S. aureus*, and group A streptococci are the Gram-negative bacteria most frequently linked to cellulitis [9,10].

Four types of antimicrobial resistance have been identified: microbial resistance, which can be attributed to either genotypic or phenotypic factors; clinical resistance, which is thought to develop when no response is observed even to higher treatment doses; cross-resistance, which occurs when pathogens develop resistance to antibiotics known to have a similar mechanism of action, such as strains resistant to both levofloxacin and ciprofloxacin; and, finally, parallel or co-resistant *S. aureus* [11,12].

Misuse of antibiotics has resulted in antimicrobial resistance, which has avoided early deaths and led to important discoveries for modern medicine [13]. Over 80% of people worldwide use traditional medicine, according to the World Health Organization [14,15]. Many groups of phytochemicals present in important medicinal plants have therapeutic qualities that can be applied to treat recently identified human diseases [16]. Because the volatile molecules are hydrophobic, they can pass through the lipids of the bacterial cell membrane, disrupting the structure of the cell wall and increasing its permeability [17]. In an attempt to identify potential supplements to conventional antibiotics that can aid in the fight against resistance, this study aims to examine the antibacterial activity of particular volatile oils against bacterial isolates.

## **MATERIALS AND METHODS**

144 clinical samples were supplied by the Iraqi Hilla General Teaching Hospital. The samples were collected between June and November of 2025, and the patients' ages varied from 3 to 52. In these investigations, samples from 64 female and 80 males were used. The size and shape of the colony, whether it was mucoid or dry, opaque or transparent, the development of a distinctive colony color or any change in the color of the agar, fermentation on MacConkey's agar medium, and whether the isolate ferments lactose were all recorded after 144 swabs from abscess were inoculated on blood agar and MacConkey agar.



One technique for differentiating between Gram-positive and Gram-negative microorganisms is Gram staining. After that, the dyed slides are examined under a microscope using an oil immersion lens [18]. Bergey's Manual of Determinative Bacteriology [19], were used to identify the bacteria. Biochemical tests for Gram negative bacteria included the Indole test, Methyl red-Voges proskauer test, Triple Sugar Iron Agar test, citrate test, urease test, and oxidase test; coagulase test, mannitol For Gram-positive cocci, the novobiocin susceptibility test and salt agar were used.

The isolated bacteria's antibiotic sensitivity was evaluated using disc diffusion in compliance with the NCCLS antimicrobial disc susceptibility test criteria [20]. To reduce the turbidity to 0.5 McFarland standard saline, the single colony from each isolated strain should be cultivated for 24 hours at 37°C in 5 mL of sterile nutritive broth. One or two Muller Hinton agar plates with antibiotic discs attached at regular intervals received a broth inocula for each strain using sterile swabs. Antibiotics used in the experiment included cefoperazone (CFP) (75µg), amikacin (AK) (30µg), ampicillin (AM) (10µg), erythromycin (E) (15µg), ofloxacin (OFX) (5µg), and penicillin (P) (10µg). Plates were incubated at 37°C for 24 hours while inhibitory zone diameters and discs were measured in order to achieve complete growth inhibition that was evident to the unaided eye [21].

By modifying the dilution procedure, the MIC and MBC were determined. Ofloxacin was diluted in test tubes at 500, 250, 125, 62.5, and 31.25 µg/ml using sterile nourishing broth. Test tubes containing 1 ml of the different ofloxacin dosages in nutritive broth were inoculated with a loopful (10 µl) of bacterial isolates culture, 0.5 McFarland standard [22], using a standard wire loop (Merck). After an incubation period of 18 to 24 hours at 37°C, the tubes were checked for growth or turbidity. A loopful of broth from each test tube that did not exhibit any growth was then added to a nutritious agar plate as an inoculant.

Five prepared essential oils from medical plants, eucalyptus, chamomile, marjoram, fennel, and spearmint were obtained from the Sekem group company in Egypt. They were made by steam distillation and stored in the dark at 4°C until being used. Tween 80 drops were added to concentrated oils, and by changing the dilution procedure, the MIC was determined. Peppermint and fennel oil were diluted at 100, 75, 50, 25, and 12.5% (v/v) in test tubes using sterile nourishing broth.

The criteria for inclusion and exclusion. Among the patient types were those who had abscess infections. Those who did not have these infections were excluded.

The data was analyzed using an IBM (PC/AL) compatible computer and the statistical analysis toolkit Initiate program, version 3.03 (Graph Pad, USA).  $P < 0.05$  signifies significance,  $P < 0.01$  indicates high significance, while  $P > 0.05$  indicates non-significance. The following shows the probability level that corresponds to the different levels of statistical significance.

## RESULTS AND DISCUSSION

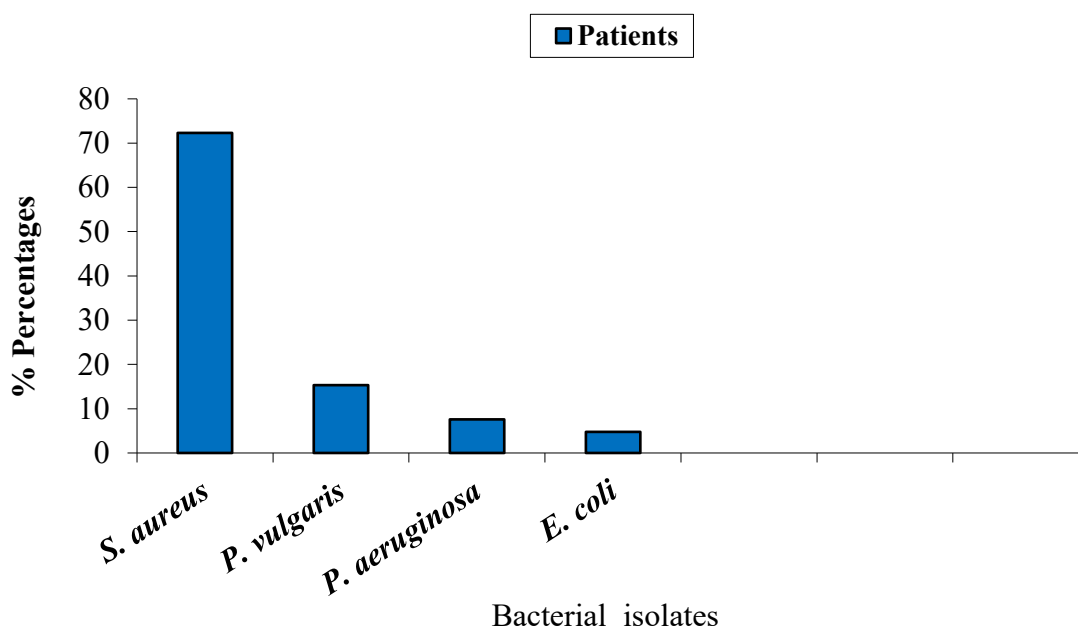


**Figure 1.** The distribution of pathogenic bacterial isolates

Samples of abscesses were taken from males and females of various ages. There were 64 females and 80 males, ages 3 to 50 and 5 to 52, respectively. The vast majority of isolated bacteria are gram-positive bacteria. While *P. vulgaris*, *P. aeruginosae*, and *E. coli* comprise 27.7% of the Gram-negative isolates, *S. aureus* accounts for 72.3% of the isolates, as illustrated in (Figure 1).

An collection of pus in any area of the body that typically results in edema and inflammation is called an abscess. Abscesses are frequently palpable. An abscess is a sensitive, easily compressed mass that is typically encircled by a pink or deep red region [23].

Gram-positive cocci were responsible for 65.4% of the bacterial infections in this investigation, whereas Gram-negative bacilli accounted for 34.5% [24]. In another study, 26 (83.87%) of the

bacterial infections were Gram-positive, while 16.13 percent were Gram-negative [25]. In line with earlier research, the results demonstrated that *Staphylococcus aureus* was the most prevalent genus, accounting for a sizable percentage (35.5%) of *S. aureus* [26].

**Table 1.** *S. aureus* sensitivity to various antibiotics is tested

| Tested antibiotics | Sensitive isolates |      | Intermediate isolates |      | Resistance isolates |       |
|--------------------|--------------------|------|-----------------------|------|---------------------|-------|
|                    | No.                | %    | No.                   | %    | No.                 | %     |
| Ofloxacin (OFX)    | 72                 | 50.0 | 12                    | 8.4  | 60                  | 41.6  |
| Amikacin (AK)      | 58                 | 40.3 | 28                    | 19.4 | 58                  | 40.3  |
| Erythromycin (E)   | 44                 | 30.5 | 16                    | 11.1 | 92                  | 58.4  |
| Ampicillin (AM)    | 18                 | 12.5 | 0                     | 0.0  | 126                 | 87.5  |
| Cefoperazone (CFP) | 0                  | 0.0  | 0                     | 0.0  | 144                 | 100.0 |
| Penicillin (P)     | 0                  | 0.0  | 0                     | 0.0  | 144                 | 100.0 |

Amikacin and erythromycin are the next most sensitive drugs against *S. aureus* isolates, with ofloxacin having a sensitivity of 50%. Isolates of *S. aureus* are completely resistant to cefoperazone, and penicillin, as illustrated in (Table 1).

Cefoperazone and penicillin are the drugs to which all pathogenic *S. aureus* are resistant, followed by erythromycin (70.18%), ampicillin (91.23%), chloramphenicol (43.86%), and amikacin (15.79%). A number of multidrug-resistant isolates of *Citrobacter freundii*, *E. coli*, *K. pneumoniae*, and *S. aureus* were resistant to twelve distinct antimicrobials. Of the 188 *S. aureus* isolates, 92 (18.9%) were resistant to erythromycin; the most resistant strains were ampicillin and penicillin G (86.7%) and cefotaxime (77.1%) [27].

**Table 2.** MICs and MBCs of ofloxacin antibiotic against *S. aureus* isolates

| Bacterial isolates | No. | (MIC)    | (MBC)    |
|--------------------|-----|----------|----------|
|                    |     | (µg /ml) | (µg /ml) |
| <i>S. aureus</i>   | 4   | 31.25    | 62.5     |
| <i>S. aureus</i>   | 10  | 31.25    | 62.5     |
| <i>S. aureus</i>   | 18  | 125      | 250      |
| <i>S. aureus</i>   | 36  | 62.5     | 125      |
| <i>S. aureus</i>   | 47  | 500      | 500      |
| <i>S. aureus</i>   | 64  | 62.5     | 62.5     |
| <i>S. aureus</i>   | 72  | 31.25    | 31.25    |
| <i>S. aureus</i>   | 90  | 31.25    | 62.5     |
| <i>S. aureus</i>   | 111 | 125      | 250      |

|                  |     |       |        |
|------------------|-----|-------|--------|
| <i>S. aureus</i> | 123 | 125   | 250    |
|                  |     | 112.5 | 165.63 |
| SD               |     | 142.2 | 147.4  |
| t                |     | 3.16  |        |
| P                |     | 0.011 |        |

MBC/MIC ratios  $\leq 2$  were found in all examined samples, suggesting a potent bactericidal action. The antimicrobial agent had a very strong killing activity in multiple instances where MBC and MIC were equal. Overall, these findings demonstrate that the tested substance has reliable and potent bactericidal qualities against every isolate that was investigated, significant difference was observed between MIC and MBC of ofloxacin ( $p < 0.05$ ), as illustrated in (Table 2).

**Table 3.** Different essential oils' diameter of inhibitory zone (mm) against *S. aureus* isolates

| Bacterial isolates | No. | Diameter of inhibition zones (mm) |          |            |          |        |           |
|--------------------|-----|-----------------------------------|----------|------------|----------|--------|-----------|
|                    |     | Eucalyptus                        | Chamomil | Peppermint | Marjoram | Fennel | Spearmint |
| <i>S. aureus</i>   | 4   | 14                                | ,0       | 15         | 12       | 12     | 10        |
| <i>S. aureus</i>   | 10  | 11                                | 0        | 15         | 10       | 15     | 15        |
| <i>S. aureus</i>   | 18  | 13                                | 8        | 20         | 12       | 11     | 12        |
| <i>S. aureus</i>   | 36  | 12                                | 10       | 13         | 13       | 15     | 10        |
| <i>S. aureus</i>   | 47  | 9                                 | 0        | 20         | 11       | 15     | 9         |
| <i>S. aureus</i>   | 64  | 10                                | 0        | 15         | 11       | 13     | 15        |
| <i>S. aureus</i>   | 72  | 0                                 | 0        | 19         | 8        | 12     | 13        |
| <i>S. aureus</i>   | 90  | 9                                 | 10       | 12         | 12       | 14     | 10        |
| <i>S. aureus</i>   | 111 | 9                                 | 0        | 15         | 10       | 15     | 9         |
| <i>S. aureus</i>   | 123 | 10                                | 11       | 15         | 13       | 14     | 10        |

Peppermint oil displayed the strongest antibacterial activity, followed by fennel oil. Spearmint and marjoram showed intermediate effects, while eucalyptus demonstrated lesser activity. Chamomile showed the weakest antimicrobial impact among all tested oils, as illustrated in (Table 3).

The antibacterial properties and chemical composition of essential oils extracted from the areal portions of *Mentha piperita* L. According to these authors' research findings, the essential oil had the strongest antibacterial effectiveness against microbes. Additionally, the disc-diffusion method revealed that *Staphylococcus aureus* ( $42.44 \pm 0.10$  mm), *Micrococcus flavus* ( $40.01 \pm 0.10$  mm), *Bacillus subtilis* ( $38.18 \pm 0.11$  mm), *Staphylococcus epidermidis* ( $35.14 \pm 0.08$  mm),



and *Salmonella enteritidis* ( $30.12 \pm 0.12$  mm) demonstrated good inhibition zones against *Mentha piperita* [28]. Eleven bacterial and four fungal clinical isolates were used to evaluate the antibacterial activity of essential oils from mint species. With a maximum zone of inhibition of  $21 \pm 0.09$  mm for *Mentha spicata* and  $19.2 \pm 0.07$  mm for *Mentha piperita*, both essential oils demonstrated maximum efficacy against *S. aureus* [29].

**Table 4.** MICs of peppermint and fennel against *S. aureus* isolates

| Bacterial isolates | No. | Peppermint<br>(MIC) | Fennel<br>(MIC) |
|--------------------|-----|---------------------|-----------------|
|                    |     | (% v/v)             | (% v/v)         |
| <i>S. aureus</i>   | 4   | 50                  | 75              |
| <i>S. aureus</i>   | 10  | 25                  | 25              |
| <i>S. aureus</i>   | 18  | 50                  | 100             |
| <i>S. aureus</i>   | 36  | 50                  | 50              |
| <i>S. aureus</i>   | 47  | 12.5                | 50              |
| <i>S. aureus</i>   | 64  | 50                  | 50              |
| <i>S. aureus</i>   | 72  | 12.5                | 50              |
| <i>S. aureus</i>   | 90  | 12.5                | 100             |
| <i>S. aureus</i>   | 111 | 50                  | 75              |
| <i>S. aureus</i>   | 123 | 25                  | 50              |
| $\bar{X}$          |     | 33.75               | 62.5            |
| SD                 |     | 17.7                | 24.3            |
| t                  |     | 3.02                |                 |
| P                  |     | 0.007               |                 |

Peppermint demonstrated superior inhibitory activity, suggesting its potential as a more effective antimicrobial agent; the difference in MIC values between peppermint and fennel was found to be highly statistically significant ( $p < 0.01$ ), as illustrated in (Table 4).

Peppermint oil's MIC and MLC values fell between 0.125-1 and 0.125- > 64  $\mu\text{l/ml}$ , respectively. Gram positive bacteria had MIC and MLC values of 0.25-1 and 0.5->64  $\mu\text{l/ml}$ , respectively. *B. cereus* was inhibited by the peppermint oil (MIC, MLC = 0.25, > 64  $\mu\text{l/ml}$ ). Compared to the other Gram-positive bacteria, peppermint oil had higher MLC values against *E. faecalis* and *E. faecium*. *S. mutans*, *S. typhimurium*, *P. aeruginosa*, *Sh. flexeneri*, *Sh. dysenteriae*, *C. albicans*, and *A. parasiticus* were all susceptible to the oil's bactericidal effects [30]. The most sensitive microbe to peppermint oil was *Candida albicans* (MIC = 0.312 mg/ml), followed by *S. epidermidis* (MIC = 0.625 mg/ml), *B. cereus*, *S. thyphimurium*, *E. aerogenes*, *S. aureus*, and *E. coli* (MIC = 1.25 mg/ml) [31].

**Table 5.** The diameter of the inhibitory zone (mm) created by combining the MICs of peppermint and ofloxacin

| Bacterial isolates | Serial No. | Ofloxacin MICs |      | Peppermint oil MICs | Combination between ofloxacin and peppermint oil MICs |
|--------------------|------------|----------------|------|---------------------|-------------------------------------------------------|
|                    |            | µg/ml          | IZ   | (% v/v)             | IZ                                                    |
| <i>S. aureus</i>   | 4          | 31.25          | 16   | 50                  | 12                                                    |
| <i>S. aureus</i>   | 10         | 31.25          | 8    | 25                  | 14                                                    |
| <i>S. aureus</i>   | 18         | 125            | 10   | 50                  | 0                                                     |
| <i>S. aureus</i>   | 36         | 62.5           | 12   | 50                  | 8                                                     |
| <i>S. aureus</i>   | 47         | 500            | 10   | 12.5                | 0                                                     |
| <i>S. aureus</i>   | 64         | 62.5           | 10   | 50                  | 0                                                     |
| <i>S. aureus</i>   | 72         | 31.25          | 12   | 12.5                | 16                                                    |
| <i>S. aureus</i>   | 90         | 31.25          | 15   | 12.5                | 0                                                     |
| <i>S. aureus</i>   | 111        | 125            | 10   | 50                  | 15                                                    |
| <i>S. aureus</i>   | 123        | 125            | 15   | 25                  | 0                                                     |
| $\bar{X}$          |            | 112.5          | 11.8 | 33.75               | 6.5                                                   |
| SD                 |            | 142.2          | 2.7  | 17.7                | 6.9                                                   |
| t                  |            |                |      |                     | 2.18                                                  |
| P                  |            |                |      |                     | 0.04                                                  |

IZ= inhibition zone

Peppermint oil and ofloxacin were found to work in concert against *S. aureus* numbers 10, 72, and 111. However, the antagonistic activity against *S. aureus* numbers 4, 18, 36, 47, 64, 90, and 123 was amply demonstrated by the combination of ofloxacin and peppermint oil. Both the ofloxacin MIC inhibition zone and the ofloxacin MIC inhibition zone when combined with peppermint oil MICs exhibit significant changes ( $p < 0.05$ ), as shown in (Table 5).

One study uses the Kirby & Bauer method to assess the synergistic efficacy of peppermint with thirteen antibiotics against *S. aureus*. Vancomycin, penicillin, ceftiofur, cotrimoxazol, and ofloxacin did not display synergistic effects, however tetracyclin, chloramphenicol, netilmicin, erythromycin, gentamycin, and oxacillin did [32].

## CONCLUSION

Since *S. aureus* inevitably develops antibiotic resistance, efforts have been made to identify natural and safe substitutes. Volatile oils have been utilized to boost the efficacy of antibiotics and eliminate dangerous germs that are resistant to drugs by including these organic components. Clinically resistant bacterial isolates were affected by peppermint and fennel oils. Combining ofloxacin MIC with peppermint volatile oil has synergistic effects. Thus, the

biological activity that prevents bacterial growth in the aforementioned plants could be used as a starting point for the creation of new antibiotics in the future with further structural clarification.

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## ANALYSIS OF GAZIPAŞA IRRIGATION SCHEME USING FAO-RAP PERFORMANCE INDICATORS

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### ABSTRACT

Water is an indispensable resource for life. While the uses of water vary globally, approximately 70% is used in agriculture. In Türkiye, water user associations manage the majority of water consumed in the agricultural sector. Therefore, monitoring and evaluation of irrigation networks are becoming increasingly important in light of climate change and drought.

Gazipaşa, due to its subtropical climate, is one of the important centers for agriculture. In this district, where population density has increased due to tourism, the newly opened airport, earthquakes in Türkiye, and wars in the region have also increased water demand. This study aims to evaluate the performance of the Gazipaşa Irrigation Scheme, which is affiliated with the Eastern Antalya Irrigation Association operating in Gazipaşa district, using External Indicators from the Rapid Assessment Procedure (RAP) of the Food and Agriculture Organization of the United Nations (FAO). The Gazipaşa Irrigation Network has a total irrigation area of 1400 hectares, and its water sources are Korubaşı Stream, Bıçkıcı Stream, Hasdere Creek, and groundwater wells. The water transmission system consists of open channels. Approximately 60% of irrigated areas use drip irrigation, and nearly 20% use sprinkler irrigation. In the irrigation network, where the irrigation rate is approximately 40%, sufficient rainfall and lack of water demand are reported as the leading reasons for the unirrigated areas. The value of production per unit area has increased with the increase in tropical fruit production, but the amount of irrigation water distributed per unit area has decreased.

**Keywords:** FAO-RAP, Gazipaşa, Irrigation modernization

## FAO SULAMA PERFORMANS GÖSTERGELERİ İLE GAZİPAŞA SULAMA ALANLARININ ANALİZİ

### ÖZET

Su, canlı yaşamı için vazgeçilmez bir kaynaktır. Dünyada suyun kullanım alanları değişmekle birlikte, yaklaşık %70'i tarımda kullanılmaktadır. Türkiye'de tarım sektöründe tüketilen suyun büyük çoğunluğunu sulama birlikleri yönetmektedir. Bu nedenle, sulama şebekelerinin izleme-değerlendirmesi iklim değişikliği ve kuraklıkla birlikte önemini artırmaktadır.

Gazipaşa, subtropik iklim nedeniyle tarım açısından önemli merkezlerden biridir. Turizm hareketliliği, yeni açılan havalimanı, Türkiye'de meydana gelen depremler ve Türkiye'ye yakın coğrafyada meydana gelen savaşlar nedeniyle nüfus yoğunluğu artmış olan ilçede, su ve gıda tüketimiyle su ihtiyacı artmıştır. Bu çalışmada, Gazipaşa ilçesinde faaliyet gösteren Doğu Antalya Sulama Birliği'ne bağlı Gazipaşa Sulama Şebekesi performansının Dünya Gıda ve Tarım Örgütü (Food and Agriculture Organization of the United Nations-FAO) kriterlerinden Hızlı Değerlendirme Prosedürü (RAP)'de bulunan Dışsal Göstergeler (External Indicators) ile değerlendirilmesi amaçlanmıştır. Gazipaşa Sulama Şebekesi toplam 1400 ha sulama alanına sahip olup su kaynaklarını Korubaşı Deresi, Bıçkıcı Deresi, Hasdere Çayı ve yeraltı su kuyuları oluşturmaktadır. Su iletim sistemi ise açık kanallardan oluşmaktadır. Sulanan alanlarda yaklaşık %60 damla, %20'ye yakını ise yağmurlama yöntemleri ile sulanmaktadır. Sulama oranı yaklaşık %40 olan sulama şebekesinde yağışların yeterli görülmesi ve su talebinin olmaması sulanmayan alanların önde gelen nedenleri olarak raporlanmıştır. Birim alandan elde edilen üretim değeri tropik meyve üretiminin artması ile artmış ancak birim alana dağıtılan sulama suyu miktarı azalmıştır.

**Anahtar Kelimeler:** FAO-RAP, Gazipaşa, Sulama modernizasyonu

## SUSTAINABILITY IN COMMUNITY FEEDING SYSTEMS

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### ABSTRACT

Increasing population and modern lifestyles have intensified ecological problems through climate change, leading to the depletion of natural resources. In addition, the rising consumption of processed and animal-based foods has worsened both health and environmental conditions. Global challenges such as rapid population growth, global warming, biodiversity loss, and limited energy and water resources threaten future generations. In response, regulating dietary habits in line with sustainable development goals has become an important strategy. Within this framework, the concept of “sustainable nutrition” has emerged. Sustainable nutrition is a holistic approach that aims to minimize environmental impacts across all stages of the food system, including production, processing, packaging, distribution, storage, and consumption. Access to healthy and sustainable food is a fundamental human right and is essential for public health, quality of life, and economic well-being. Therefore, ensuring continuous access to safe and healthy food depends on the effectiveness of sustainable food systems that integrate environmental, economic, and social dimensions. In these systems, both nutritional quality and the environmental impact of food services must be considered. Community Feeding Systems (CFS), such as schools, hospitals, and nursing homes, play a key role in promoting environmental sustainability due to their large-scale food service operations. Food produced through sustainable methods contributes to ecosystem protection, biodiversity conservation, and food security. Key strategies in this context include waste reduction, energy efficiency, recycling, holistic waste management, sustainable menu planning, and stakeholder education. This review examines sustainable nutrition practices in food catering systems, focusing on approaches that reduce environmental impacts. It also compares the ecological impacts of food and evaluates waste management and environmentally friendly practices in catering services. Overall, this study aims to contribute to the improvement and restructuring of sustainable food catering systems in response to the growing climate crisis and natural resource depletion.

**Keywords:** Climate change, sustainable food systems, nutritional system transformation, natural resource scarcity, environmental sustainability.

## TOPLU BESLENME SİSTEMLERİNDE SÜRDÜRÜLEBİLİRLİK

### ÖZET

Artan nüfus ve modern yaşam biçimleri, iklim değişikliği ile ekolojik sorunları derinleştirerek doğal kaynakların azalmasına yol açmış; hazır ve hayvansal gıda tüketiminin artışı hem sağlık sorunlarını hem de çevresel sorunları artırmıştır. Gelecek nesiller için tehdit oluşturan hızlı nüfus artışı, küresel ısınma, azalan biyoçeşitlilik ile sınırlı enerji ve su kaynaklarıyla mücadelede sürdürülebilir kalkınma hedefleri doğrultusunda beslenme alışkanlıklarının düzenlenmesi önemli bir strateji olarak öne çıkmış ve bu kapsamda “sürdürülebilir beslenme” kavramı geliştirilmiştir. Sürdürülebilir beslenme, besinlerin üretiminden tüketimine kadar olan süreçte; ambalajlama, işleme, dağıtım, depolama ve ulaşım gibi tüm aşamalarda çevresel etkileri en aza indirmeyi hedefleyen bütüncül bir yaklaşımdır. Sağlıklı ve sürdürülebilir beslenmeye erişim, evrensel bir insan hakkı olup, yaşam kalitesi, toplumsal sağlık ve ekonomik refah açısından önemlidir. Bu nedenle bireylerin sağlıklı besinlere sürekli ve güvenli erişimi, çevresel, ekonomik ve sosyal boyutları kapsayan sürdürülebilir besin sistemlerinin etkinliğine bağlıdır. Bu sistemlerde yalnızca sağlık ve hijyen değil, menülerin çevresel etkileri de değerlendirilmelidir. Okul, hastane ve huzurevi gibi Toplu Beslenme Sistemleri (TBS) geniş kitlelere hizmet vermeleri nedeniyle çevresel sürdürülebilirlik uygulamalarında kritik bir rol üstlenmektedir. Sürdürülebilir üretimle elde edilen besinler, ekosistem ve biyolojik çeşitliliğin korunmasına katkı sağlamakta ve besin güvencesini desteklemektedir. Bu kapsamda israfın azaltılması, enerji verimliliği, geri dönüşüm ve bütüncül atık yönetimi, ekolojik ayak izine uygun menü planlaması ve paydaşların eğitimi temel stratejiler arasında yer almaktadır. Bu derlemenin temel amacı, TBS bağlamında sürdürülebilir beslenme uygulamalarını inceleyerek, çevresel etkileri en aza indiren stratejilere odaklanmaktır. Bu kapsamda besinlerin ekolojik etkileri karşılaştırılmakta; atık yönetimi, gıda israfının azaltılması ve çevre dostu uygulamaların toplu yemek hizmetlerine entegrasyonu değerlendirilmektedir. Bu derleme artan iklim krizi ve doğal kaynakların tükenmesi karşısında, beslenme sistemlerinin sürdürülebilirliğinin yeniden yapılandırılmasına katkı sağlamayı hedeflemektedir.

**Anahtar kelimeler:** İklim değişikliği, sürdürülebilir gıda sistemleri, beslenme sistemleri dönüşümü, doğal kaynak kıtlığı, çevresel sürdürülebilirlik.

### GİRİŞ

Sağlıklı ve sürdürülebilir beslenmeye erişim, evrensel bir insan hakkı olarak kabul edilmekte olup, bireylerin yaşam kalitesi, toplumsal sağlık düzeyi, ekonomik kalkınma ve genel refahın sağlanmasında temel bir rol oynamaktadır. Bu çerçevede, bireylerin sağlıklı besinlere sürekli ve güvenli biçimde ulaşabilmesi, yalnızca sağlık politikalarının değil, aynı zamanda çevresel, ekonomik ve sosyal boyutları içeren sürdürülebilir gıda sistemlerinin etkinliğine bağlıdır (Pekcan, 2024). Günümüzde yaşam koşullarındaki değişim, bireylerin beslenme alışkanlıklarını etkilemiş; hazır ve hayvansal kaynaklı gıdaların tüketimi artarken, geleneksel diyetler geri planda kalmıştır. Bu durum, beslenmeye bağlı hastalıkların artmasına ve çevresel sorunlara yol açmaktadır. Araştırmalar, insan kaynaklı sera gazı emisyonlarının üçte birinin beslenme ve gıda



üretimiyle ilişkili olduğunu göstermektedir. Bu bağlamda, çevresel etkileri azaltan diyetlerin benimsenmesi önem kazanmaktadır. FAO, sürdürülebilir diyetleri; besin güvenliğini sağlayan, çevreye duyarlı ve kuşaklar arası sağlıklı yaşamı destekleyen beslenme biçimleri olarak tanımlamaktadır (Madalı ve ark., 2021).

Sürdürülebilir üretim sistemleriyle elde edilen gıdaların, çevresel etkileri azaltarak ekosistem ve biyolojik çeşitliliğin korunmasına katkı sağladığı, aynı zamanda mevcut ve gelecek nesiller için besin güvencesi sunduğu belirtilmektedir. Toplu Beslenme Sistemleri (TBS), giderek daha fazla bireye hizmet sunmaları nedeniyle çevresel sürdürülebilirlik açısından önemli bir rol üstlenmektedir. Bu bağlamda, gıda israfının azaltılması hem çevresel hem de ekonomik açıdan sürdürülebilirliğe katkı sağlayan temel bir stratejidir. Atık oluşumunu kaynağında önlemeye yönelik uygulamalar, bütüncül atık yönetiminin en öncelikli adımları arasında yer almaktadır. TBS kapsamında sürdürülebilirliğin sağlanması için; enerji verimliliği, ambalaj atıklarının geri dönüştürülmesi, ekolojik ayak izine göre menü planlaması, tüketici memnuniyeti odaklı hizmet kalitesi, kalite güvence sistemlerinin yapılandırılması ve çevre dostu temizlik uygulamaları gibi unsurlar dikkate alınmalıdır. Ayrıca, tüm paydaşların sürekli eğitimi, sürdürülebilir yemek hizmetlerinin geliştirilmesinde kritik bir faktör olarak öne çıkmaktadır. Bu çerçevede, yemek hizmeti sektörünün çevresel etkilerini azaltmaya yönelik stratejik yaklaşımlar bu bölümde kapsamlı şekilde ele alınmıştır (Ongan ve Songür Bozdağ, 2024).

Türkiye'de bir üniversite yemekhane menüsü üzerine yapılan bir araştırmada, hayvansal kaynaklı gıdaların yoğun olarak kullanıldığı yemeklerin, diğer yemeklere kıyasla daha fazla karbon ve su ayak izine sahip olduğu ortaya konmuştur (Taş Özdemir, 2020). Ankara'da bir devlet dairesinde düzenlenen bir yıllık menünün; en yüksek sera gazı emisyon düzeyinin ilkbahar mevsiminde verilen menü (227.5 CO<sub>2</sub> eşdeğeri/ kg) olduğu, en düşük menünün ise kış mevsiminde (178.9 CO<sub>2</sub> eşdeğeri/kg) olduğu ve tek öğün verilen bu kurumda yıllık ortalama su ayak izi değerinin 644.97 m<sup>3</sup>/ton olduğu belirlenmiştir (Madalı ve ark., 2021). Türkiye'nin yedi bölgesinden birer okul seçilerek toplam yedi özel lisenin bir aylık öğle yemeği menüsüyle yapılan çalışmada, bazı besin öğeleri ile menülerin karbon ve su ayak izleri arasında ve menülerin kalitesi ile çevresel etkisi arasında pozitif bir ilişki olduğu belirlenmiştir (Aytekin Şahin ve ark., 2024). Araştırmalar, hayvansal kökenli gıdaların, bitkisel temelli besinlere kıyasla çevre üzerinde daha yüksek olumsuz etkilere sahip olduğunu ortaya koymaktadır. Bu durumun temel nedenleri arasında, hayvansal üretimin daha fazla sera gazı salımına neden

olması, geniş alanlara ihtiyaç duyması, yem üretiminde yüksek düzeyde girdi ve enerji kullanımı ile ruminant hayvanlarda gerçekleşen enterik fermentasyon süreci sonucunda açığa çıkan yüksek miktarda metan gazı yer almaktadır (Madalı ve ark., 2021).

Bu derlemenin temel amacı, toplu beslenme sistemleri bağlamında sürdürülebilir beslenme uygulamalarını inceleyerek, çevresel etkileri en aza indiren stratejilere odaklanmaktır. Çalışma kapsamında özellikle hayvansal ve bitkisel kaynaklı gıdaların ekolojik etkileri karşılaştırılmakta; atık yönetimi, gıda israfının azaltılması ve çevre dostu uygulamaların toplu yemek hizmetlerine entegrasyonu değerlendirilmektedir. Araştırma, yalnızca çevresel sürdürülebilirlik boyutuyla sınırlandırılmış olup ekonomik ve sosyo-kültürel yönleri kapsam dışı bırakılmıştır. Artan iklim krizi ve doğal kaynakların tükenmesi karşısında, sürdürülebilir beslenme sistemlerinin yapılandırılması açısından bu çalışma önemli bir katkı sunmayı hedeflemektedir.

## **MATERYAL VE YÖNTEM**

Bu derleme, sürdürülebilirlik, toplu beslenme sistemleri, gıda israfı ve atıklar ile ilgili hakemli makaleler, raporlar ve uluslararası politika belgelerinin kapsamlı bir literatür taramasına dayanmaktadır. Toplu beslenme sistemlerinde sürdürülebilirlik uygulamalarını değerlendirmek için bilimsel veri tabanları ve kurumsal yayınlar analiz edilmiştir.

## **BULGULAR VE TARTIŞMA**

### **Sürdürülebilir Beslenme**

#### **Sürdürülebilir Beslenmenin Tanımı ve Tarihçesi**

Sürdürülebilirlik, mevcut kaynakların verimli kullanımıyla gelecek nesillere doğal varlıkların ve kaynakların kalitesini koruyarak aktarılması olarak tanımlanmaktadır. Bu bağlamda sürdürülebilir beslenme, hem toplumun hem de gelecek kuşakların sağlıklı yaşamlarını destekleyen, besin güvenliğini sağlayan ve çevresel etkileri minimize eden bir beslenme modeli olarak kabul edilmektedir. Dünya nüfustaki artış, iklim değişiklikleri ve sınırlı enerji kaynakları nedeniyle sürdürülebilirlik kavramının önemi giderek artmaktadır (Öktem Güngör, 2022).

Birleşmiş Milletler'in Dünya Çevre ve Kalkınma Komisyonunun düzenlediği ve 1987 yılında yayımladığı "Brundtland Raporu"nda sürdürülebilir kalkınma, "günümüz nesillerinin

gereksinimlerini karşılama yeteneğini tehlikeye atmadan gelecek nesillerin ihtiyaçlarını karşılamak” şeklinde tanımlanmıştır (Keeble, 1988). Günümüzde nüfusun hızla artması, küresel ısınma, iklim değişikliği, azalan biyoçeşitlilik ile sınırlı enerji ve su kaynakları, gelecek nesiller için tehditler oluşturmaktadır (Tomba ve ark., 2020). Bu tehditlerle mücadelede sürdürülebilir kalkınma hedefleri baz alınarak bireylerin besin tercihlerinin düzenlenmesi önemli bir strateji olarak ön plana çıkmış ve bu kapsamda “sürdürülebilir beslenme” kavramı geliştirilmiştir (Ünal Özen, 2019).

FAO’nun 2010 yılında yaptığı tanıma göre sürdürülebilir beslenme, insan ve doğal kaynakların etkin kullanımı, biyoçeşitlilik ve ekosisteme saygı, kültürel uygunluk, ekonomik erişilebilirlik ve besinlerin çevresel etkilerinin azaltılması kriterlerini içeren ve daha az besin ayak izine sahip olan diyetlerdir (Willett ve ark., 2019). Sürdürülebilir beslenme tutumu, besin üretiminden tüketimine kadar olan süreçte; ambalajlama, işleme, satış, dağıtım, depolama, ulaşım gibi besin zincirinin tüm aşamalarında çevre üzerindeki etkileri en aza indirmeyi hedeflemektedir. Bu doğrultuda, sürdürülebilir beslenme; besin tercihlerinin çevre üzerindeki etkilerini en aza indirerek, besin atıklarının ve kayıplarının önlenmesini, yerel ve mevsimine uygun ürünlerin seçilmesini ve hayvansal kaynaklı, özellikle yağ oranı yüksek gıdaların yerine bitkisel kaynaklı besinlerin tüketimini teşvik etmektedir (Demir ve Akay, 2020; Yolcuoğlu ve Kızıltan, 2021).

Sürdürülebilir beslenme kavramı ilk kez 1986 yılında Gussow ve Clancy tarafından kullanılmıştır. Beslenme kılavuzlarında gıda ve sağlık arasındaki ilişkinin incelendiğini ancak gıda ve çevre arasındaki ilişkinin dikkate alınmadığını belirterek beslenme seçimlerinin çevresel etkilerini incelemişlerdir (Gussow ve Clancy, 1986). Sürdürülebilir diyet kavramı, 2010 yılına dek resmi olarak tanımlanmamış ya da net bir çerçeveye oturtulmamıştır. 2010 yılında Gıda ve Tarım Örgütü (FAO) tarafından Roma’da gerçekleştirilen Biyoçeşitlilik ve Sürdürülebilir Diyetler sempozyumunda “Sürdürülebilir diyetler günümüz ve gelecek nesillerde sağlıklı yaşam için besin ve beslenme güvenliğine katkı sağlayan düşük çevresel etkileri olan diyetlerdir. Sürdürülebilir diyetler ekolojik sisteme ve biyolojik çeşitliliğe karşı saygılı ve koruyucudur, kültürel olarak kabul edilebilir, erişilebilir, ekonomik olarak adil ve uygun fiyatlı, doğal ve insan kaynaklarını en iyi şekilde kullanırken beslenme açısından yeterli, güvenli ve sağlıklı diyetlerdir” şeklinde tanım yapılmıştır (FAO, 2010).

Dünya, bütün canlıların ortak yaşam alanı olarak artan nüfusla birlikte iklim değişikliği, ekolojik dengesizlikler ve küresel tehditlerle karşı karşıya kalmaktadır. Bu değişimler, doğal kaynakların verimliliğinin azalmasına ve kıtlık sorunlarının ortaya çıkmasına neden olmaktadır. Gelecek kuşakların sağlıklı ve güvenli gıdaya erişimi, günümüz neslinin sürdürülebilir besin seçimleri yapmasına bağlıdır. Sürdürülebilir beslenme, tercih edilen besinlerin yaşam döngüsünün çevre üzerindeki etkilerini değerlendirerek optimum beslenmeyi mümkün kılmaktadır. Literatürde sürdürülebilir beslenmenin, sera gazı emisyonları ve su ayak izi düşük, enerji ve arazi kullanımında verimli, besin atık ve kayıplarını en aza indirgeyen bir tutum olduğu vurgulanmaktadır. Bitkisel gıdalar; meyveler, sebzeler, tam tahıllar, baklagiller, yağlı tohumlar ve düşük çevresel etkiye sahip balık, kümes hayvanları, zeytin ve zeytinyağı sürdürülebilir beslenmenin temel unsurlarını oluşturmaktadır. Buna rağmen hayvansal besinler, kırmızı etler, işlenmiş gıdalar, doymuş yağlar, ve şekerli yiyecekler ise ekolojik dengeyi olumsuz etkilemeleri sebebiyle sınırlanmalıdır (Olgun ve ark., 2022).

Küresel nüfus artışı, sanayileşme ve kentleşme gibi etkenler çevresel bozulmaya yol açarak ekosistem dengesini tehlikeye sokmaktadır. Bu süreçte, gıda sistemleri sera gazı salımları ile su ve arazi gibi doğal kaynakların kullanımı açısından önemli bir rol oynamaktadır. Gıda üretiminden tüketimine kadar olan tüm aşamalarda ortaya çıkan çevresel etkiler, sürdürülebilir beslenme kavramının önemini artırmaktadır. Özellikle hayvansal ürünlerin üretim ve tüketimi, yüksek oranda sera gazı emisyonuna sebep olurken, bitki temelli beslenme biçimleri hem çevresel sürdürülebilirliği hem de bireylerin sağlık durumunu olumlu yönde desteklemektedir.

Tükettiğimiz gıdalar ve bunların üretim metodları insanların ve dünyanın sağlığını belirleyerek büyük bir etkileşim içine girmektedir. Besinlerin çevre üzerindeki olumsuz etkilerini değerlendirmede kullanılan özellikle su ayak izi ve karbon ayak izi olarak tanımlanan iki önemli kavram bulunmaktadır (Clune ve ark., 2017; Hoekstra ve ark., 2011). Bir gıdanın karbon ayak izi, üretimden tüketime kadar geçen süreçte - yani üretim, taşıma, depolama, işleme, ambalajlama, pişirme ve tüketim aşamalarında - ortaya çıkan toplam sera gazı salımını ifade eder. Et ürünlerinin, tahıl ve sebze gibi bitkisel kaynaklı besinlerle karşılaştırıldığında daha yüksek karbon ayak izine sahip olduğu görülmektedir (Takacs ve ark., 2022). Öte yandan, gıdaların üretimi ve tüketimi sırasında doğrudan ya da dolaylı olarak harcanan su miktarı "su ayak izi" kavramıyla tanımlanır. Bir gıdanın su ayak izi, üretim sürecindeki tüm aşamalarda harcanan su miktarının toplamını kapsar (Mekonnen & Hoekstra, 2012). Örneğin, bir fincan

kahve içildiğinde yaklaşık 200 mL su kullanılmış gibi görünse de, üretim sürecinde harcanan su da hesaba katıldığında bu miktar 140 litreye kadar çıkmaktadır (TÜBER, 2022). Bu durum, gıda üretiminin su tüketiminde büyük bir yer kapladığını göstermektedir. Nitekim dünya genelindeki su tüketiminin yaklaşık %92'si tarımsal üretim için kullanılmaktadır. Özellikle hayvansal kökenli ürünler, bitkisel kaynaklı gıdalara kıyasla aynı enerji miktarı için çok daha fazla suya ihtiyaç duymaktadır (Gerbens-Leenes ve ark., 2013).

Besinlerin ve beslenme modellerinin çevre üzerindeki etkilerinin belirtilmesinde, su ve karbon ayak izi hesaplama yöntemleri kullanılmaktadır. Daha düşük su ve karbon ayak izine sahip olan besinler daha düşük çevresel etkiye sahiptir (Pegram ve ark., 2014).



**Şekil 1.** Çevresel Etkilerine Göre Besin Piramit Modeli (Barilla Center for Food and Nutrition, 2013)\*\*\*

\*\*\* Besinlerin çevresel etkileri; üretim tekniğine, üretim bölgesine ve diğer birçok faktöre bağlı olarak değişebilmektedir.

## Karbon Ayak İzi

Karbon ayak izi, bir ürünün yaşam döngüsü boyunca -üretimden kullanıma ve sonrasında bertarafa kadar- oluşan toplam sera gazı emisyonlarının ölçüsüdür. Bu emisyonların hesaplanması için literatürde çeşitli yöntemler geliştirilmiştir. Bunlardan yaşam döngüsü analizi



(LCA), ürün veya hizmetlerin üretim, dağıtım, kullanım ve atık yönetimi aşamalarında çevresel etkileri değerlendirmek, emisyon miktarlarını ve kaynak tüketimini belirlemek amacıyla yaygın şekilde kullanılmaktadır (Hertwich, 2005).

### **Su Ayak İzi**

Yaşamın sürdürülmesi için temiz ve sağlıklı elzemdir/gereklidir. Su kaynaklarının sürdürülebilirliğini sağlamak için her damla suyun kullanımına dikkat edilmelidir. Su ayak izi kullanılan su miktarının ölçülmesi olarak tanımlanır (Pekcan, 2017). Su ayak izi terimi, ürünlerin tedarik zincirleri süresince su kullanımını belirlemek için kullanılmaktadır. Genel olarak, besinlerin su ayak izi litre/kilogram (L/kg) ya da metreküp/ton (m<sup>3</sup>/ton) birimleriyle ifade edilmektedir (Mekonnen ve Hoekstra, 2011). Çalışmaların değerlendirilmesinde su ayak izinin iki temel yaklaşımı kullanılmaktadır: Su ayak izinin hesaplanmasında, Su Ayak İzi Ağı (Water Footprint Network) tarafından geliştirilen yöntem (Hoekstra ve ark., 2011) ile Yaşam Döngüsü Değerlendirmesi (LCA) Komitesi tarafından oluşturulan yaşam döngüsü temelli yaklaşım (Ridoutt ve Pfister, 2013) yaygın olarak kullanılmaktadır.

Turan (2017) tarafından hazırlanan Türkiye'nin Su Ayak İzi Raporu'nda, kişi başına düşen su ayak izi 5412,7 L/g olarak belirlenmiştir. Ancak bu çalışmada yalnızca bireylerin besin tüketiminden kaynaklanan su ayak izi dikkate alınmıştır. Öte yandan, Türkiye genelini kapsayan daha kapsamlı Su Ayak İzi Raporu'nda ise bireylerin sadece beslenme alışkanlıkları değil, aynı zamanda su tüketimine etki eden diğer faktörler de değerlendirmeye alınmıştır. Bu durum, iki raporun doğrudan karşılaştırılmasını güçleştirmektedir.

Water Footprint Network (Su Ayak İzi Ağı), su ayak izini üç temel bileşen altında değerlendirmektedir: mavi, yeşil ve gri su. Bu bileşenler hem suyun kullanım biçimini hem de kaynağını (örneğin yağmur suyu, yüzey ve yer altı suyu) dikkate alarak, kirleticilerin seyreltilmesi için ihtiyaç duyulan temiz su miktarını da içermektedir. Mavi su ayak izi, bir ürünün üretimi sırasında doğrudan tüketilen veya buharlaşan yüzey ve yer altı suyu miktarını ifade ederken; yeşil su ayak izi, tarımsal üretim için gerekli olan ve toprakta biriken yağmur suyunun kullanımıyla ilişkilidir. Gri su ayak izi ise, ürün üretimi sonucu oluşan kirleticilerin belirli bir su kalite standardına ulaşabilmesi için seyreltilmesinde gerekli olan temiz su hacmini göstermektedir (Küçükçankurtaran ve ark., 2022).

## Toplu Beslenme Sistemlerinde Sürdürülebilirlik

2022 verilerine göre küresel yemek hizmet sektörü 2,8 milyar dolarlık bir ekonomik büyüklüğe ulaşmış olup, her yıl milyarlarca öğün sunulması sayesinde sürdürülebilir dönüşüm açısından önemli bir potansiyele sahiptir (Speck ve ark., 2022). Besin sistemleri ise, dünya genelindeki toplam sera gazı emisyonlarının yaklaşık %25-30'unu oluşturarak çevresel etkilerin başlıca nedenlerinden biri olarak değerlendirilmektedir (Masson-Delmotte ve ark., 2019). Beslenmenin yalnızca sağlık değil, çevre ile de doğrudan ilişkili olduğu ve bu ilişkinin son yıllarda giderek daha fazla önem kazandığı ifade edilmektedir. Gıda sektörü, küresel çevresel değişimin başlıca itici güçlerinden biri olarak görülmektedir (Serra-Majem ve ark., 2020). Bu nedenle, okul, hastane ve huzurevi gibi kurumlarda verilen toplu beslenme hizmetlerinde sadece sağlık ve hijyen değil, aynı zamanda menülerin çevresel etkilerinin de göz önünde bulundurulması gerekmektedir.

Birleşmiş Milletler'in projeksiyonlarına göre, 2017 yılında yaklaşık 7,6 milyar olan dünya nüfusunun 2050 yılına kadar 10 milyara ulaşması beklenmektedir (United Nations, 2017). Bu hızlı nüfus artışı, sınırlı kaynaklarla daha fazla insanı besleme zorunluluğunu beraberinde getirirken, mevcut gıda sistemlerinin bu ihtiyacı karşılamada yetersiz kaldığı görülmektedir. Gıda üretimi, mevcut haliyle hem gıda güvencesini riske atmakta hem de çevresel bozulmaya neden olarak halk sağlığı üzerinde olumsuz etkiler yaratmaktadır (Fischer & Garnett, 2016; Wiseman et al., 2019).

Gıda sistemleri, küresel sera gazı emisyonlarının %20-30'unu oluşturarak iklim değişikliğinde önemli bir paya sahiptir (Fischer & Garnett, 2016). Bununla birlikte biyoçeşitlilik kaybı, ormansızlaşma ve arazi kullanımındaki değişiklikler de bu sistemlerin çevresel baskılarından bazılarıdır. Tarım sektörü, dünya üzerindeki tatlı su kaynaklarının %70'ini ve ekilebilir arazilerin büyük kısmını tüketmektedir (IPCC, 2015; Whitmee et al., 2015). Gıdanın üretimden tüketime kadar geçen tüm aşamaları çevresel etkiler doğururken, özellikle hayvansal ürünlerin tüketimi—özellikle kırmızı etin—bitkisel kaynaklı besinlere göre daha fazla karbon salımına yol açmaktadır (Hedenus et al., 2014). Örneğin, günlük et tüketimi 100 gramın üzerinde olduğunda kişi başına düşen sera gazı salımı 7,2 kg CO<sub>2</sub> eşdeğeri seviyesine ulaşırken, tüketimin 50 gramın altına düşürülmesi durumunda bu değer 4,7 kg CO<sub>2</sub> eşdeğerine gerilemektedir (Wiseman ve ark., 2019).

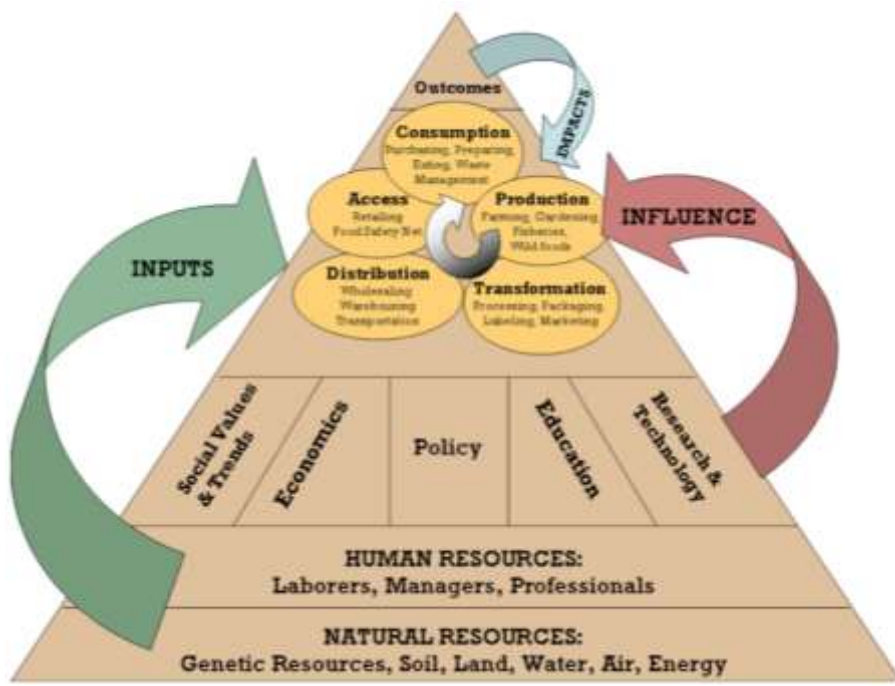
Öte yandan, artan nüfusu beslemek için tarım sektöründe üretimi artırma baskısı devam ederken, iklim değişikliğinin getirdiği olumsuzluklar bu süreci daha karmaşık hale getirmektedir (Fischer & Garnett, 2016; Macdiarmid et al., 2012). Mevcut gıda sisteminin, hem gezegenin sınırları hem de insan sağlığı açısından sürdürülebilir olmaktan uzaklaştığı görülmektedir. 2050 yılına kadar nüfusun ve küresel gelirin artması ile birlikte gıda sisteminin çevresel etkilerinin %50 ila %92 oranında artacağı öngörülmektedir (Springmann et al., 2018). Bu öngörü, gıda sistemlerinin sağlıklı ve sürdürülebilir bir yapıya dönüştürülmesini zorunlu kılmaktadır (Wiseman et al., 2019).

Birleşmiş Milletler'in desteklediği sürdürülebilir besin sistemi yaklaşımı, gelecek nesillerin ihtiyaçlarını gözeten, doğal kaynakların korunmasını esas alan ve gıda güvenliğini önceliklendiren uzun vadeli stratejilere dayanmaktadır (Haspolat, 2015). Bu kapsamda 2030 yılına kadar uygulanması hedeflenen Sürdürülebilir Kalkınma Amaçları (SKA), açlığın sona erdirilmesi, gıda güvenliğinin sağlanması ve sağlıklı beslenmenin yaygınlaştırılmasını hedeflemektedir (Lindgren et al., 2018). Ayrıca, bulaşıcı olmayan hastalıkların artışı, mikro besin eksiklikleri ve yetersiz beslenme gibi küresel düzeydeki beslenme sorunlarının çözümünde, gıda sistemlerinin dönüşümü ile iş birliğine dayalı politikaların uygulanması kritik önemdedir (Erdoğan Gövez & Köksal, 2024).

Sürdürülebilir gıda sistemleri birbiriyle bağlantılı olup, üretim öncesinden, üretime, tedarik zincirlerine ve tüketime kadar tüm tarımsal değer zincirini temsil eder (Şekil 2) (Farming First, 2022).



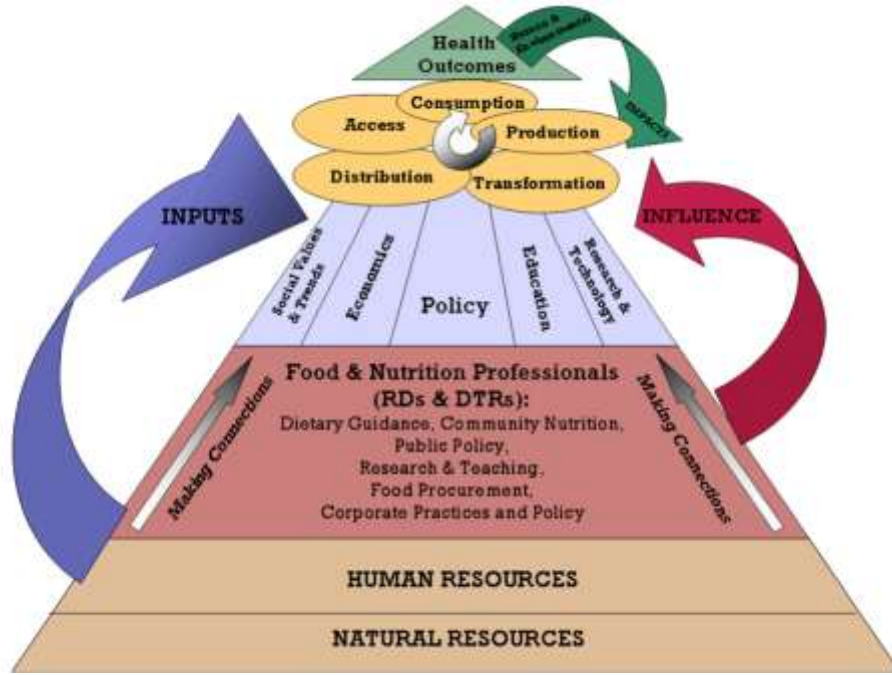
**Şekil 2.** Üretimden tüketime sürdürülebilir gıda sistemi (farmingfirst.org, 2022)



**Şekil 3.** Sürdürülebilir Gıda Sistemleri Modeli (American Dietetic Association Sustainable Food System Task Force, 2007)

Şekil 3'te de görüldüğü üzere sürdürülebilir gıda sistemi temelindeki girdiler doğal kaynaklar (genetik, toprak, arazi, su, hava ve enerji) ile insan kaynakları (çalışanlar, yöneticiler ve profesyoneller) üzerine kurulmuştur. Sosyal değerler ve eğilimler, ekonomik durum, politika, eğitim ve araştırma ve teknoloji bu sistem içinde önemli rol oynamaktadır. Gıda sistemi beş temel halkadan oluşan bir zincirdir: Gıdanın üretimi (çiftçilik, bahçecilik, balıkçılık, yabani bitkiler), dönüşümü (işlenmesi, paketlenmesi, etiketlenmesi ve pazarlanması), dağıtımı (toptancıya ulaşımı, depolanması ve transferi), erişimi (perakendecilere, gıda güvenliği ağına ulaşması) tüketimi (satın alınması, hazırlanması, tüketilmesi ve atık yönetimi). Bu zincirin halkaları birbirlerinden, sistemin girdilerinden ve çevresel etmenlerden etkilenmektedir (Tagtow ve Harmon, 2008).

## Diyetisyenlerin Sürdürülebilir Beslenme Sistemlerini Desteklemedeki Rolü



**Şekil 4.** Sürdürülebilir Bir Gıda Sistemini Desteklemede Diyetisyenin Rolü (American Dietetic Association Sustainable Food System Task Force, 2007)

Şekil 4'te görüldüğü üzere gıda ve beslenme uzmanları, sürdürülebilir bir gıda sisteminin temelinde kritik bir unsur olma fırsatına sahiptir. Diyetisyenler, gıda sisteminde üstlendikleri çeşitli roller ile insan sağlığını destekleyen, yerel tarımın güçlenmesine katkı sağlayan, doğal kaynakların korunmasını gözeten, katı atık oluşumunu en aza indiren ve ekolojik sürdürülebilirliği ön plana alan sürdürülebilir diyetleri teşvik edebilmektedirler (Şekil 4). Örnek verilecek olursa:

**Diyet Rehberliği:** Klinik diyetisyenler ve diyet rehberliği sağlayan diğerleri, sürdürülebilir bir gıda sisteminin tüketim sektöründe önemli oyuncular ve hasta ve danışan gıda seçimlerini, düşünce kalıplarını, gıda davranışlarını ve yerel ve küresel gıda sistemi sorunlarına katılımı etkileme potansiyeline sahiptirler.

**Toplum Beslenmesi:** Toplum beslenmesi alanında görev yapan diyetisyenler, yerel üreticilerle tüketiciler arasında köprü kurmayı hedefleyen gıda odaklı toplum projelerine katkı sunarak yerel gıda sistemlerinin güçlenmesine destek olabilirler. Bu kapsamda; çiftlikten okula



programları, toplum destekli tarım girişimleri ve çiftçi pazarlarında yürütülen beslenme eğitimi projeleri örnek olarak gösterilebilir.

**Kamu Politikası:** Diyetisyenler, Çiftlik Güvenliği ve Kırsal Yatırım Yasası, daha iyi bilinen adıyla Çiftlik Yasası ve Çocuk Beslenmesi ve WIC Yeniden Yetkilendirme Yasası gibi gıda sisteminin tüm sektörlerinde sürdürülebilir uygulamaları destekleyen politikaları savunabilmektedirler.

**Araştırma ve Öğretim:** Geleceğin araştırmacıları ve/veya eğitimcileri olan diyetisyenler, sürdürülebilir gıda sistemi kavramlarını üniversite derslerine, stajlarına ve araştırma gündemlerine dahil edebilmektedirler.

**Gıda Tedariki:** Hastaneler, okullar, restoranlar ve diğer tesislerdeki gıda hizmeti operasyonları, büyük miktarlarda sürdürülebilir şekilde üretilen gıdaları tedarik ederek, hazırlayarak ve servis ederek sürdürülebilir bir gıda sisteminin gıda dağıtımı, erişimi ve tüketim sektörlerinde önemli bir role sahiptir. Ayrıca, gıda hizmeti operatörleri kurumlarında enerji ve su tasarrufu ve atık azaltma stratejilerini teşvik edebilir veya bunlara katılabilmektedirler.

**Kurumsal Uygulamalar ve Politika:** Gıda sektöründe görev yapan diyetisyenler, sürdürülebilir ürünlerin geliştirilmesi, hammaddelerin enerji açısından verimli biçimde temin edilmesi, etiketleme yoluyla tüketicilere bilgilendirici içerik sunulması ve israfı önlemek amacıyla besleyici ürünlerin gıda bankaları ya da gıda depolarına yönlendirilmesi gibi uygulamalarla; sürdürülebilir gıda sisteminin üretim, dağıtım ve erişim süreçlerinde önemli roller üstlenmektedirler.

Sürdürülebilir gıda sistemlerini benimsemenin en iyi yollarından biri rol model olmaktır. Yerel çiftçilerle bağlantı kurun, mevsimlik gıdalar hakkında bilgi edinin, çiftçi pazarlarını veya gıda kooperatiflerini ziyaret edin ve gıda politikası tartışmalarına katılın. Bu bağlantıları bireyler ve ardından profesyoneller olarak kurmak, gelecek nesillerin sürdürülebilir bir gıda sisteminden güvenli ve besleyici gıdalara erişebilmesini sağlamanın ilk adımıdır (Tagtow ve Harmon, 2008).

## Besin Atıkları ve Kayıpları

Besin atıkları ve kayıpları, sürdürülebilirliğin beslenme boyutunda önemli bir sorun teşkil etmektedir. Bu iki kavram birbirinden farklıdır; besin atıkları, tüketiciler tarafından yenilebilir durumda olan gıdaların atılması iken, besin kayıpları, üretimden dağıtıma kadar geçen süreçte ürün miktarında meydana gelen azalmalar olarak tanımlanmaktadır (Parfitt, Barthel ve Macnaughton, 2010). 2016 yılında FAO tarafından yayımlanan rapora göre, dünya genelinde insanların tüketimine sunulan gıdaların yaklaşık üçte biri üretim sürecinden tüketime kadar olan yaşam döngüsü boyunca ya kaybolmakta ya da israf edilmektedir. FAO, bu miktarın yılda yaklaşık 1,3 milyar ton olduğunu belirtmektedir (FAO, 2016). Besin kayıplarının başlıca nedenleri arasında işleme hataları, yanlış depolama ve soğutma uygulamaları ile taşıma esnasında yaşanan problemler yer almakta ve bu durum hem doğrudan hem de dolaylı olarak besin atıklarını artırmaktadır (Slorach ve ark., 2019). Bu kayıplar, toprak, su ve enerji gibi değerli doğal kaynakların israfına yol açarken, aynı zamanda sera gazı salınımını da artırmaktadır (FAO, 2016).

Avrupa Komisyonu 2025 yılına kadar gelen süreçte besin atıkları ve kayıplarının çevre üzerindeki etkileri üzerine yapılan çalışmalara dayanarak Avrupa'daki gıda israfını %50 oranında düşürmeyi hedeflemiştir (Heller ve Keoleian, 2015). Öte yandan, FAO'nun 2019 raporu, dünya genelinde yetersiz beslenme sorununun giderek büyüdüğünü ve 820 milyondan fazla kişinin açlık çektiğini ortaya koymaktadır. Bu durum, her dokuz kişiden birinin açlıkla mücadele ettiği şeklinde ifade edilmiştir (FAO, 2019a). Sürdürülebilirlik hedefleri arasında besin atık ve kayıplarının azaltılması, çevrenin korunmasının yanı sıra insan sağlığı ve açlıkla mücadelede kritik bir öneme sahiptir. Tarımsal üretim verimliliğinin artırılması, sera gazı emisyonlarının azaltılması ve gıda sistemlerindeki kayıp ve atıkların önlenmesi sürdürülebilirliğin sağlanmasında temel unsurlar olarak öne çıkmaktadır (FAO, 2019b). Bu doğrultuda yürütülen çalışmalar, doğal kaynakların daha etkin kullanımını sağlarken, aynı zamanda tüketim düzeyinin düşürülmesine ve gıda israfının azaltılmasına katkıda bulunmaktadır (Slorach ve ark., 2019).

## SONUÇ

Günümüzde çevresel sorunların artmasıyla birlikte, sürdürülebilir ve çevreye duyarlı beslenme alışkanlıklarının yaygınlaştırılması büyük önem kazanmıştır. Sürdürülebilir üretim

sistemlerinden elde edilen gıdalar, ekosistemlerin korunmasına, biyolojik çeşitliliğin sürdürülmesine ve iklim değişikliğinin etkilerinin azaltılmasına katkı sağlamaktadır. Toplu beslenme hizmetleri ise, sundukları geniş ölçekli beslenme imkanları nedeniyle çevresel sürdürülebilirlik hedeflerine ulaşmada kritik bir role sahiptir. Bu bağlamda, porsiyonların dengeli ayarlanması ve mevsimsel, yerel ürünlerin tercih edilmesi gibi stratejiler, sera gazı salınımının azaltılmasında etkili olacaktır.

Ayrıca, yemek atıklarının önlenmesi ve etkin atık yönetimi uygulamalarının toplu beslenme sistemlerine entegre edilmesi, kaynakların verimli kullanımını destekleyerek çevresel yükün azalmasına katkı sağlayacaktır. Menülerin uzman kişiler tarafından planlanması ve bitkisel ile hayvansal kaynakların dengeli dağılımının sağlanması hem besin değerinin artırılmasına hem de çevresel etkilerin minimize edilmesine olanak tanır. Besin israfının önüne geçilmesi, yalnızca çevresel sürdürülebilirlik açısından değil, aynı zamanda küresel açlıkla mücadelede de önemli bir adımdır.

Bu çalışma, toplu beslenme sistemlerinin çevresel etkilerinin değerlendirilmesinde ve sürdürülebilirlik ilkelerinin uygulanmasında yol gösterici olacak niteliktedir. Gıda üretimi ve tüketimindeki kaynak verimliliğinin artırılması, iklim değişikliğiyle mücadelede önemli bir araç olarak öne çıkmakta; bu nedenle, sürdürülebilir beslenme stratejilerinin hayata geçirilmesi toplum sağlığı ve çevrenin korunması için kritik bir gerekliliktir.

## TEŞEKKÜR

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## ASSOCIATIONS OF CHRONOTYPE AND NIGHT EATING SYNDROME WITH FASTING BLOOD GLUCOSE AND HbA1c IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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### ABSTRACT

In the management of type 2 diabetes mellitus (T2DM), not only pharmacological treatments but also biological rhythms and meal timing play a crucial role in achieving glycemic control. Chronotype, an individual characteristic reflecting the circadian system, and associated night eating behavior may influence the timing of metabolic processes and thereby affect glycemic regulation. This study aimed to investigate the associations of chronotype and night eating behavior with fasting blood glucose and HbA1c levels in patients with T2DM.

This cross-sectional and observational study was conducted between March and August 2024 at the Family Medicine outpatient clinic of Alanya Training and Research Hospital. A total of 150 patients aged 18 years and older with T2DM were included. The Morningness–Eveningness Questionnaire and the Night Eating Questionnaire were administered face-to-face. Fasting blood glucose, HbA1c, and body mass index (BMI) were recorded. Statistical analyses included Spearman correlation analysis and analysis of covariance (ANCOVA).

Among the participants, 61.3% were classified as having an evening chronotype, and 52.7% were identified as having possible night eating syndrome. A statistically significant association was found between chronotype and HbA1c levels ( $p<0.001$ ). HbA1c values were significantly higher in individuals with an evening chronotype than in those with morning or intermediate chronotypes. This association remained significant after controlling for night eating behavior. Furthermore, night eating behavior had an independent effect on HbA1c levels ( $p=0.002$ ). Correlation analysis revealed a strong negative association between chronotype score and night eating behavior ( $r=-0.822$ ), and a positive association between night eating behavior and HbA1c levels ( $r=0.648$ ). Individuals with night eating syndrome had significantly higher fasting blood glucose, HbA1c, and BMI values than those without the syndrome ( $p<0.001$ ).

Evening chronotype and night eating behavior are associated with poor glycemic control in patients with T2DM and appear to be independent risk factors. These findings suggest that meal timing and circadian rhythm are important modifiable targets that should be considered in diabetes management.

**Keywords:** Diabetes, Glycemic control, Chronotype, Night Eating Syndrome

**Note:** This study was derived from the medical specialty thesis of Dr. İrem Doğukaya, conducted at Alanya Alaaddin Keykubat University.

## TİP-2 DİYABET HASTALARININ KRONOTİPİNİN GECE YEME SENDROMU, AÇLIK KAN GLUKOZU VE HbA1c İLE İLİŞKİSİNİN İNCELENMESİ

### ÖZET

Tip 2 diyabetes mellitus (T2DM) yönetiminde glisemik kontrolün sağlanmasında yalnızca farmakolojik tedaviler değil, biyolojik ritim ve beslenme zamanlaması da önemli rol oynamaktadır. Sirkadiyen sistemin bireysel yansıması olan kronotip ve buna bağlı gelişebilen gece yeme davranışı, metabolik süreçlerin zamanlamasını etkileyerek glisemik kontrol üzerinde belirleyici olabilir. Bu çalışmada, T2DM hastalarında kronotip ve gece yeme davranışının açlık kan glukozu ve HbA1c düzeyleri ile ilişkisini incelemek amaçlanmıştır.

Bu kesitsel ve gözlemsel çalışma, Mart–Ağustos 2024 tarihleri arasında Alanya Eğitim ve Araştırma Hastanesi Aile Hekimliği polikliniğinde yürütülmüştür. Çalışmaya 18 yaş ve üzeri 150 T2DM hastasına Sabahçıl-Akşamcıl Anketi ve Gece Yeme Anketi yüz yüze uygulanmıştır. Açlık kan glukozu, HbA1c ve beden kitle indeksi (BKİ) kaydedilmiştir. İstatistiksel analizlerde Spearman korelasyon analizi ve kovaryans analizi (ANCOVA) kullanılmıştır. Katılımcıların %61.3’ü akşamcıl kronotipte olup, %52.7’sinde olası gece yeme sendromu saptanmıştır. Kronotip ile HbA1c düzeyleri arasında anlamlı ilişki bulunmuştur ( $p<0.001$ ). Akşamcıl bireylerde HbA1c değerleri sabahçıl ve ara tiplere göre anlamlı olarak daha yüksek saptanmıştır. Bu ilişkinin, gece yeme davranışı kontrol edildiğinde de devam ettiği görülmüştür. Ayrıca gece yeme davranışının HbA1c üzerinde bağımsız bir etkisi olduğu belirlenmiştir ( $p=0.002$ ). Korelasyon analizinde kronotip puanı ile gece yeme davranışı arasında güçlü negatif ilişki ( $r=-0.822$ ), gece yeme davranışı ile HbA1c arasında pozitif ilişki ( $r=0.648$ ) saptanmıştır. Gece yeme davranışı olan bireylerde açlık kan glukozu, HbA1c ve BKİ değerleri anlamlı olarak daha yüksek bulunmuştur ( $p<0.001$ ).

Akşamcıl kronotip ve gece yeme davranışı, T2DM hastalarında kötü glisemik kontrol ile ilişkili olup, birbirinden bağımsız risk faktörleri olarak öne çıkmaktadır. Bu bulgular, beslenme zamanlaması ve sirkadiyen ritmin diyabet yönetiminde dikkate alınması gereken modifiye edilebilir önemli hedefler olduğunu göstermektedir.

**Anahtar Kelimeler:** Diyabet, Glisemik kontrol, Kronotip, Gece Yeme Sendromu

**Not:** “Bu çalışma Alanya Alaaddin Keykubat Üniversitesi bünyesinde devam etmekte olan Dr. İrem Doğukaya’nın tıpta uzmanlık tezinden üretilmiştir.”

## THE ASSOCIATION OF DIETARY INTAKE, NUTRITION KNOWLEDGE, AND ANTHROPOMETRIC MEASUREMENTS WITH SPORTS PERFORMANCE AMONG COLLEGIATE AMERICAN FOOTBALL PLAYERS

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### ABSTRACT

This study aimed to investigate the associations among dietary intakes, nutrition knowledge, anthropometric measurements, and sports performance among male American Football players (21.9±1.6 years, n=34) at a private university. Sociodemographic characteristics, anthropometric measurements, sports performance tests (40-yard dash, broad jump, and 20-yard shuttle), the General and Athlete Nutrition Knowledge Scale (GeSNK), and 3-day food records were obtained. Among the participants, 61.7% (n=21) played offense, while the remaining played defense. The mean BMI was 27.5±4.7 kg/m<sup>2</sup>, the waist-to-hip ratio was 0.88±0.01, the skeletal muscle mass was 44.1±5.5 kg, and the internal organ fat level was 6.4±5.6. The mean GeSNK score was 60.7±8.3, with 73.5% (n=26) of athletes classified as having high nutrition knowledge. The mean 40-yard dash time was 5.3±0.4 seconds, the broad jump distance was 228.6±22.0 cm, and the 20-yard shuttle time was 5.0±0.3 seconds. Significant differences were observed between offense and defense players in total energy, carbohydrate, cholesterol, dietary fiber, iron, and potassium intake (p<0.05), all of which were higher among offense players. Correlation analysis showed that BMI, body fat mass, body fat percentage, waist-to-hip ratio, and internal organ fat level were significantly associated with sports performance variables. BMI was positively correlated with 40-yard dash time (r=0.393) and 20-yard shuttle time (r=0.482) (p<0.05), while it was negatively correlated with broad jump performance (r=-0.364) (p<0.05). Similarly, body fat mass, body fat percentage, waist-to-hip ratio, and internal organ fat level were positively correlated with 40-yard dash and 20-yard shuttle times, and negatively correlated with broad jump performance (p<0.001). No significant

relationship was found between nutritional knowledge and sports performance ( $p>0.05$ ). Body composition parameters, particularly indicators of body fat, were significantly associated with sports performance. Overall, these findings suggest that optimizing body composition through appropriate nutrition and training strategies, along with improving the practical application of nutrition knowledge, may enhance athletic performance.

**Keywords:** American Football, Sports Performance, Anthropometric Measurements Nutrition Knowledge, Dietary Intake

## A BIBLIOMETRIC ANALYSIS OF VISUAL-MOTOR INTEGRATION STUDIES CONDUCTED USING THE BEERY-BUKTENICA TEST BETWEEN 2000-2026

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### ABSTRACT

This study aims to examine the global academic literature on the Beery-Buktenica Visual-Motor Coordination Test (Beery-VMI) recognised as a fundamental tool for assessing visual-motor skills in child development from a bibliometric perspective. Within the scope of the research, 293 scientific articles spanning the years 2000–2026, retrieved from the Web of Science (WoS) database using the keywords “visual motor integration” and “child”, were analysed in terms of annual publication trends, citation rates, the most influential journals, institutions, and author collaborations. Analysis of the data revealed that the literature reached its annual production peak in 2020 and that the United States (USA) is the hub of scientific output and academic networks in this field. Concept mapping, triadic diagrams and network analyses conducted using the R-based Bibliometrix (Biblioshiny) software scientifically demonstrate that the themes of ‘handwriting’, ‘fine motor skills’ and ‘education’ constitute the dynamic and central areas of research within the literature. The results of social network analyses indicate that international academic collaboration is concentrated along the North America and Europe axis, whilst Turkey’s representation within these global networks remains at an early stage of development, and that its integration into collaborative networks needs to be enhanced. These findings document that the topic of handwriting readiness skills in pre-school children—the focus of this study—is consistent with the global literature. This analysis highlights the strategic importance of transferring local data to international platforms, whilst providing a comprehensive literature roadmap for future intervention programmes and early childhood policies.

**Keywords:** Beery-VMI, visual-motor coordination, child, motor skills, developmental assessment, bibliometric analysis.



## 2000-2026 YILLARI ARASINDA BEERY-BUKTENICA TESTİ KULLANILARAK YÜRÜTÜLEN GÖRSEL-MOTOR ENTEGRASYON ÇALIŞMALARININ BİBLİYOMETRİK ANALİZİ

### ÖZET

Bu çalışma, çocuk gelişiminde görsel-motor becerilerin değerlendirilmesinde temel bir araç kabul edilen Beery-Buktenica Görsel-Motor Koordinasyon Testi (Beery-VMI) üzerine dünya genelinde yürütülen akademik literatürü bibliyometrik bir perspektifle incelemeyi amaçlamaktadır. Araştırma kapsamında, 2000-2026 yılları arasında kapsayan ve Web of Science (WoS) veri tabanından “visual motor integration” ve “child” anahtar kelimeleri kullanılarak erişilen 293 bilimsel makale; yıllık yayın trendleri, atıf oranları, en etkili dergiler, kurumlar ve yazar iş birlikleri açısından analiz edilmiştir. Verilerin çözümlenmesi sonucunda, literatürün 2020 yılında yıllık bazda üretim zirvesine ulaştığı ve Amerika Birleşik Devletleri’nin (USA) bu alandaki bilimsel üretimin ve akademik ağların merkezi olduğu saptanmıştır. R tabanlı Bibliometrix (Biblioshiny) yazılımı ile gerçekleştirilen kavramsal haritalama, üçlü diyagram ve ağ analizleri; "handwriting" (el yazısı), "fine motor skills" (ince motor beceriler) ve "education" (eğitim) temalarının literatürün dinamik ve merkezi çalışma alanlarını oluşturduğunu bilimsel olarak kanıtlamaktadır. Sosyal ağ analizleri sonucunda ülkeler arası akademik iş birliğinin Kuzey Amerika ve Avrupa ekseninde yoğunlaştığı, Türkiye’nin ise bu küresel ağlardaki temsilinin henüz gelişim aşamasında kaldığı ve iş birliği ağlarına entegrasyonunun artırılması gerektiği görülmektedir. Elde edilen bu bulgular, çalışmanın odak noktasını oluşturan okul öncesi çocuklarda el yazısı hazırlık becerileri konusunun dünya literatürüyle uyum içinde olduğunu belgelemektedir. Bu analiz, yerel verilerin uluslararası platformlara taşınmasının stratejik önemini vurgularken, gelecekteki müdahale programları ve erken çocukluk politikaları için kapsamlı bir literatür yol haritası sunmaktadır.

**Anahtar Kelimeler:** Beery-VMI, görsel motor koordinasyon, çocuk, motor beceriler, gelişimsel değerlendirme, bibliyometrik analiz.

### GİRİŞ

Erken çocukluk dönemi, motor becerilerin hızla geliştiği ve çocuğun çevresiyle girdiği etkileşimin temelini oluşturan kritik bir süreçtir. Bu süreçte motor gelişim; yalnızca fiziksel bir büyüme değil, bilişsel ve algısal süreçlerle iç içe karmaşık bir yapı sergilemektedir. Gelişimsel olarak çocuk, bilişsel, dil, sosyal-duygusal, fiziksel ve psikomotor olmak üzere beş temel gelişim alanında gelişim göstermektedir (Ulutaş ve ark., 2017). Her bir gelişim alanı çocuk için ayrı bir öneme sahip olmakla birlikte bir bütünün parçalarını oluşturmaktadır (Özer ve Özer, 2016). Görsel algı, çevreden görsel bilgiyi alma ve düzenleme sürecidir (Sortor ve Kulp, 2003). Görsel-motor koordinasyon becerisi, görsel olarak algılanan bir nesnenin motor çıktıya dönüştürülmesi ile karakterize bir beceridir (Tekok-Kılıç ve ark., 2010)

Görsel algı ve motor becerileri koordine etme becerisi olan görsel-motor koordinasyon ise; nesneleri görme, kullanma, emekleme, yürüme, koşma, gibi temel becerilerden çizme, boyama, yazı yazma gibi akademik becerilere ve bilgisayar kullanma, araç kullanma gibi daha ileri becerilere kadar birçok alanda kullanılmaktadır (Ercan ve Aral, 2011). Erken çocukluk döneminde hızla gelişen görsel motor koordinasyon akademik becerilerin gelişiminde ve sağlıklı hayatın sürdürülmesinde önemli rol oynamaktadır (Akçin 1993; Marr ve ark., 2001; Dankert ve ark., 2003; Brown ve Gaboury 2006). Görsel algı ya da motor becerilerdeki yetersizlikler ya da gecikmeler akademik becerileri kazanma, okul etkinliklerine katılıma, sosyal ilişkiler ve benlik algısında gibi konularda kısacası çocuğun tüm yaşamında olumsuzluklara yol açmaktadır (Goyen ve Duff 2005; Ratzon ve ark., 2007).

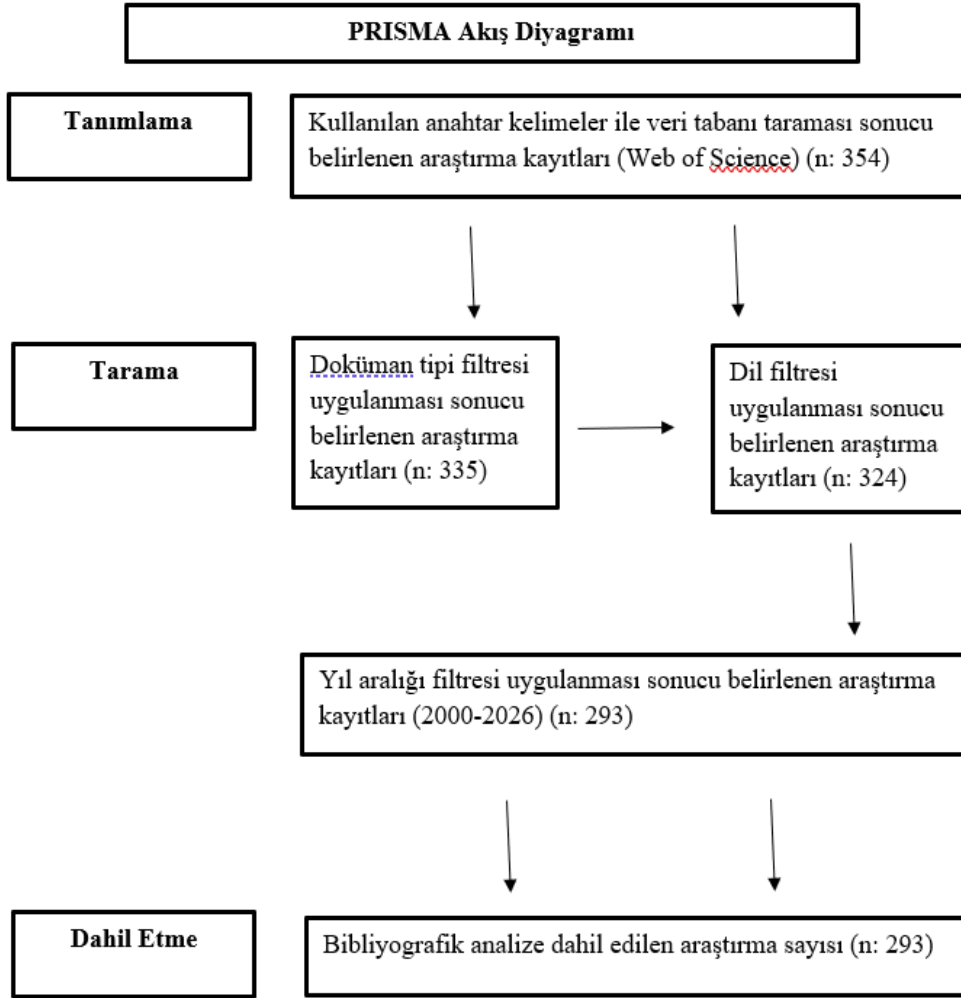
Görsel-Motor Koordinasyon Testi (Beery VMI), görsel motor koordinasyon becerilerinin standartlaştırılmış değerlendirilmesi için yaygın olarak kullanılan bir araçtır (Beery ve Beery, 2010). Bu değerlendirme, Görsel Algı (VP: geometrik şekilleri eşleştirme) ve Motor Koordinasyon (MC: geometrik şekilleri çizme) olmak üzere iki ek alt test içerir. Bu alt testlerin amacı, uzmanların bu testi kullanarak çocuğun görsel motor koordinasyon performansını tespit etmesine olanak sağlamak ve görsel motor koordinasyon becerilerinde sorun olup olmadığını veya görsel algı ya da motor koordinasyon alt boyutlarında yaşanan zorluklarının görsel motor koordinasyon puanını düşürüp düşürmediğini ortaya çıkarmaktır (van Vreeswijk, 2014). 2010 yılında yayınlanan güncellenmiş versiyonu olan Görsel-Motor Entegrasyon Gelişim Testi altıncı baskı (Beery VMI-6), Amerikan popülasyonuna uygulandığında iyi bir güvenilirliğe ve yeterli geçerliliğe sahip olduğu bulunmuştur (Poteat, 2014; Rodger ve ark., 2007). Ölçeğin 60-72 aylık Türk çocuklarına uyarlaması (Ercan ve Aral, 2011) yapılmış olup günümüzde kullanılmaya devam etmektedir.

Beery-VMI ölçeğinin yaygın kullanımı, bu konuda çok sayıda çalışma yapılmasına neden olmuştur. Ancak bu çalışmaların hangi alanlarda yoğunlaştığını ve zaman içinde nasıl değiştiğine dair bütüncül bir bakış açısına ihtiyaç duyulmaktadır. Bu çalışma, 2000-2026 yılları arasındaki Beery-VMI yayınlarını inceleyerek dünyadaki genel eğilimleri belirlemeyi amaçlamaktadır. Elde edilen sonuçların, özellikle ulusal literatürdeki eksiklikleri göstermesi ve yeni araştırmalara rehberlik etmesi hedeflenmektedir.

## MATERYAL VE YÖNTEM

Bu çalışmada, görsel-motor koordinasyon alanında yaygın kullanılan ölçme araçlarından biri olan Beery-Buktenica Gelişimsel Görsel Motor Koordinasyon Ölçeği'ne (Beery-VMI) yönelik akademik literatürün bibliyometrik bir analizi hedeflenmiştir. Bu çalışmada bibliyometrik analiz yönteminin kullanılmasının temel nedeni, söz konusu ölçeğin uluslararası literatürdeki kullanımını ve bununla ilgili yapılan araştırmaları kapsamlı, sistematik ve objektif bir şekilde haritalandırma ihtiyacıdır. Bunun için de son yıllarda yaygın olarak kullanılan bibliyometrik analiz yöntemi tercih edilmiştir (Sarı, 2022). Elde edilen verilerin analizi ve görselleştirilmesi için R tabanlı Bibliometrix (Biblioshiny) paketi kullanılmıştır (Aria ve Cuccurullo, 2017).

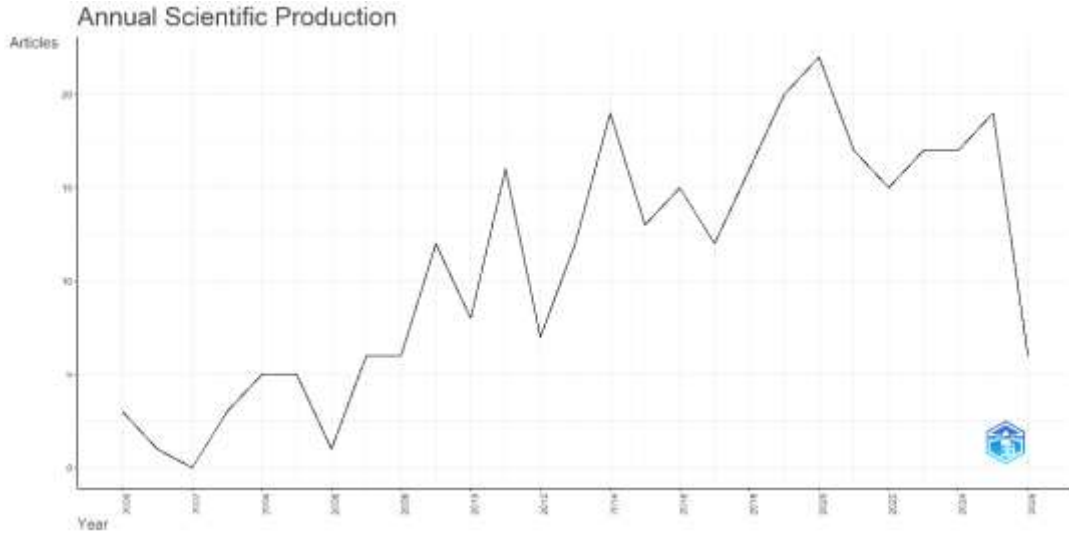
Veriler, Mart 2026 tarihinde Web of Science veri tabanından 'visual motor integration' (görsel motor koordinasyon) ve 'child' (çocuk) anahtar kelimeleri kullanılarak çekilmiştir. Elde edilen 354 kayıt; 2000 yılı sonrası yayınlanmış olma, uluslararası literatür hakimiyetini belirlemek için İngilizce dilinde yazılma kriterlerine göre filtrelenmiştir. Ayrıca çalışmaya sadece araştırma makaleleri, derleme makaleler ve erken erişimdeki makaleler dahil edilmiştir. Diğer çalışma türleri analizin dışında bırakılmıştır. Nihai olarak 293 araştırma; yıllık yayın sayısı, en çok yayın yapan dergi dağılımı, en fazla yayın yapan yazar dağılımı, yazarların en sık kullanıldığı anahtar kelimelerin dağılımı ve konu ile ilgili en çok yayın üreten ülkelerin haritalandırılması bakımından analiz edilmiştir.



Şekil 1. Bibliyografik analiz sürecine yönelik PRISMA akış şeması (Moher et al., 2009; akt. Sarı & Aypay, 2024)

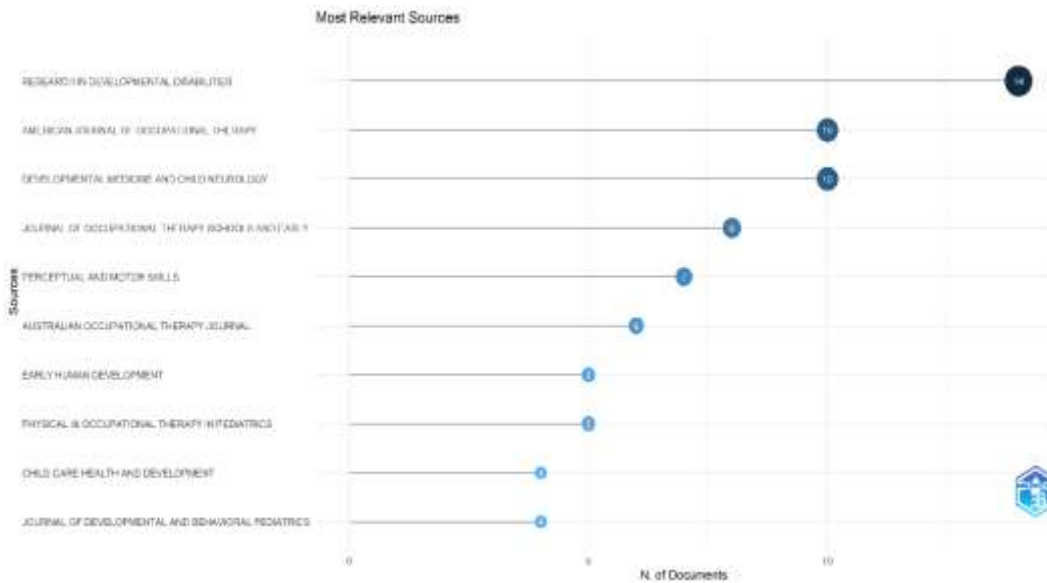
## BULGULAR

Beery-VMI üzerine 2000-2026 yılları arasını kapsayan bibliyometrik analiz sonuçlarına göre, literatürün genel seyri Şekil 2’de sunulmuştur. Beery-VMI üzerine 2000-2026 yılları arasını kapsayan bibliyometrik analiz sonuçlarına göre literatürün genel seyri incelendiğinde (Şekil 2), 2000’li yılların başında yıllık 0-3 yayın ile sınırlı olan ilginin zamanla dalgalı bir artış gösterdiği görülmektedir.



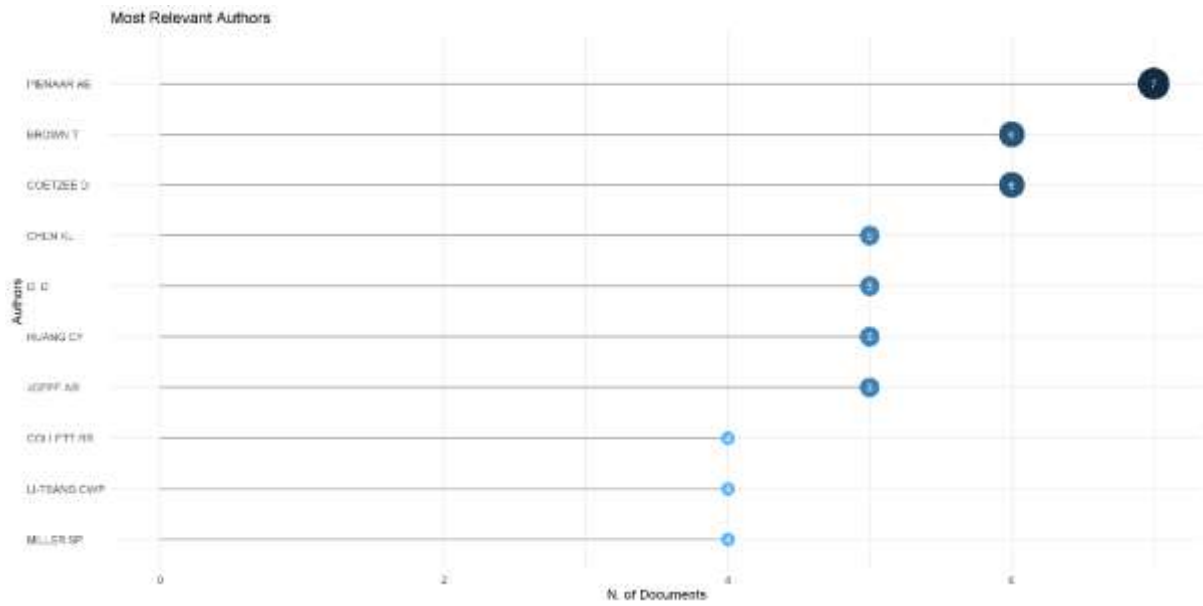
Şekil 2. Literatürün genel görünümü ve yıllık yayın sayısı

İncelenen 26 yıllık süreçte en yüksek akademik üretkenliğe 22 yayınlı 2020 yılında ulaşıldığı saptanmıştır. Bu durum, görsel-motor entegrasyon konusuna olan akademik ilginin son yıllarda en yüksek seviyeye çıktığını kanıtlar niteliktedir. Güncel veriler ışığında 2024 yılında da yayın sayısının zirveye yakın seyretmesi (n=19) konunun popülerliğini koruduğunu gösterirken, 2026 yılındaki sayısal düşüşün ise yılın henüz tamamlanmamış olmasından kaynaklandığı olarak değerlendirilmektedir. Beery-VMI literatüründe en fazla yayın yapılan kaynakların dağılımı Şekil 3’te sunulmuştur.



Şekil 3. Beery-VMI literatüründe en fazla yayın yapılan kaynakların dağılımı (İlk 10 dergi)

Literatürün yayınlandığı temel bilimsel dergiler incelendiğinde, en yüksek akademik üretkenliğin Research in Developmental Disabilities (n=14) dergisinde gerçekleştiği saptanmıştır (Şekil 3). Bu kaynağı, her biri 10’ar yayımla American Journal of Occupational Therapy ve Developmental Medicine and Child Neurology dergileri takip etmektedir. İlk on sırada yer alan diğer dergiler arasında Journal of Occupational Therapy, Schools, and Early Intervention (n=8) ve Perceptual and Motor Skills (n=7) gibi yayınların bulunması, Beery-VMI konusundaki literatürün temel olarak gelişimsel yetersizlikler, çocuk sağlığı ve özellikle ergoterapi disiplinleri çerçevesinde şekillendiğini kanıtlamaktadır. Bu durum, testin sadece genel gelişimsel süreçlerde değil, aynı zamanda rehabilitasyon ve müdahale programlarının etkinliğini değerlendirmede de bir araç olarak kullanıldığını göstermektedir. Beery-VMI konusunda en fazla yayın yapan ilk 10 yazar Şekil 4’te sunulmuştur.



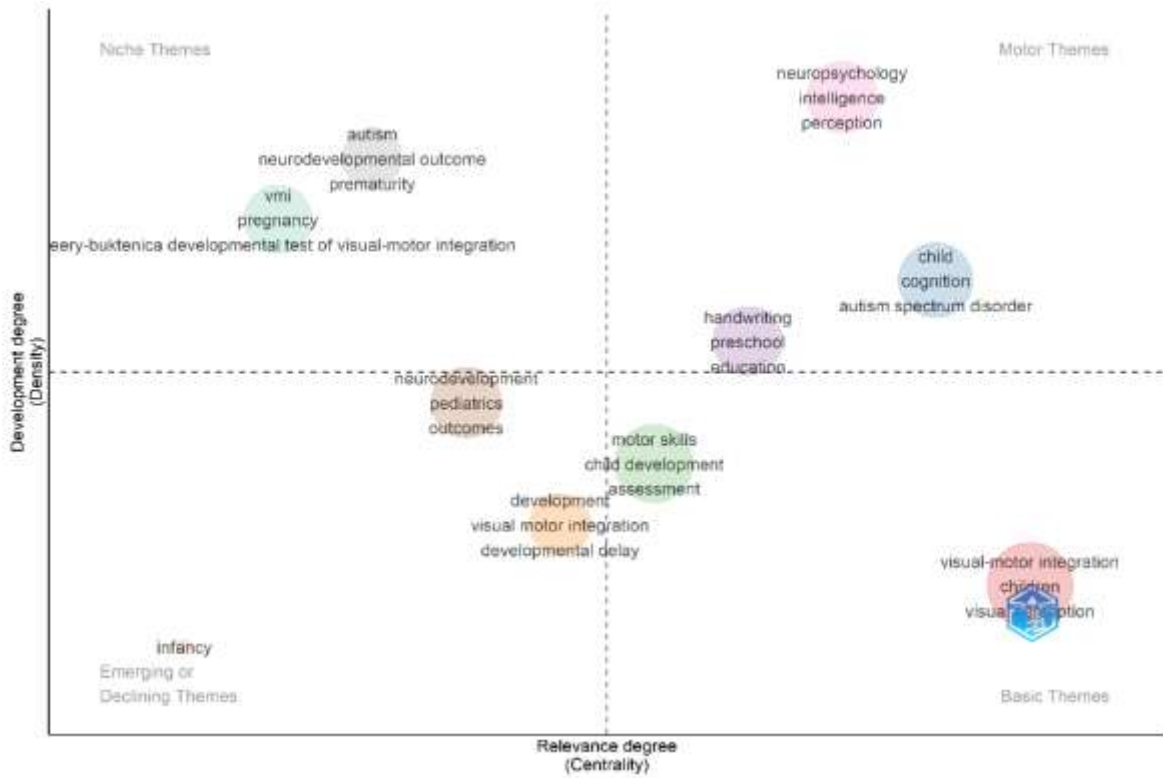
**Şekil 4.** Beery-VMI konusunda en fazla yayın yapan ilk 10 yazarın dağılımı

Literatüre en yüksek katkıyı sunan yazarların dağılımı incelendiğinde, Pienaar A.E.’nin 7 yayımla (n=7) en üretken isim olduğu saptanmıştır (Şekil 4). Bu ismi 6’şar yayımla Brown T. ve Coetzee D. takip ederken, Chen K.L., Huang C.Y. ve Joffe A.R. gibi isimlerin her birinin 5’er yayımla (n=5) alana önemli katkılar sunduğu görülmektedir. İlk 10 sırada yer alan yazarların yayın sayıları arasındaki yakınlık, Beery-VMI konusundaki akademik üretimin tek bir yazarın tekelinde olmadığını, aksine farklı uzmanlık alanlarındaki araştırmacılar tarafından dengeli bir şekilde paylaşıldığını göstermektedir.





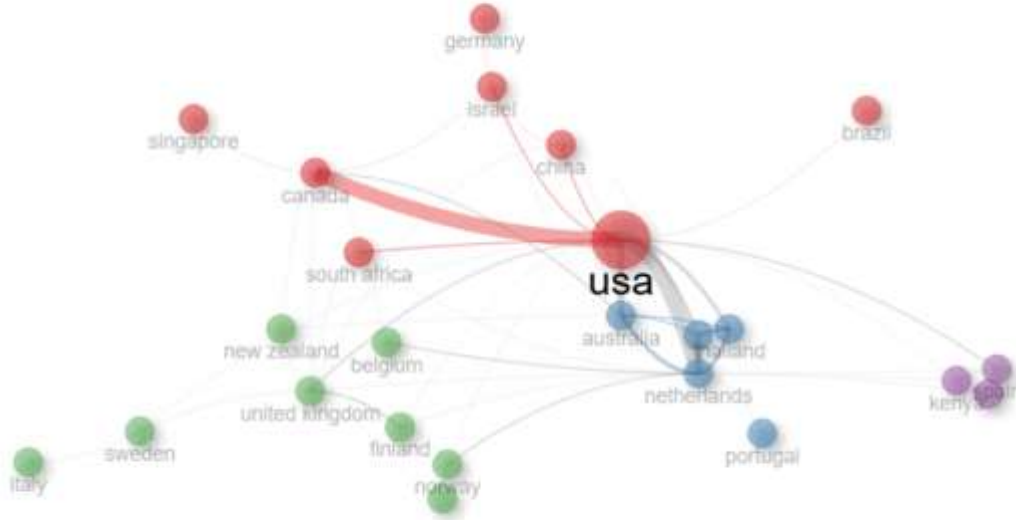
Anahtar kelimelerin birlikte kullanım sıklıklarına dayalı olarak gerçekleştirilen ağ analizi sonucunda (Şekil 6), literatürün iki ana odak etrafında kümelendiği görülmektedir. Mavi ve mor kümeler, 'görsel-motor entegrasyon' ve 'motor beceriler' kavramları üzerinden literatürün daha çok klinik ve rehabilitasyon ağırlıklı (ergoterapi/fizyoterapi) bir yapıya sahip olduğunu kanıtlamaktadır. Buna karşın, yeşil kümede yer alan 'el yazısı' (handwriting), 'çocuk' ve 'okul öncesi' (preschool) temaları ise konunun eğitimsel ve gelişimsel boyutunu temsil etmektedir. Ancak bu kümenin diğerlerine göre daha sınırlı bir hacme sahip olması, çocuk gelişimi ve okul öncesi eğitimi perspektifinden yürütülen çalışmaların literatürde henüz gelişim aşamasında olduğunu ve bu alanda önemli bir araştırma boşluğu bulunduğunu ortaya koymaktadır.



Şekil 7. Beery-VMI literatürünün tematik haritası

Literatürün stratejik konumunu belirleyen tematik harita analizi sonucunda (Şekil 7), Beery-VMI çalışmalarının dört temel bölgede kümелendiği görülmektedir. Haritanın sağ üst çeyreğinde yer alan "Motor Themes"(Motor Temalar) bölgesinde neuropsychology (nöropsikoloji), intelligence (zekâ), cognition (biliş) ve özellikle handwriting (el yazısı), preschool (okul öncesi), education (eğitim) temalarının bulunması, bu konuların hem çok gelişmiş hem de literatürün merkezinde yer aldığını göstermektedir. Sağ alt çeyrekteki "Basic Themes" (Temel Temalar) bölgesinde yer alan visual-motor integration (görsel-motor koordinasyon) ve visual perception (görsel algı) kavramları, alanın teorik altyapısını oluşturmaktadır. Sol üstteki "Niche Themes" (Özel Temalar) bölgesinde prematurity (erken doğum) ve pregnancy (gebelik) gibi spesifik klinik alanlar dikkat çekerken; sol alttaki "Emerging or Declining Themes" (Yükselen ve Düşüşte Olan Temalar) bölgesinde yer alan infancy (bebeklik dönemi) teması, literatürde henüz gelişmekte olan veya odağını kaybetmeye başlayan bir alan olarak saptanmıştır. Bu harita, okul öncesi eğitim ve el yazısı becerileri odağındaki çalışmaların literatürün en dinamik ve merkezi parçasını oluşturduğunu teyit etmektedir.

Beery-VMI çalışmalarının küresel ölçekteki sosyal haritasını ve ülkeler arasındaki akademik iş birliği örüntülerini gösteren ağ grafiği Şekil 8’de sunulmuştur.



**Şekil 8.** Beery-VMI literatüründe ülkeler arası iş birliği ağı

Beery-VMI literatürünün küresel ölçekteki sosyal yapısı ve ülkeler arası akademik iş birliği ağı incelendiğinde (Şekil 8), USA'nın (ABD) ağı merkezinde yer alan en baskın ülke olduğu saptanmıştır. Özellikle USA ve Kanada arasındaki kalın bağ çizgisi, literatürdeki en yoğun uluslararası iş birliğinin bu iki ülke arasında gerçekleştiğini kanıtlamaktadır. Ağı diğer kanatlarında yer alan Avustralya, Birleşik Krallık (UK) ve Hollanda gibi ülkelerin kendi aralarında ve ABD ile kurdukları köprüler, görsel-motor koordinasyon araştırmalarının küresel bir ekosistem içinde geliştiğini göstermektedir. Analiz sonuçları, Türkiye'nin Beery-VMI konusundaki küresel ağların dışında kaldığını belgelemektedir. Dünya genelindeki bu akademik iş birliği ağına Türkiye'nin henüz dahil olmaması, ülkemizdeki çalışmaların uluslararası platformlarda daha fazla görünür kılınması gerektiğini ortaya koymaktadır.

## TARTIŞMA

Bu çalışma, Beery-VMI literatürünün 2000-2026 yılları arasındaki gelişimini incelemeyi amaçlayan bibliyometrik bir analizdir. Elde edilen bulgulardan hareketle Beery-VMI

literatürünün 2000-2026 yılları arasındaki zamansal gelişimi incelendiğinde, konuya olan akademik ilginin genel bir artış eğiliminde olduğu görülmektedir. Özellikle 2010 yılından sonra çalışmaların ivme kazandığı ve 2020 yılında yıllık bazda üretim zirvesine (n=22) ulaştığı saptanmıştır. Bu durum, görsel-motor koordinasyonun çocuk gelişimi ve pediatri araştırmalarında hala güncelliğini koruyan temel bir konu olduğunu kanıtlamaktadır. (Şekil 2).

Literatürün hangi alanlarda yoğunlaştığı incelendiğinde; "Research in Developmental Disabilities" ve "American Journal of Occupational Therapy" gibi dergilerin ön plana çıktığı görülmektedir. Bu sonuçlar, Beery-VMI çalışmalarının dünya genelinde ağırlıklı olarak ergoterapi, rehabilitasyon ve klinik pediatri disiplinleri tarafından sahiplendiğini göstermektedir. Akademik tartışmaların bu klinik odaklı dergilerde toplanması, testin eğitimsel boyutundan ziyade tedavi edici ve tanı koyucu yönünün daha baskın çalışıldığını ispatlamaktadır (Şekil 3).

Yazar bazlı analiz sonuçları; Pienaar A.E., Brown T. ve Coetzee D. gibi isimlerin Beery-VMI literatürüne en yüksek katkıyı sağlayan araştırmacılar olduğunu ortaya koymaktadır. Bu yazarların uzmanlık alanları ve yayın sayıları, literatürdeki bilimsel birikimin belirli akademik merkezler ve uzman isimler etrafında şekillendiğini göstermektedir. Bu araştırmacıların süreklilik arz eden çalışmaları, alanın metodolojik gelişimine yön vermektedir (Şekil 4).

Kelime bulutu incelendiğinde; "visual-motor integration" (görsel motor koordinasyon), "children" (çocuklar) ve "motor skills" (motor beceriler) kavramlarının literatürün merkezinde yer aldığı görülmektedir. Bununla birlikte, "handwriting" (el yazısı) ve "preschool" (okul öncesi) anahtar kelimelerinin belirginliği, testin okul öncesi dönemdeki akademik hazırlık süreçleriyle olan güçlü bağınyı yansıtmaktadır. Diğer yandan "occupational therapy" (ergoterapi) ve "pediatrics" (pediatri) gibi kavramların varlığı, literatürün klinik ve eğitimsel odak noktaları arasındaki dağılımını özetlemektedir (Şekil 5).

Ağ analizi sonuçları, Beery-VMI literatürünün farklı uzmanlık alanlarına bölündüğünü açıkça göstermektedir. "Motor skills" (mor küme) ve "visual-motor integration" (mavi küme) etrafında toplanan gruplar, literatürün klinik ve rehabilitasyon ağırlıklı yapısını temsil etmektedir. Öte yandan, "handwriting" ve "preschool" kavramlarını içeren yeşil küme, testin eğitimsel boyutunu yansıtsa da diğer kümelere kıyasla daha dar bir alanda kalmaktadır. Bu ayırım, görsel-

motor becerilerin eğitim ve çocuk gelişimi perspektifinden daha fazla çalışılması gerektiğini kanıtlamaktadır (Şekil 6).

Çalışmanın en dikkat çekici bulgusu, araştırmaların disiplinler arası dağılımındaki dengesizliktir. Tematik harita sonuçları, literatürdeki kavramların gelişim düzeyini ve stratejik önemini ortaya koymaktadır. Sağ üst çeyrekte yer alan "handwriting"(el yazısı), "preschool" (okul öncesi) ve "education" (eğitim) temaları, literatürün en güçlü ve gelişmiş "motor temaları" olarak saptanmıştır. Bu durum, el yazısı ve eğitim odaklı çalışmaların alanda merkezi bir öneme sahip olduğunu doğrulamaktadır. Sol üstteki "niche themes" (niş temalar) ise otizm ve erken doğum gibi daha spesifik klinik gruplara odaklanıldığını göstermektedir (Şekil 7).

Küresel ölçekte ise çalışmaların merkezinde ABD ve Kanada yer almakta, en güçlü iş birlikleri bu iki ülke arasında kurulmaktadır. Özellikle ABD ve Kanada arasındaki güçlü bağ, akademik üretimin Kuzey Amerika ekseninde yoğunlaştığını kanıtlamaktadır. Avrupa ülkelerinin (Birleşik Krallık, İtalya, İsveç) kendi içindeki ağ yapısı dikkat çekiciyken Türkiye'nin bu uluslararası ağlarda henüz aktif bir yer almaması, yerel çalışmaların artırılması gerektiğini göstermektedir (Şekil 8).

Literatürün klinik/tedavi edici boyutu oldukça doyurucu bir seviyeye ulaşmışken, Beery-VMI ölçeğinin okul öncesi eğitim programlarının ve gelişimsel müdahale süreçlerinin bir parçası olarak ele alınması gerektiği saptanmıştır. Gelecek çalışmaların, testi sadece bir tanı aracı olarak değil, erken çocukluk dönemindeki akademik hazırbulunuşluk ve el yazısı hazırlık süreçlerini destekleyecek eğitimsel müdahaleler odağında incelemesi önerilmektedir.

## SONUÇ

Bu bibliyometrik analiz Beery-VMI üzerine 2000-2026 yılları arasını kapsayan araştırmaları incelemeyi amaçlamaktadır. Elde edilen sonuçlar görsel-motor entegrasyon literatürünün küresel ölçekte istikrarlı bir büyüme sergilediğini ve güncelliğini koruduğunu ortaya koymaktadır. Analiz sonuçlarına göre; Amerika Birleşik Devletleri (USA) bu alandaki akademik üretimin merkezi konumundayken, "handwriting" (el yazısı) ve "education" (eğitim) temalarının literatürü zenginleştiren en stratejik ve merkezi çalışma alanları olduğu saptanmıştır. Küresel iş birliği ağlarında Türkiye'nin henüz sınırlı düzeyde temsil edilmesi, yerel ölçekte yürütülen özgün araştırmaların uluslararası platformlara entegre edilmesi noktasında kritik bir gelişim alanı olduğunu göstermektedir. Nihayetinde bu çalışma;

çocuklarda görsel-motor koordinasyon ve el yazısı hazırlık becerileri odağındaki bilimsel ilginin akademik literatürün ana eksenine uyum içinde olduğunu belgeleyerek, gelecekteki müdahale programları ve akademik çalışmalar için somut bir yol haritası sunmaktadır.

Gelecekteki araştırmaların; Türkiye’de bu alanda yürütülen özgün çalışmaları ve biriken bilimsel tecrübeyi, dünyadaki büyük projelerle birleştirecek uluslararası akademik iş birliklerine odaklanması önerilmektedir. Bunun yanı sıra, testin sadece bir tanı aracı olarak değil, erken çocukluk dönemindeki akademik hazırbulunuşluk ve el yazısı hazırlık süreçlerini destekleyecek eğitimsel müdahaleler odağında incelenmesi önerilmektedir.

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## C2–C3 CROSS-SECTIONAL AREA MORPHOLOGICAL EVALUATION; BIOMARKER SEARCH IN MULTIPLE SCLEROSIS

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### ABSTRACT

Multiple sclerosis (MS) is an autoimmune disease characterized by inflammation, demyelination, and neurodegeneration in the central nervous system. In recent years, morphological changes at the upper cervical level, especially gray matter (GM) and white matter (WM) loss, have been suggested to occur in the early stages of the disease and to be associated with clinical disability.

The aim of this study is to evaluate total cross-sectional area (TCA), gray matter (GM), and white matter (WM) areas at the C2–C3 level in patients with MS, compare them with healthy individuals, and reveal possible morphometric changes.

In this retrospective study, magnetic resonance images of a total of 63 individuals aged 18–65 were analyzed. Of the participants, 34 were MS patients and 29 were healthy controls. Measurements were performed on the AX Merge sequence obtained in the axial plane. At the C2–C3 level, TCA, GM, and WM areas were manually measured via the Sectra system. In addition, GM/WM, GM/TCA, and WM/TCA ratios were calculated. Statistical analyses were performed using IBM SPSS 25.0 software. Normal distribution of the data was evaluated with the Shapiro-Wilk test, and independent samples t-test was used for comparisons between groups. Correlation analyses were performed using Pearson's test.

In the MS group, the mean total cross-sectional area (TCA) was  $237.12 \pm 34.41 \text{ mm}^2$ , while in the control group it was  $251.01 \pm 40.12 \text{ mm}^2$ . White matter (WM) area was measured as  $159.19 \pm 33.22 \text{ mm}^2$  in the MS group and  $172.31 \pm 37.83 \text{ mm}^2$  in the control group. Gray matter (GM) area was found to be  $77.92 \pm 13.12 \text{ mm}^2$  in the MS group and  $78.69 \pm 9.29 \text{ mm}^2$  in the control group.

In the ratio analysis, GM/WM and GM/TCA ratios were observed to be slightly increased in the MS group compared to the control group. However, no statistically significant difference was found between the MS and control groups in terms of TCA, GM, and WM areas ( $p>0.05$ ).

In gender analysis, both TCA and GM areas were significantly higher in male participants ( $p<0.05$ ). No significant correlation was observed between age and all morphometric parameters.

**Keywords:** Multiple sclerosis, gray matter, total cross-sectional area, morphometric analysis, magnetic resonance imaging

## **INTRODUCTION**

Multiple sclerosis (MS) is a autoimmune, inflammatory, and neurodegenerative disease of the central nervous system (CNS). Although traditionally considered a white matter disease, current evidence suggests that gray matter damage begins in the very early stages of the disease and shows a stronger association with clinical disability than white matter lesions. The spinal cord, the part of the CNS that develops from the embryonic neural tube and undergoes the least changes, is approximately 40-45 cm long, 1 cm in diameter, and weighs about 30 grams in adults. Although it constitutes only 2% of the CNS mass, it has vital functions such as transmitting impulses from most of the body to the brain, carrying impulses that initiate voluntary movements to skeletal muscles, and providing autonomic innervation (Arıncı & Elhan, 2025; Arifoğlu, 2019). Beginning within the vertebral canal, at the level of the upper edge of the atlas, this structure merges with the medulla oblongata, narrowing to a cone shape at its lower end and becoming called the conus medullaris, usually terminating at the L1-L2 vertebral level (Ozan, 2014). However, this termination point can vary according to gender; in women, it can descend to the lower border of the L2 vertebra. After the conus medullaris, the structure continues downwards as the filum terminale, surrounded by nerve roots originating from the lower segments and called the cauda equina (Figure 1) (Arıncı & Elhan, 2025).

The morphological structure of the spinal cord shows expansions in some areas due to the density of nerve fibers going to the extremities. The cervical intumescent (Figure 2), containing the C4-T1 segments responsible for upper extremity innervation, and the lumbosacral intumescent (Figure 3), containing the L1-S3 segments innervating the lower extremity, are the regions with the largest cross-sectional areas of the spinal cord (Arifoğlu, 2019). In transverse sections, the spinal cord consists of the substantia alba (white matter), composed of descending and ascending extensions of neurons on the outside, and the substantia grisea (gray matter), shaped like the letter "H," formed by neuron cell bodies and unmyelinated fibers on the inside

(Figure 4) (Ozan, 2014). Functionally, the gray matter consists of the anterior corneus (motor neurons), the posterior corneus (sensory neurons), and the lateral corneus, which houses autonomic neurons between the T1-L2 and S2-S4 segments. This structural organization exhibits a laminar arrangement from I to X known as Rexed laminae; for example, the anterior cornea houses Lamina VII, VIII, and IX, forming the main center of motor control (Arıncı & Elhan, 2025).

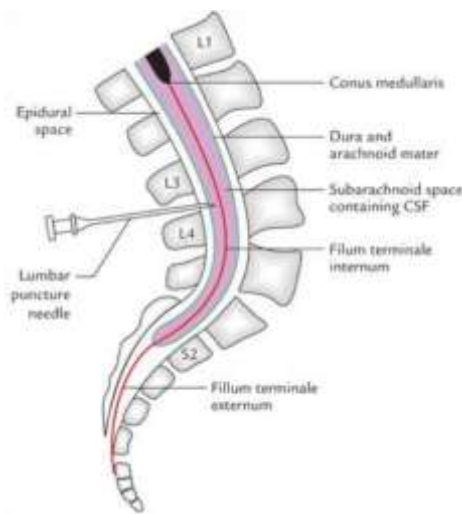


**Figure 1:** Filum terminale internum + externum (www.kenhub.com)



**Figure 2:** Intumescentia cervicalis (www.kenhub.com)



**Figure 3:** Intumescentia lumbosacralis (www.kenhub.com)

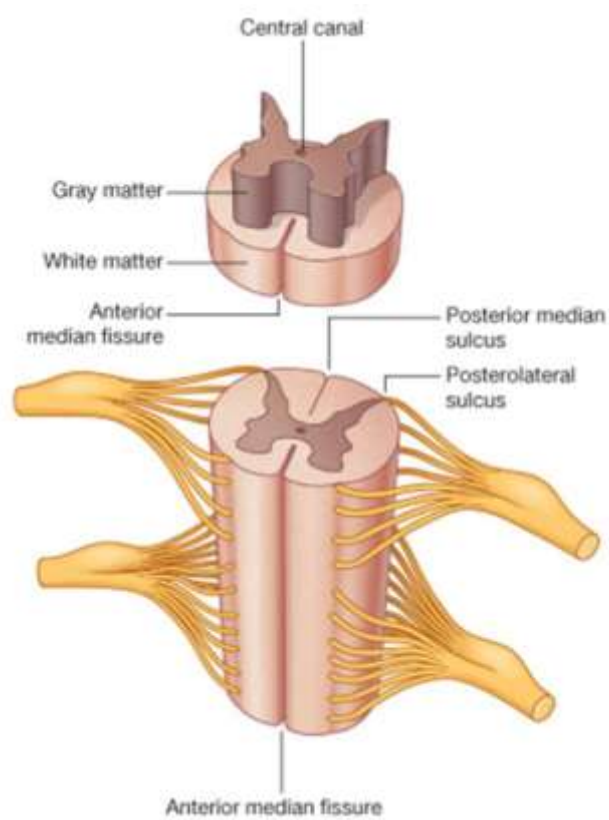


**Figure 4:** Substantia grisea + substantia alba (www.kenhub.com)

In MS pathology, morphometric changes and tissue losses, particularly in the upper cervical region (C2–C3), are known to play a critical role in predicting the level of clinical disability. The cervical region is susceptible to neurodegeneration both because it is a dense junction of motor and sensory pathways and because of the critical balance of vascularization provided by the anterior spinal artery and the paired posterior spinal arteries. However, the discrepancy between the lesion burden observed in standard MRI scans and the patient's clinical condition, i.e., the "clinical-radiological paradox," necessitates the search for more sensitive biomarkers (Cohen et al., 2012; Testud et al, 2023). The "Network Degeneration Hypothesis," which suggests that gray matter atrophy can develop independently of axonal damage in the white matter, has made it necessary to examine these two tissue compartments separately (Schlaeger et al., 2014).

## **MATERIALS AND METHODS**

The methodological design of the study was structured as a retrospective case-control design, adhering to the standards of the Helsinki Declaration, in accordance with the approval numbered "2026/08-01" received from the Non-Interventional Research Ethics Committee of Alanya Alaaddin Keykubat University. The research population consisted of 34 patients with a definitive MS diagnosis according to McDonald criteria (Thompson et al, 2017) and followed up by the neurology outpatient clinic, and 29 healthy volunteers matched for age and gender with this group and without any neurological or systemic disease. The selection of participants was based on the criterion of being between 18-65 years of age; individuals with pathologies that may affect cervical cord morphometry, such as a history of spinal surgery, trauma, cord tumors, or degenerative disc diseases, were excluded from the study. The imaging process was standardized using a magnetic resonance imaging system. For morphometric analysis of the cervical region, a high-resolution AX Merge (Multi-Echo Recombined Gradient Echo) sequence was applied in the axial plane, maximizing the contrast difference between gray and white matter and allowing for clear visualization of tissue boundaries. The resulting high-resolution DICOM images were digitally analyzed using the SECTRA program to ensure accuracy in anatomical measurements. The focus of the measurements was the intervertebral disc plane at the C2–C3 vertebral level, which is considered to provide the most stable data of the spinal cord both clinically and radiologically. In sections taken from this level, the outermost boundaries of the cord were manually marked to determine the total cross-sectional area (TCA); then, the gray matter (GM) area was quantified by following the characteristic "H"-shaped

structure in the inner part (Schlaeger et al., 2014; Kesenheimer et al., 2021). The white matter (WM) area was calculated by mathematically subtracting the gray matter area from the total area ( $WM = TCA - GM$ ) (Figure 5). In addition, tissue ratios such as GM/WM, GM/TKA, and WM/TKA were calculated to analyze tissue-specific atrophy more deeply; statistical analysis of all these data was performed using IBM SPSS 25.0 software with normality tests (Shapiro-Wilk), followed by Independent Samples t-test and Mann-Whitney U test at a significance level of  $p < 0.05$ .

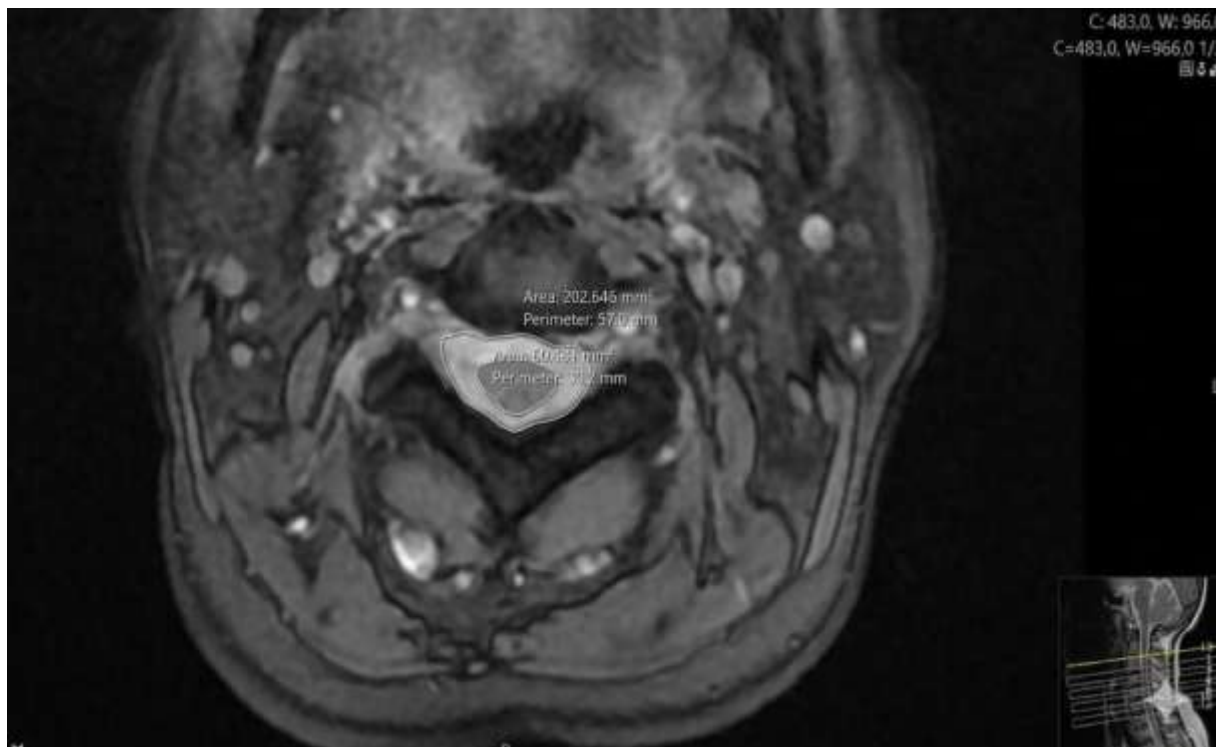


**Figure 5:** Manual delineation of the total cord cross-sectional area (TCA) and gray matter (GM) area at the C2-C3 intervertebral disc level.

## RESULTS AND DISCUSSION

Magnetic resonance imaging (MRI) images of a total of 63 participants included in the study were analyzed morphometrically and statistically. The study group consisted of 29 (46.03%) healthy control individuals (12 men, 17 women) and 34 (53.97%) patients diagnosed with MS (8 men, 26 women). In terms of average age, the control group had an average age of  $45.8 \pm [SD]$  years, while the MS patient group had an average age of  $37.82 \pm [SD]$  years. According to Pearson correlation analysis results, no significant relationship was found between the measured cross-sectional area parameters and the calculated ratios with the participants' age



( $p > 0.05$ ). After confirming the normal distribution of the data using the Shapiro-Wilk test, further analyses revealed no statistically significant differences between the MS patient group and the healthy control group in any of the morphometric parameters (TKA, GM, WM) ( $p > 0.05$ ). However, it was observed that total cross-sectional area (TCA) and white matter (WM) area data were lower in the control group compared to the MS group, while other parameters were higher in the MS group. When the data were compared based on gender, total cross-sectional area (TCA) and gray matter (GM) values were found to be statistically significantly higher in male participants than in female participants in both patient and control groups ( $p < 0.05$ ). Although no statistical significance was reached in other morphometric measurements, it was determined that the cross-sectional areas in men were larger than in women ( $p > 0.05$ ). Within the scope of descriptive statistics, the mean total cross-sectional area (TCA) in the control group (Group 1) was calculated as  $251.02 \pm 40.13 \text{ mm}^2$ , gray matter (GM) area as  $78.70 \pm 9.29 \text{ mm}^2$ , and white matter (WM) area as  $172.32 \pm 37.84 \text{ mm}^2$ . When the ratios reflecting the interaction between tissue compartments were examined; In the control group, the mean GM/WM ratio was determined to be  $0.478 \pm 0.115$ .

Although the monitoring of neurodegeneration in Multiple Sclerosis (MS) has traditionally been carried out through atrophy and lesion burden in the brain parenchyma, in recent years the strategic role of the spinal cord in this process has attracted more attention due to its success in explaining the clinical picture. Because the spinal cord contains the densest fiber pathways in the central nervous system and is the focal point of afferent/efferent transmission, even minimal tissue loss here can lead to irreversible and severe motor and sensory deficits in the patient (Minagar & Alexander, 2019). This study aimed to quantify the gray and white matter areas at the C2–C3 level, one of the most anatomically and radiologically stable segments of the spinal cord, and to reveal the effect of MS pathology on these structures. The literature suggests that cervical cord gray matter atrophy shows a high correlation with the Expanded Disability Status Scale (EDSS) and that this loss follows a course independent of white matter damage (Schlaeger et al., 2014; Kesenheimer et al., 2021). However, our findings revealed no statistically significant difference in total cross-sectional area (TCA), gray matter (GM), and white matter (WM) parameters between the MS group and healthy controls ( $p > 0.05$ ). This can be explained by the duration of the disease in our sample group, the effects of the treatments used, or the fact that cord atrophy had not yet reached a detectable threshold with current imaging techniques. One of the most striking findings of our study is that TCA and WM data were numerically lower

in the control group compared to the MS group. While lower volumetric values are expected in the MS group due to neural loss in the normal pathophysiological process, this observed pattern can be associated with the phenomenon described in the literature as "pseudo-normalization." It is known that chronic inflammation, microglial activation, astrogliosis, and the resulting edema seen in the early or active stages of MS can mask tissue loss volumetrically, making cross-sectional areas appear larger than they are (Schmierer & Miquel, 2018). Furthermore, the lack of correlation between the measured parameters and the age of the participants (18-65 years) proves that the morphometric changes in the spinal cord are dependent on individual anatomical configuration or the specific course of the disease, rather than being a physiological process related to aging. At this point, the question of whether atrophy in subcortical gray matter structures progresses simultaneously with spinal cord atrophy remains an important focus of discussion for future studies to understand the holistic degeneration of the central nervous system (Barc et al., 2023; Tekin et al., 2024). The relationship between iron accumulation and volume loss in deep gray matter structures and clinical scores is also part of this holistic approach (Voon et al., 2025).

From an anatomical perspective, the significantly higher TKA and GM values of male participants compared to females in both groups ( $p < 0.05$ ) demonstrates how decisive the gender factor is as a key biological variable in cervical cord morphometry (Kesenheimer et al., 2021). This finding suggests that men have a larger initial neural reserve and spinal cord volume, but the potential protective effect of this structural advantage on clinical course and disability should be investigated in larger cohorts. Although limitations of the study include its retrospective design and the exclusion of direct correlation between EDSS scores and cord areas at this stage, it confirmed that manual segmentation at the C2-C3 level is a sensitive tool for monitoring tissue-specific changes (Cohen et al., 2012). Consequently, the lack of a significant difference between groups suggests that spinal cord atrophy does not progress at the same rate in every MS patient and that volume loss, especially in early-stage or stable cases, may be balanced by inflammatory processes.

## CONCLUSION

This study reveals neurodegenerative processes at the upper cervical spinal cord (C2–C3) level in Multiple Sclerosis (MS) pathology through a comprehensive morphometric analysis that addresses the gray and white matter compartments separately. Data obtained using manual

segmentation provide a highly anatomically accurate approach for quantifying tissue-specific changes in the cord (Schlaeger et al., 2014). Although no statistically significant difference in atrophy was found between the MS group and healthy controls in total cross-sectional area (TCA), gray matter (GM), and white matter (WM) parameters ( $p > 0.05$ ), the numerical data obtained support the "pseudo-normalization" phenomenon in MS pathophysiology. This situation, consistent with the literature, reveals that chronic inflammatory processes and accompanying edema, especially in the early or active phases of the disease, can volumetrically mask the existing tissue loss (Schmierer & Miquel, 2018).

One of the most important outcomes of the study is that the cross-sectional area values of male participants in both the patient and control groups were found to be significantly higher than those of female participants ( $p < 0.05$ ). This finding proves that gender must be taken into account as a fundamental biological variable in biomarker studies on spinal cord morphometry and that future normative data studies should be designed to be gender-specific (Kesenheimer et al., 2021; Alsema et al., 2024). In addition, the lack of correlation between the measured morphometric parameters and the age of the participants suggests that structural changes in the spinal cord are related to the unique pathological dynamics of MS and individual neural reserve capacity, rather than the physiological aging process. Ultimately, detailed morphometric analyses performed at the C2–C3 level have the potential to be a cost-effective and objective imaging biomarker applicable in clinical practice for MS follow-up (Cohen et al., 2012). This study contributes to the literature by emphasizing that the masking effect of inflammatory processes on atrophy should be considered in clinical evaluations, even in stable cases where no statistically significant difference was found. In the future, research with a larger patient sample, encompassing different clinical phenotypes of the disease (RRMS, PPMS, SPMS) and including clinical disability scores (EDSS) and long-term follow-ups, will solidify the reliability and prognostic value of upper cervical cord morphometry as a biomarker (Tekin et al., 2024; Voon et al., 2025).

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## COFFEE (COFFEA SPP.) PRODUCTION IN THE GAZIPAŞA ECOSYSTEM

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### ABSTRACT

Coffee is an indispensable beverage in many countries. *Coffea arabica L.* production accounts for approximately 64% of world production. Türkiye has a deeply rooted coffee consumption culture. Therefore, coffee production trials are gaining importance in Türkiye as well. Coffee production is particularly widespread in and around the Gazipaşa district of Antalya thanks to the suitability of climate conditions. It is known that protected cultivation of *Coffea arabica L.* evaluated for commercial purposes, is currently conducted on a total area of approximately 4 da in Gazipaşa, whereas open-field coffee cultivation is generally carried out as hobby-oriented experimental trials. BATEM (Batı Akdeniz Agricultural Research Institute) is researching coffee cultivation, and some private companies state that commercial coffee cultivation is economically viable. This study aims to examine coffee production areas in Türkiye and investigate the importance of Gazipaşa in the selection of coffee production areas. It has been observed that Gazipaşa, located in the south of the country, contributes to the cultivation of coffee, a tropical fruit, especially due to climate change; however, since it does not possess all the necessary climatic characteristics for coffee, production in greenhouses is more effective and economical.

**Keywords:** Gazipaşa, Coffee production, Tropical fruits, Greenhouse cultivation

### GAZIPAŞA EKOSİSTEMİNDE KAHVE (*COFFEA SPP.*) ÜRETİCİLİĞİ

#### ÖZET

Kahve birçok ülkede vazgeçilmez bir içecektir. Dünya üretiminin yaklaşık %64'ünü *Coffea arabica L.* üretimi oluşturmaktadır. Türkiye, kahve tüketimi açısından çok köklü bir kültüre sahiptir. Bu nedenle, kahve üretimi denemeleri Türkiye'de de önem kazanmaktadır. Kahve üretimi özellikle Antalya'nın Gazipaşa ilçesi ve çevresinde iklim koşullarının uygunluğu nedeniyle üretilmekte olup, yaygınlaşmaktadır. Gazipaşa'da toplam yaklaşık 4 da alanda ticari amaçlı değerlendirilen örtü altı *Coffea arabica L.* yetiştiriciliği yapıldığı bilinmektedir. Açık alanda ise kahve yetiştiriciliği genellikle hobi amaçlı denemeler şeklinde gerçekleştirilmektedir. Özellikle BATEM (Batı Akdeniz Tarımsal Araştırma Enstitüsü) kahve yetiştiriciliği hakkında çalışmalar yürütmekte olup bazı özel şirketler ticari kahve yetiştiriciliğin ekonomik olduğunu belirtmektedirler. Bu çalışmada, Türkiye'de kahve üretim alanlarının incelenmesi ve kahve üretim alanı seçiminde Gazipaşa'nın öneminin araştırılması amaçlanmıştır. Özellikle iklim

değişikliği nedeniyle ülkenin güneyinde yer alan Gazipaşa'nın tropik bir meyve olan kahvenin yetiştirilmesine katkıda bulunmakta, ancak kahve için gerekli olan tüm iklim özelliklerine sahip olmadığı için seralarda yapılan üretimlerin daha etkili ve ekonomik olduğu gözlemlenmiştir.

**Anahtar kelimeler:** Gazipaşa, Kahve üretimi, Tropik meyveler, Örtü altı yetiştiriciliği



## BIBLIOMETRIC ANALYSIS OF STUDIES ON FOOTBALL AND ANALYTICS BETWEEN 2006-2025

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### ABSTRACT

Football has become a data-driven sport in which performance analysis and evidence-based decision-making processes are widely utilized. In recent years, analytical approaches have played a significant role in evaluating player performance, developing match strategies, and predicting injury risks. In this context, examining the scientific literature at the intersection of football and analytics is crucial for understanding research trends and the development of the field. Therefore, this study aims to analyze the bibliometric characteristics of research conducted in football analytics between 2006 and 2025.

A bibliometric analysis method was employed, and the dataset was obtained from the Web of Science database using the keywords “football” and “analytics.” A total of 513 scientific publications were analyzed within the specified period. The analysis included indicators such as publication output, annual growth rate, citation counts, keyword usage, and the most productive journals, institutions, and authors.

The findings revealed that 1,525 authors contributed to the publications, with 1,432 unique keywords and 15,133 cited references. The annual growth rate was 26.34%, and the average number of citations per document was 12.57. Scientific production showed a notable increase, rising from 17 publications in 2016 to 85 in 2025. Additionally, leading journals, institutions, and authors were identified as key contributors to the field.

Overall, the results indicate a rapid increase in football analytics research and highlight the growing importance of data-driven approaches in sports science. Future studies are expected to focus on advanced techniques such as artificial intelligence and machine learning.

**Keywords:** Football, Sports Analytics, Bibliometric Analysis, Performance Analysis

## ENVIRONMENTAL IMPACTS OF AIRPORT OPERATIONS AND SUSTAINABILITY PRACTICES: THE CASE OF GAZIPAŞA-ALANYA AIRPORT

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### ABSTRACT

The aviation sector, while being an essential part of global transportation, plays a critical role in global mobility and economic development. It is at the center of sustainability discussions due to its impacts such as energy consumption, carbon emissions, noise pollution, and waste production. When examining previous studies in the literature, it is observed that while extensive research has been conducted on the sustainability performances of large-scale airports, the roles and strategic approaches of small-scale airports in this process have not been sufficiently investigated. The objective of this study is to analyze sustainable management practices and the unique dynamics encountered through the example of Gazipaşa-Alanya Airport, a small-scale airport. By drawing support from the analyzed findings, it is aimed to design development and improvement-oriented studies by looking at the status of sustainability and environmental impacts of small-scale airports. In this study, where the case study design one of the qualitative research methods is adopted; it is planned to examine the airport's energy efficiency, zero waste management, water conservation, and carbon accreditation processes. The capacity of Gazipaşa-Alanya Airport, under the management of TAV Airports, to adapt to environmental goals through its operational flexibility and service approach will be evaluated. The findings to be obtained will demonstrate the ability of small-scale airports to successfully implement sustainability strategies, despite limited resources, thanks to their rapid decision-making mechanisms and the bonds they establish with the local ecosystem. The study aims to contribute to the relevant literature and sector stakeholders by providing a model for the "Green Airport" transformation processes of small-scale airports.

**Keywords:** Sustainable Aviation, Environmental Management, Small-Scale Airports, Gazipaşa-Alanya Airport, Green Airport.

### INTRODUCTION

The aviation sector plays a strategic role in ensuring the continuity of global trade, facilitating interaction between societies, and developing tourism. Among transportation systems, the

aviation sector occupies a unique position due to its diverse service offerings and its integration with other transportation systems (Torum and Küçük Yılmaz, 2009). Particularly in the last two decades, due to technological advancements and the increasing need for mobility, aviation activities have experienced massive growth worldwide. However, this growth also poses serious challenges in terms of environmental sustainability. Aviation operations are at the center of ecological degradation and global warming discussions due to their environmental outputs such as carbon emissions, high energy consumption, intensive waste production, and noise problems. Regardless of the sector, ensuring sustainability requires meeting the needs of the current population while conserving and protecting resources to meet future requirements (Frangapoulos, 2006). Therefore, as businesses grow and develop, their social and environmental responsibilities also increase, which has led to the concept of sustainability gaining much more importance (Akduman and Karahan, 2025). Today, the concept of "Sustainability" represents not only a corporate responsibility but also an operational necessity for the aviation sector. International civil aviation organizations and local authorities support "Green Airport" projects and carbon accreditation programs to minimize the environmental footprint. When the academic literature is examined, it is seen that the vast majority of research on sustainability performance focuses on large-scale airports with "hub" (transfer center) characteristics, which have large financial resources and high passenger traffic. Therefore, the challenges, strategic roles, and implementation capacities of small-scale airports, which are vital for regional tourism and local economies, are not sufficiently represented in the literature. In our research, we examine Gazipaşa-Alanya Airport (GZP), a small-scale airport example, to address this gap. This airport, operated by TAV Airports, is a unique model in terms of the applicability of sustainability strategies, both due to its relationship with the regional tourism ecosystem and its boutique operational structure. Within the scope of the research, the airport's zero-waste management, energy efficiency, water conservation, and carbon accreditation processes are examined; and how facilities with limited resources can create environmental advantages through operational flexibility and rapid decision-making mechanisms is investigated (Çayalan and Rodoplu, 2025). In this context, the current research aims to guide sectoral stakeholders and make a unique contribution to the sustainability literature in aviation management by analyzing the "Green Airport" transformation processes of small-scale airports on a practical and institutional level.

## **THEORETICAL FRAMEWORK AND LITERATURE REVIEW**

The aviation sector, which enables the rapid development and digitalization of transportation and trade in our world, is also prominent in sustainability discussions due to the environmental damage caused by the fuels used, the carbon footprint, and the use of environmental resources (Akduman and Karahan, 2025). With the aim of eliminating these negative impacts, the International Air Transport Association (IATA) has set sustainability goals such as taking actions to protect the environment, using sustainable aviation fuels, and achieving net zero carbon emissions by 2050 (IATA, 2023). To support the goal of a sustainable world, the State Airports Authority (DHMI) implements an "Operating Services and Environmental Policy." Within the scope of this environmental policy, operating services aim to reduce greenhouse gas emissions, promote zero waste, efficiently utilize existing energy resources, support all stakeholders with training to increase environmental responsibility and awareness, and organize environmental management system activities integrated with other management systems (DHMI, 2023). However, sustainability reports have ceased to be merely a requirement and have become a strategic communication tool that enhances corporate reputation, builds stakeholder trust, and creates a competitive advantage (L'Abate, Vitolla, Esposito, & Raimo, 2023; Karagiannis, Vouros, Skouloudis, & Evangelinos, 2019). Thus, sustainable airport management has begun to be addressed holistically, encompassing environmental, economic, and social dimensions (Thomas and Scandurra, 2023). Karagiannis, Vouros, Skouloudis, and Evangelinos (2019), by examining sustainability reports of airports in Europe through a comprehensive content analysis, found that disclosure rates were generally limited and that reporting largely focused on environmental indicators (Yalvaç and Atik, 2026). Similarly, Thomas and Scandurra (2023) revealed that a large proportion of airport operators in Italy voluntarily report on environmental and social sustainability, but the quality of reporting varies between 42% and 82%. This result indicates that airports in Europe have made progress in terms of sustainability reporting in terms of form, but the reports are still in the development process in terms of content depth, verifiability of indicators, and consistency in performance measurement (Yalvaç and Atik, 2026). Heathrow Airport takes care to use a comprehensive separation system to prevent waste from mixing. Recycling points in the terminal help passengers separate materials such as paper, plastic, and glass. In addition, it has been observed that energy is produced by converting food waste into biogas (Heathrow Airport, 2023). Istanbul Airport, within the framework of sustainable waste management policies, aims to

increase recycling rates through practices such as separating waste at the source and storing it separately according to its type; The airport has contributed to environmental sustainability by implementing energy recovery methods such as composting organic waste and biogas production. Furthermore, it has aimed to increase awareness of waste management through training programs for passengers and staff, and as a result of these efforts, it has achieved a significant success in the field of waste management by obtaining a zero-waste certificate. The implementation of these strategies has contributed to reducing the amount of waste and increasing recycling rates at the airport (Kalyoncu, 2023). Expanding social responsibility projects within the framework of sustainability will increase the public perception of the aviation sector and will help it gain the encouragement of a wider audience in the future. A review of the literature and the field of study revealed research on hub centers and large-scale airports; however, when keywords were searched, no research focusing on environmental impact and sustainability within the framework of a small-scale airport was found. This situation supports the underlying reasons and focus of our study; therefore, the investigation of the environmental impact and sustainability status of Gazipaşa-Alanya Airport aims to contribute to filling a gap in the literature as an original study.

## **MATERIALS AND METHODS**

The current research is based on a qualitative research methodology, aiming to analyze the environmental impacts of airport operations and the sustainability strategies developed in this process in depth. Beyond quantitative data, managerial processes and application models have been adopted to understand the unique dynamics of small-scale airports.

### **Research Design**

The research focuses on a case study design, which allows for the analysis of a specific phenomenon within its real context. This design was chosen to describe in detail the transformation process and operational flexibility of Gazipaşa-Alanya Airport into a "Green Airport".

### **Data Sources and Materials**

To obtain the basic data for the research, official documents and institutional reports belonging to Gazipaşa-Alanya Airport (GZP) will be created. The following sources are planned to be used in the data collection process:

- **Corporate Reports:** Annual sustainability and activity reports of TAV Airports, the airport operator.
- **Official Certifications:** The airport possesses carbon accreditation certificates, "Zero Waste" protocols, and energy management documents.
- **Operational Data:** Technical data on energy consumption, water conservation practices, and waste management processes.

### Data Collection and Analysis Process

Qualitative content analysis method was used in the analysis of the data. The research process consists of the following stages:

1. **Categorization:** The obtained data were classified under four main headings: energy efficiency, zero waste management, water conservation, and carbon accreditation.
2. **Operational Evaluation:** The sustainability performance of GZP, a small-scale port, was evaluated based on its ability to make quick decisions and connect with the local ecosystem despite limited resources.
3. **Model Creation:** In light of the analyzed findings, the aim was to design a "Green Airport" transformation model for other small-scale airports.

### RESULTS AND DISCUSSION

The research conducted on the sustainability performance of Gazipaşa-Alanya Airport (GZP) within the scope of the current study has revealed that, despite being a small-scale airport, the facility adheres to international standards in environmental management strategies. The key findings are listed below:

- **Carbon Management and Emission Control:** GZP has participated in the Airport Carbon Accreditation (ACA) program developed by the International Airports Council (ACI) within the scope of TAV Airports' global sustainability vision. In this context, the airport systematically measures its carbon footprint and optimizes its operations to reduce it (TAV Airports Holding, 2024).
- **Energy Efficiency and Technical Infrastructure:** It has been concluded that energy efficiency has been achieved at the airport thanks to technical improvements such as the transition to LED lighting systems and the automation of air conditioning units. These practices demonstrate the high speed of technological adaptation in small-scale airports.

- **Waste Management and Zero Waste Protocols:** The facility fully complies with the "Zero Waste" standards of the Ministry of Environment, Urbanization and Climate Change, demonstrating operational success in separating and storing waste at the source and increasing recycling rates.
- **Water Resource Conservation:** The small-scale port structure, real-time monitoring of water consumption, and the preference for water-efficient options in landscaping help minimize the water footprint.

## DISCUSSION

The findings are consistent with the thesis highlighted in the literature by Greer et al. (2020), which states that small-scale airports, despite having limited resources, can implement sustainability projects more effectively thanks to their operational flexibility. The lengthy processes that occur in large-scale airports due to implementation complexity are overcome in the case of GZP through rapid decision-making systems. Adopting the "Green Airport" criteria mentioned by Işıl (2022) as a business model specifically for GZP could contribute to the facility becoming a regional "role model".

## CONCLUSION

This research examines the sustainability roadmap of Gazipaşa-Alanya Airport and analyzes the potential of small-scale airports in environmental management.

- **Overall Conclusion:** Small-scale airports are not merely stations feeding large hubs; thanks to their rapid decision-making capabilities and relationships with the local ecosystem, they can be pioneering laboratories for sustainable aviation transformation.
- **Sectoral Recommendation:** GZP's operational flexibility and service-oriented sustainability approach can serve as a model for a "Green Airport Transformation" for other regional airports of similar scale.
- **Future Studies:** To more clearly reveal the environmental impacts of airport operations, it is recommended that quantitative studies be conducted on the cost-benefit analysis of renewable energy investments (Solar Power Plants, etc.).



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## THE EFFECT OF INSULATION THICKNESS ON ENERGY SAVING IN LAYING HEN HOUSE WALLS

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### ABSTRACT

In regions with cold climates, the majority of energy consumed in buildings is spent on heating them to provide thermal comfort. The best way to reduce heat loss in buildings is to insulate the building's external envelope elements. Building insulation has become even more important in countries that meet a large portion of their energy needs through imports and where fuel prices are high. For this purpose, the study first determined the annual heating load for the laying hen coop using the degree-day method. Subsequently, for the construction of externally insulated walls, optimum insulation thickness, energy savings, and payback periods were calculated using two different fuel types (coal and natural gas) and rock wool as insulation material. According to the results obtained, the optimum insulation thickness for a wall insulated with rock wool was calculated to be 0.12 m and 0.10 m respectively when using coal and natural gas as fuel. Depending on the optimum insulation thickness in the laying hen house, the energy cost savings were determined to be 12.96 \$/m<sup>2</sup>-year when heating with coal compared to an uninsulated wall, and 8.32 \$/m<sup>2</sup>-year when using natural gas. The payback period for insulation in laying hen houses is 1.8 years when heating is done with coal, and 2 years when natural gas is used. The study concludes that, given the ever-increasing energy costs, determining the optimum insulation thickness in buildings is extremely important. Furthermore, this will contribute to enterprises reducing the share of heating in its production costs.

**Keywords:** Heating requirement, degree-day method, energy saving, optimum insulation thickness.

## INVESTIGATION OF THE UTILIZATION OF BIOGAS POTENTIAL PRODUCED FROM ANIMAL MANURE FOR GREENHOUSE HEATING

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### ABSTRACT

Within the agricultural sector, a large portion of the energy required per unit area is generated in greenhouse operations. In greenhouses where off-season cultivation is practiced, a significant portion of this energy is used for heating. This study investigated the possibility of meeting the heat energy requirements of a greenhouse using biogas derived from animal manure. First, the heat requirement was calculated as 962,880.0 kWh/year and 66,2592.0 kWh/year, respectively, with and without a thermal curtain, when the indoor temperatures in the greenhouse are maintained at 16/21°C night and day. Accordingly, it was determined that the use of a heat curtain would reduce the required heat energy by 31.2%. Subsequently, the biogas and electricity energy potential that a farm with 100 dairy cows could produce was determined. The amount of methane that can be obtained from animal manure is calculated as 40670.9 m<sup>3</sup>-CH<sub>4</sub>/year, the energy value that can be produced is 406709.1 kWh/year, and the electrical energy value is 142348.2 kWh/year. The amount of CO<sub>2</sub> that can be prevented from being released into the atmosphere with the electrical energy that can be obtained using this method has been determined to be 82561.9 kg/year. Accordingly, it has been determined that a portion of the energy required in the greenhouse during the cold days of the year can be met with biogas energy. During periods of higher temperatures, the excess biogas can be converted into electricity and used for mechanical ventilation, cooling, irrigation, and lighting in the greenhouse. The results show that energy derived from animal manure is an important resource in terms of being an alternative to fossil fuels and reducing carbon dioxide emissions.

**Keywords:** Greenhouse, animal manure, biogas generation, energy recovery.

## INVESTIGATING THE IMPACT OF HIGH-INTENSITY KINEMATIC DATA ON GOAL SCORING IN FOOTBALL

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### ABSTRACT

Football (soccer) is a sport where running of varying intensity, distance, and direction, as well as tactics, technique, and motor skills, are crucial. The aim of this study is to examine the effect of certain kinematic data on goals scored and conceded in football. A correlational survey model was used in the study. The sample consisted of data obtained from 23 matches played by the Super League Youth Academy U19 (PAF) age group during the 2025-2026 season. The data comprised eight different data points provided by the Statsports Apex device attached to the players before the matches. IBM SPSS 25.0 for Windows Statistical Package Program was used for the statistical analysis of the data. Pearson correlation analysis was used as a correlation test, and the significance level was tested at  $p < 0.05$ . The study revealed a statistically significant positive correlation ( $p = 0.03$ ) between the number of goals scored and the number of sprints (43%), and a statistically significant positive correlation ( $p = 0.02$ ) between the number of goals scored and the distance of sprints (47%). In football, the time spent in high-intensity exercise zones and anaerobic capacity are directly related to offensive effectiveness. Accordingly, it can be recommended that footballers implement high-intensity interval training to increase their sprint count and distance training capacity, small-sided games in technical-tactical training that increase the intensity of sprint count and distance, repeated sprint exercises, and anaerobic endurance training programs to improve lactate tolerance.

**Keywords:** Soccer; Kinematics; Goals scored; Sprint; Sprint Distance

## FUTBOLDA YÜKSEK ŞİDDET İÇEREN KİNEMATİK VERİLERİN ATILAN GOLE ETKİSİNİN İNCELENMESİ

### ÖZET

Futbol, farklı şiddet, mesafe ve yönlerde koşuların yanı sıra, taktik, teknik ve motorik becerilerin belirleyici olduğu bir spor dalıdır. Bu çalışmanın amacı futbolda bazı kinematik verilerin atılan gol, yenilen gol etkisinin incelenmesidir. Araştırmada ilişkisel tarama modeli kullanılmıştır. Araştırmanın örneklemini Süper Lig Altyapısı U19 (PAF) yaş grubunun 2025-2026 Sezonunda oynadığı 23 müsabakadan elde edilen veriler oluşturmuştur. Veriler müsabaka öncesi futbolculara takılan Statsports Apex cihazının sağladığı sekiz farklı verilerden oluşmaktadır. Verilerin istatistiksel analizi için IBM SPSS 25.0 for Windows İstatistiksel Paket Programı kullanılmıştır. İlişki testlerinden pearson korelasyon analizi kullanılmış ve anlamlılık değeri  $p<0.05$  ile test edilmiştir. Araştırma sonucunda atılan gol ile sprint sayısı arasında %43 pozitif yönlü istatistiksel olarak anlamlı ( $p=0.03$ ) ilişki, atılan gol ile sprint mesafesi arasında %47 pozitif yönlü istatistiksel olarak anlamlı ( $p=0.02$ ) ilişki tespit edilmiştir. Futbolda yüksek yoğunluklu egzersiz bölgelerinde geçirilen süre ve anaerobik kapasite hücum etkinliğiyle doğrudan ilişkilidir. Bu doğrultuda, futbolculara sprint sayısı ve sprint mesafesi antrenman kapasitelerini artırmaya yönelik yüksek yoğunluklu interval antrenmanlar, teknik-taktik antrenmanlarda sprint sayısı ve sprint mesafesi yoğunluğunu artıran küçük alan oyunları, tekrarlı sprint çalışmaları ve laktat toleransını artırmaya yönelik anaerobik dayanıklılık antrenman programları uygulamaları önerilebilir.

**Anahtar Kelimeler:** Futbol; Kinematik; Atılan Gol; Sprint; Sprint Mesafesi.

## AN EXAMINATION OF SUFFICIENTLY PROFITABLE AGRICULTURAL LAND SIZE: THE ALANYA EXAMPLE

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### ABSTRACT

Land consolidation is a multi-purpose rural planning tool that enables the creation of suitable parcel shapes for agricultural production from scattered and fragmented lands, and the provision of services such as irrigation, field roads, and drainage. Land consolidation efforts aim to bring farm sizes to "sufficient income farm sizes," and if possible, to "optimum farm sizes." Alanya district of Antalya province, which stands out with its semi-tropical climate advantage in Türkiye, has been experiencing a transformation and development from traditional agriculture to high value-added tropical fruit production in recent years. Within the scope of this study, the concepts of minimum and sufficient income agricultural land size, as defined within the framework of the Soil Protection and Land Use Law No. 5403, are examined; and agricultural reports published in the region are used for evaluation purposes.

The aim of this study is to evaluate the current structure of agricultural lands in Alanya in terms of sufficient income agricultural land size and to investigate the current situation. In this context, existing reports prepared for Alanya, literature studies, and laws regarding sufficient and optimum farm sizes have been examined. In Alanya, the average number of plots per farm is 10, and the average plot size is approximately 4 decares. This increases fuel and labor costs, and urbanization necessitates the modernization of irrigation systems.

**Keywords:** Alanya, tropical fruits, sufficient income farm size

## YETER GELİRLİ TARIMSAL ARAZİ BÜYÜKLÜĞÜNÜN İNCELENMESİ: ALANYA ÖRNEĞİ

### ÖZET

Arazi toplulaştırması, dağınık ve parçalı arazilerin tarımsal üretime uygun parsel şekillerinin oluşturulması ile sulama- tarla içi yol, drenaj gibi hizmetlerin verilmesini sağlayan çok amaçlı bir kırsal planlama aracıdır. Arazi toplulaştırma çalışmaları ile işletme büyüklüklerinin “yeter gelir işletme büyüklüklerine”, mümkünse “optimum işletme büyüklüklerine” getirilmesi istenen bir durumdur. Türkiye’nin yarı tropik iklim avantajıyla öne çıkan Antalya ili Alanya ilçesi, son yıllarda geleneksel tarımdan katma değeri yüksek tropikal meyve üretimine doğru bir dönüşüm ve gelişim yaşamaktadır. Çalışma kapsamında, 5403 sayılı Toprak Koruma ve Arazi Kullanımı Kanunu çerçevesinde tanımlanan asgari ve yeter gelirli tarımsal arazi büyüklüğü kavramları incelenerek; bölgede yayımlanan tarımsal raporlar değerlendirme amacıyla kullanılmıştır.

Bu çalışmanın amacı, Alanya’daki tarım arazilerinin mevcut yapısını yeter gelirli tarımsal arazi büyüklüğü açısından değerlendirerek, mevcut durumu araştırmayı planlamaktır. Bu kapsamda mevcut Alanya için hazırlanan raporlar, literatür çalışmaları, yeter ve optimum işletme büyüklükleri hakkında kanunlar incelenmiştir. Alanya’da işletme başına düşen ortalama parsel sayısının 10, ortalama parsel büyüklüğünün ise yaklaşık 4 da olduğu, bunun yakıt ve işçilik maliyetlerini artırdığı ve kentleşme nedeniyle sulama sistemlerinin modernizasyona ihtiyacı belirlenmiştir.

**Anahtar Kelimeler:** Alanya, tropikal meyveler, yeter gelir işletme büyüklüğü



## EVALUATION OF ATTITUDES AND CLINICAL OUTCOMES AMONG PATIENTS ADMITTING TO A TRADITIONAL AND COMPLEMENTARY MEDICINE CENTER

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### ABSTRACT

Expectations from healthcare services are evolving, with an increasing interest in person-centered and holistic approaches. In this context, Traditional and Complementary Medicine (TCM) applications have gained a significant position in healthcare. This study aimed to examine the knowledge, attitudes, and behaviors of patients applying to a TCM practice center in a training and research hospital and to evaluate the clinical impact of these interventions on pain levels. This cross-sectional study was conducted between November 2023 and February 2024 with 200 voluntary participants aged 18–75. Data were collected using a personal information form, the Attitudes Toward Using Complementary Therapies Scale (ATCTS), and the Visual Analog Scale (VAS) to measure pain intensity. Statistical analyses were performed using Jamovi (v 2.6.25). The mean age of the participants was  $49.5 \pm 11.7$  years, and 62% were female. Wet cupping (66%) was the most preferred application. Among first-time TCM users, wet cupping was predominantly chosen (74.5%). While 58% of participants perceived TCM as a supplementary method, 76.5% stated that their primary reason for choosing this center was that the procedures were performed by a physician. The mean ATCTS score was  $23.9 \pm 5.1$ . Analysis revealed that patients planned for wet cupping had significantly higher attitude scores than those planned for prolotherapy ( $p=0.04$ ). Perceptions toward TCM significantly influenced scale scores ( $p=0.012$ ). Clinical evaluation showed a statistically significant reduction in pain intensity across all TCM modalities; the median VAS score significantly decreased from 5 (pre-treatment) to 3 (post-treatment) ( $p=0.001$ ). Furthermore, hirudotherapy and wet cupping provided significantly higher benefit levels compared to prolotherapy ( $p=0.004$  and  $p=0.043$ , respectively). The findings indicate increasing public awareness of TCM and demonstrate that individuals derive significant clinical benefits from these methods. These results provide critical evidence for the safe, effective, and evidence-based integration of TCM into mainstream healthcare services.

**Keywords:** Complementary therapies, medicine traditional, health knowledge, attitudes, practice.

## CONFIDENTIALITY, THERAPEUTIC RELATIONSHIP, AND SUSTAINABILITY IN DIGITAL PSYCHIATRY: A CURRENT LITERATURE REVIEW

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### ABSTRACT

Digitalization offers significant opportunities in mental health services by increasing access, facilitating monitoring processes, and supporting continuity of care. However, the widespread adoption of digital psychiatry is not merely a technical transformation, but also a multidimensional shift with clinical, ethical, and societal consequences. The aim of this review is to discuss the risks emerging in digital psychiatry, particularly in relation to confidentiality, the therapeutic relationship, and sustainability, in light of the current literature. The literature indicates that sensitive data collected through digital mental health applications are often processed through insufficiently transparent consent procedures and remain vulnerable in terms of data sharing and cybersecurity. Furthermore, reduced face-to-face contact may weaken the therapeutic alliance by limiting the assessment of affect, body language, and other clinical nuances. This may particularly affect the quality of care for individuals with severe mental disorders. In addition, the sustainability of digital solutions depends not only on technological infrastructure, but also on ethical governance, clinician training, cultural sensitivity, and levels of digital literacy. Socioeconomic inequalities and the digital divide mean that these services are often not equally accessible to all, but instead remain selectively available. In conclusion, while digital psychiatry is a powerful tool for supporting mental health services, it should be understood as a model that complements rather than replaces human interaction. Without safeguarding clinical trust, patient confidentiality, and the long-term sustainability of care, digitalization is unlikely to fully realize its expected benefits in mental health services. Within this framework, future applications should be developed through an approach that is ethically grounded, culturally sensitive, and committed to maintaining clinical quality.

**Keywords:** Digital psychiatry, confidentiality, therapeutic relationship, sustainability, mental health

## DİJİTAL PSİKİYATRİDE GİZLİLİK, TERAPÖTİK İLİŞKİ VE SÜRDÜRÜLEBİLİRLİK: GÜNCEL LİTERATÜRE DAYALI BİR DEĞERLENDİRME

### ÖZET

Dijitalleşme, ruh sağlığı hizmetlerinde erişimi artırma, izlem süreçlerini kolaylaştırma ve bakım sürekliliğini destekleme açısından önemli fırsatlar sunmaktadır. Bununla birlikte, dijital psikiyatrinin yaygınlaşması yalnızca teknik bir dönüşüm değil, aynı zamanda klinik, etik ve toplumsal sonuçları olan çok boyutlu bir değişim alanıdır. Bu derlemenin amacı, dijital psikiyatride özellikle gizlilik, terapötik ilişki ve sürdürülebilirlik ekseninde ortaya çıkan riskleri güncel literatür ışığında tartışmaktır. Literatür, dijital ruh sağlığı uygulamalarında toplanan hassas verilerin yeterince şeffaf olmayan onam süreçleriyle işlendiğini, veri paylaşımı ve siber güvenlik açısından önemli kırılganlıklar taşıdığını göstermektedir. Ayrıca yüz yüze temasın azalması; duygulanım, beden dili ve klinik nüansların değerlendirilmesini güçleştirerek terapötik ittifakı zayıflatabilmektedir. Bu durum özellikle ağır ruhsal bozukluğu olan bireylerde bakım kalitesini etkileyebilmektedir. Öte yandan dijital çözümlerin sürdürülebilirliği yalnızca teknolojik altyapıya değil, etik yönetim, klinisyen eğitimi, kültürel duyarlılık ve dijital okuryazarlık düzeyine de bağlıdır. Sosyoekonomik eşitsizlikler ve dijital uçurum, bu hizmetlerin herkese eşit değil, çoğu zaman seçici biçimde ulaşmasına yol açmaktadır. Sonuç olarak dijital psikiyatri, ruh sağlığı hizmetlerini destekleyen güçlü bir araç olmakla birlikte, insan ilişkisinin yerini alan değil, onu tamamlayan bir model içinde ele alınmalıdır. Klinik güven, hasta mahremiyeti ve hizmetin uzun dönemli sürdürülebilirliği korunmadan dijitalleşmenin ruh sağlığı alanında beklenen yararı tam olarak sağlayamayacağı düşünülmektedir. Bu çerçevede gelecekteki uygulamaların etik ilkelere dayalı, kültürel açıdan duyarlı ve klinik kaliteyi önceleyen bir yaklaşımla geliştirilmesi gerekmektedir.

**Anahtar Kelimeler:** Dijital psikiyatri, gizlilik, terapötik ilişki, sürdürülebilirlik, ruh sağlığı

### INTRODUCTION

Mental health services have undergone a significant transformation in recent years with the rapid development of digital technologies. Telepsychiatry, mobile mental health applications, online psychotherapy platforms, digital monitoring tools, artificial intelligence-supported decision systems, chatbots, and digital phenotyping are among the main components of this transformation. Digital psychiatry has the potential to improve access to services, reduce geographical barriers, provide alternative channels for individuals who avoid seeking help due to stigma, and support continuity in treatment monitoring (Torous et al., 2021; Volpe et al., 2026).

Moreover, psychiatry differs from many other medical disciplines in that it relies heavily on interpersonal relationships, the understanding of subjective experiences, nonverbal cues, contextual assessment, and the quality of the therapeutic alliance. Therefore, transferring mental

health services to digital environments does not merely represent a change in the mode of service delivery; it also brings the nature of clinical assessment, the boundaries of the patient–physician relationship, concepts of privacy, professional responsibilities, and the sustainability of care back into discussion.

Volpe et al. (2026) state that digital psychiatry entails clinical, ethical, sociocultural, technological, and regulatory risks, and that these risks should be considered in terms of patient safety, quality of care, and professional standards. The most frequently discussed areas of concern in digital mental health practices include the protection of sensitive data, transparent informed consent processes, algorithmic bias, digital inequality, lack of clinical oversight, and weakening of the therapeutic relationship (Char et al., 2018; Huckvale et al., 2019; Martinez-Martin & Kreitmair, 2018; Wykes et al., 2019).

This study evaluates digital psychiatry through the foundations of confidentiality, the therapeutic relationship, and sustainability. These three domains are fundamental not only for determining the technical success of digital mental health practices, but also for establishing their ethical validity, clinical reliability, and long-term applicability.

## **MATERIALS AND METHODS**

This study is a review that aims to evaluate the risks of digital psychiatry discussed in the current literature. The objective of the study is to discuss the dimensions of confidentiality, the therapeutic relationship, and sustainability in digital psychiatry practices from clinical and ethical perspectives.

In this review, current studies that are directly relevant to the topic and contribute to the discussion were taken as the basis. These studies were related to the concepts of digital psychiatry, digital mental health, telepsychiatry, mobile mental health applications, privacy, informed consent, therapeutic alliance, digital phenotyping, artificial intelligence, machine learning, digital health literacy, and sustainable care. This text does not claim to be a systematic review; rather, it aims to provide a critical and integrative evaluation of the existing literature.

### **Opportunities Provided by Digital Psychiatry**

Digital psychiatry has the potential to offer solutions to certain structural problems currently present in mental health services. Geographical distance, shortage of specialists, economic difficulties, stigma, transportation problems, and long waiting times are important barriers to

accessing mental health care. Telepsychiatry and online mental health applications may increase accessibility, particularly for individuals living in rural areas, those with limited mobility, those who have difficulty attending regular appointments due to demanding working conditions, or those who are concerned about stigma associated with face-to-face psychiatric consultation (Torous et al., 2021).

Mobile applications and digital monitoring tools may enable more continuous data collection in areas such as mood changes, sleep patterns, physical activity, social interaction, medication adherence, and symptom severity. Oudin et al. (2023) state that digital phenotyping may allow data-driven inferences about mental state based on an individual's digital behavioral patterns. This approach may offer important opportunities for early warning systems, monitoring relapse risk, and developing personalized interventions.

However, these opportunities should not be evaluated solely in terms of technical capacity. The clinical benefit of digital tools should be considered together with scientific validity, patient safety, data security, clinical oversight, patient autonomy, and ethical responsibility. Otherwise, digitalization may create new vulnerabilities and inequalities rather than improving the quality of care.

### **Confidentiality, Privacy, and Data Security**

In psychiatric practice, confidentiality is not merely a legal obligation, but one of the fundamental conditions of the therapeutic relationship. Information concerning mental disorders constitutes sensitive data that may lead to consequences such as stigma, discrimination, social exclusion, disadvantages in professional life, and family-related problems. Therefore, in digital mental health practices, the nature of the data collected, how they are stored, their sharing with third parties, their commercial use, and the extent to which these processes are understood by users are of particular importance.

In their study evaluating data-sharing and privacy practices in depression and smoking cessation applications, Huckvale et al. (2019) demonstrated that many applications were not sufficiently transparent regarding the sharing of user data with third parties. This finding indicates that the mere existence of a privacy policy in digital mental health applications is not sufficient; such policies must also be understandable, accessible, transparent, and consistent with actual practices.

Informed consent is another important ethical issue in digital psychiatry. In traditional clinical settings, consent is based on a reciprocal process between the patient and the clinician involving explanation, understanding, and the opportunity to ask questions. In digital platforms, however, consent is often obtained through terms of use that are lengthy, technical, legally complex, and frequently accepted without being read by the user. Martinez-Martin and Kreitmair (2018) note that the lack of sufficient clarity in accountability, data protection, and consent processes in direct-to-consumer digital psychotherapy applications gives rise to significant ethical concerns.

Wykes et al. (2019) emphasize that ethical standards in digital mental health applications should not be limited to privacy alone, but should also include the principles of safety, effectiveness, user benefit, non-maleficence, transparency, and responsibility. This perspective suggests that ethical evaluation in digital psychiatry should begin not after an application has been released, but from the design stage onward.

The issue of confidentiality in digital psychiatry is not limited solely to the risk of data breaches. The use of collected data for commercial purposes, their transfer to advertising algorithms, risks of insurance- or employer-based discrimination, their potential accessibility in legal proceedings, and users' inability to foresee these possibilities must also be taken into account. In particular, mood records, suicidal thoughts, sleep data, location information, patterns of social interaction, and behavioral digital traces may allow highly sensitive inferences to be made about an individual's mental state. Therefore, in the clinical use of digital mental health tools, data minimization, explicit consent, comprehensible privacy policies, strong cybersecurity measures, independent ethical oversight, and regular updates should be adopted as fundamental principles.

### **Artificial Intelligence, Algorithmic Bias, and Accountability**

Artificial intelligence- and machine learning-based tools have increasingly become a central part of current discussions in digital psychiatry. These tools can be used in areas such as screening, risk classification, symptom monitoring, crisis prediction, treatment recommendation, and clinical decision support. However, the clinical use of machine learning systems may give rise to significant ethical concerns.

Char et al. (2018) emphasize that the ethical issues involved in the implementation of machine learning in health care are not limited to data security alone; algorithmic bias, transparency,

clinical responsibility, and accountability are also of fundamental importance. If algorithms are trained on limited, homogeneous datasets or on datasets that do not adequately represent certain groups, the resulting models may produce more inaccurate outcomes for minority groups, in different cultural contexts, or among individuals with complex clinical presentations. This may increase the risk of “diagnostic injustice” in digital psychiatry.

Psychiatric assessment is not based solely on the numerical classification of symptoms. A person’s life history, cultural context, relational patterns, traumatic experiences, social conditions, and affective cues observed during the clinical interview are also incorporated into the evaluation. Therefore, it would not be appropriate for artificial intelligence systems to replace human clinicians in areas that require clinical intuition, ethical responsibility, and contextual interpretation. The safest way to use these tools is to position them not as systems that automatically determine clinical decisions, but as auxiliary tools that support the clinician’s assessment.

### **Digital Phenotyping and Continuous Monitoring**

Digital phenotyping is an approach that aims to make inferences about an individual’s mental state through data obtained from smartphones, wearable technologies, and online behaviors. This model has the potential to develop early warning systems, particularly in areas such as mood disorders, psychotic disorders, and suicide risk. Oudin et al. (2023) state that digital phenotyping may create new opportunities for treatment and monitoring in psychiatry; however, they also note that this approach carries the risk of weakening the fundamental human element of psychotherapy.

Continuous monitoring may be clinically useful, but it may also create a psychological burden. The feeling of being constantly monitored may increase anxiety in some individuals, lead to excessive preoccupation with illness, or undermine their perception of privacy. In addition, it should be clearly defined which data are clinically meaningful, how false-positive alerts will be managed, who will be responsible when a crisis signal is generated, and how long these data will be stored.

Therefore, digital phenotyping should be considered not merely as a technological opportunity, but as a field of practice with clearly defined ethical and clinical boundaries. Patients should be informed in an understandable manner about which data are collected, for what purposes these

data are used, with whom they may be shared, and how they can withdraw from this process whenever they wish.

### **Therapeutic Relationship and Risks in Clinical Assessment**

In psychiatry, the therapeutic relationship is not merely an accompanying element of treatment, but one of the core components that directly determines treatment effectiveness. The patient's feeling of being understood, the establishment of a relationship of trust, the ability to express emotions, and participation in the treatment process are closely related to the therapeutic alliance. Although digital platforms do not completely eliminate this relationship, they may alter its form, intensity, and depth.

In face-to-face interviews, the clinician evaluates multiple clinical cues together, including body language, eye contact, psychomotor activity, subtle aspects of affect, rhythm of speech, pauses, environmental context, and relational transference during the interview. Some of these cues may be preserved in video consultations; however, connection problems, image quality, screen-mediated communication, the inability to control the patient's environment, and privacy concerns may affect the quality of clinical assessment. In text-based or asynchronous applications, these limitations may become even more pronounced.

Volpe et al. (2026) emphasize that if digital platforms become overly dependent on symptom checklists and structured inputs, they may carry the risk of simplifying the complexity of psychiatric conditions. Psychiatric diagnosis is not merely the sum of symptoms; context, history, cultural meaning, interpersonal functioning, and clinical intuition are also part of the assessment process. Therefore, while digital tools may be useful in assuming a supportive role in diagnosis and monitoring, their use as substitutes for clinicians may lead to clinical errors.

Chatbots and artificial intelligence-supported platforms may facilitate access and provide psychoeducation for some users. However, these tools cannot replace the empathic, contextual, and ethically responsible position of the human clinician. Particularly in clinical conditions such as suicide risk, psychotic symptoms, complex trauma history, substance use, severe depression, or severe personality organization, interventions based solely on digital tools may remain insufficient. Therefore, digital psychiatry should be designed as a complementary model of care that does not reduce human contact, but strengthens it when needed.



### **Patient Autonomy and the Right to Choose the Mode of Service**

One important dimension of the ethical debate in digital psychiatry is patient autonomy. Although the ability of digital services to increase access is valuable, patients should be able to make realistic and informed choices between digital and face-to-face service options. Trachsel and Sedlakova (2022) emphasize the ethical importance of the patient's autonomous choice between telepsychiatry and face-to-face treatment.

While some patients may find digital consultations more accessible and comfortable, others may need the reassuring quality of an in-person therapeutic relationship. Particularly in cases of severe mental disorders, cognitive limitations, situations in which privacy cannot be ensured in the home environment, difficulties in using digital tools, or among patients who perceive face-to-face interaction as more reliable for cultural reasons, maintaining access to face-to-face services is an ethical necessity. In this context, the ideal model is a blended care approach in which digital and face-to-face services do not exclude one another, but are integrated according to the patient's clinical needs.

### **Digital Inequality and Digital Health Literacy**

One of the most important risks of digital psychiatry is the possibility that it may reproduce existing inequalities in health care rather than reduce them. The fact that digital services are theoretically available to everyone does not mean that everyone can benefit from these services equally. Internet access, device ownership, digital skills, health literacy, age, income level, education, language, and cultural context are important factors that determine the capacity to benefit from digital services.

Strudwick et al. (2026) state that digital mental health technologies are becoming increasingly embedded in routine psychiatric care; however, patients, clinicians, and health systems do not always have the necessary skills and confidence to use these tools safely and effectively. Even when individuals with severe mental illness own digital devices, deficiencies in basic digital skills may persist. With the expansion of digital services, this situation may lead to further exclusion of certain patient groups from the care system.

Therefore, sustainability in digital psychiatry is possible not only through access to technology, but also through the development of digital health literacy. Patients should be able to understand how applications are used, in which situations professional help is required, how their data are

processed, and what the limitations of digital tools are. Clinicians, in turn, should be able to evaluate the reliability of these tools, their suitability for the target patient group, and the patient's level of digital competence when prescribing or recommending digital tools.

### **Cultural Sensitivity and Clinical Adaptation**

A significant proportion of digital mental health tools are built upon Western-centered assessment models, linguistic assumptions, and cultural norms. However, the ways in which psychological distress is expressed, help-seeking behaviors, family and community relationships, perceptions of privacy, and the meanings attributed to treatment may vary across cultures. If standardized digital tools overlook these differences, the risk of misassessment or inadequate intervention may increase.

For digital psychiatry to be culturally safe, translation alone is not sufficient. Content should be adapted to the local cultural context, user feedback should be obtained, different socioeconomic groups should be involved in the design process, and clinical assessment tools should be tested for cultural validity. Otherwise, rather than universalizing mental health services, digitalization may turn into a structure that is more suitable for certain groups while becoming more exclusionary for others.

### **Sustainability: Clinical, Ethical, and Institutional Dimensions**

The sustainability of digital psychiatry does not depend solely on the technical functionality of platforms. Sustainability requires the combined assurance of clinical effectiveness, ethical reliability, economic feasibility, user acceptance, regulatory oversight, and professional integration. The fact that an application increases access in the short term does not necessarily mean that it is safe and effective in the long term.

For digital mental health tools to be used sustainably, their scientific validity must first be demonstrated. Applications that are not evidence-based, not regularly updated, or not subject to clinical oversight may pose risks to patient safety. In addition, how these applications will be integrated into the care system, who will be responsible in emergencies, who will monitor the data, and how the data will be transferred to clinicians should be clearly defined.

The ethical standards approach emphasized by Wykes et al. (2019) indicates that digital mental health applications should not be left solely to the initiative of technology companies. Clinical experts, ethicists, patient representatives, software developers, legal professionals, and

policymakers should work together. Without such interdisciplinary collaboration, it is difficult for digital psychiatry to develop in a reliable and sustainable manner.

Clinician training is one of the important components of sustainability. Psychiatrists and mental health professionals should know not only how to use digital tools technically, but also the limitations of these tools, their ethical risks, the dimensions of data security, and how they should be integrated into clinical decision-making processes. Similarly, patients should be informed about what digital applications can provide, in which situations they may remain insufficient, and how their data will be used.

## **DISCUSSION**

Digital psychiatry is becoming an inevitable component of contemporary mental health services. However, the rapid expansion of this transformation does not necessarily mean that the ethical and clinical framework is developing at the same pace. The main warning highlighted in the literature is that the potential benefits of digital tools become meaningful only when accompanied by careful regulation, clinical oversight, data security, cultural sensitivity, and digital literacy (Char et al., 2018; Martinez-Martin & Kreitmair, 2018; Strudwick et al., 2026; Wykes et al., 2019).

In this context, three fundamental balances should be considered in digital psychiatry practices. The first is the balance between access and quality. Digital tools may facilitate access to services; however, this convenience should not reduce the quality of clinical assessment. The second is the balance between innovation and safety. The use of new technologies may be encouraged; nevertheless, scientific validity, privacy, data security, and patient safety should not be relegated to a secondary position. The third is the balance between automation and human relationship. Artificial intelligence and digital systems may support clinical processes; however, they should not replace the human relationship at the center of psychiatric care.

The future of digital psychiatry will depend not so much on how advanced the technology becomes, but on the ethical principles, clinical standards, and sense of social responsibility with which this technology is used. Therefore, digitalization should not be regarded simply as an inevitable progress in mental health services, but as a clinical and ethical transformation that must be carefully managed.

## **CONCLUSION**

Digital psychiatry offers important opportunities for increasing access to mental health services, strengthening continuity of care, and improving the possibilities for personalized care. However, these opportunities cannot be evaluated without considering the risks that emerge in the areas of confidentiality, the therapeutic relationship, and sustainability. The protection of sensitive mental health data, the establishment of transparent informed consent processes, the maintenance of the therapeutic alliance, the prevention of algorithmic bias, the reduction of digital inequalities, and the assurance of cultural sensitivity are fundamental conditions for the ethical and clinical validity of digital psychiatry.

In this regard, digital mental health applications should be evaluated in terms of scientific validity and data security; patients should be offered the opportunity to make autonomous choices between digital and face-to-face services; clinicians should be trained on the ethical, technical, and clinical limitations of digital tools; and digital health literacy programs should be developed in a way that includes vulnerable groups in particular. In addition, applications of artificial intelligence, machine learning, and digital phenotyping should be positioned as supportive tools in clinical decision-making processes, rather than being presented as independent treatment models that replace human interaction.

In conclusion, digital psychiatry should be developed not as a substitute model that weakens human contact, but as a complementary model of care that is bounded by ethical principles and integrated with clinical quality. Without preserving clinical trust, patient privacy, and long-term sustainability, it does not seem possible for digitalization to fully provide the expected benefits in the field of mental health.

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## A REVIEW OF MASTER’S THESES IN THE FIELD OF LIFE KINEMATICS IN TÜRKİYE

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### ABSTRACT

The purpose of this study is to systematically examine graduate theses conducted in the field of life kinetics in Türkiye. The study was designed within a qualitative research framework and employed document analysis as the primary data collection method, along with content analysis as the analytical technique. As a result of the literature review, a total of 52 master’s and doctoral theses related to life kinetics in Türkiye were identified. However, in order to ensure homogeneity and increase the generalizability of the findings, the sample was limited to 41 theses focusing on children with typical development. The theses were analyzed with respect to type, year of publication, university, institute, department, developmental domains, and study group characteristics. The findings revealed that the majority of the theses were conducted at the master’s level. In terms of publication year, the highest concentration of theses was observed in 2024. Mersin University was identified as the leading institution in terms of thesis production, while the Institute of Health Sciences and the Department of Physical Education and Sports emerged as the most prominent institute and department, respectively. With regard to research methodology, all of the examined theses employed qualitative research methods. In terms of developmental domains addressed within the scope of life kinetics, motor and cognitive development were found to be the most frequently studied areas. Furthermore, the findings indicated that the studies predominantly focused on children aged between 10 and 14 years. In conclusion, it is suggested that future research should expand into diverse fields and place greater emphasis on different developmental domains, particularly within the context of early childhood. Such efforts are expected to make substantial contributions to both child development and the existing body of literature.

**Keywords:** Life kinetics, Brain-based movement exercises, Children.

### TÜRKİYE’DE LİFE KİNETİK ALANINDA YAPILMIŞ LİSANSÜSTÜ TEZLERİN İNCELENMESİ

#### ÖZET

Bu çalışmanın amacı, Life Kinetik alanında Türkiye’de yapılan lisansüstü tezlerin incelenmesidir. Nitel bir desenle yürütülen araştırmada doküman analizi yöntemi ve içerik analizi tekniği kullanılmıştır. Araştırma kapsamında yapılan taramada Life Kinetik alanında Türkiye’de yapılmış toplam 52 yüksek lisans ve doktora tezine ulaşılmıştır. Ancak çalışmaya, homojenlik sağlamak ve bulguların genellenebilirliğini artırmak amacıyla örnekleme, tipik gelişim gösteren çocuklardan oluşan toplam 41 yüksek lisans ve doktora tezi dahil edilmiştir. Lisansüstü tezler ‘tür, yayınlanan yıl, üniversite, enstitü, anabilim dalı, gelişim alanları ve çalışma grubu’ bakımından incelenmiştir. Araştırma bulguları, en çok yüksek lisans düzeyinde tez hazırlandığını, yıllara göre değerlendirildiğinde ise yayınlanan yıl açısından en fazla 2024 yılında yoğunlaştığını göstermektedir. Tez üretiminin en fazla olduğu üniversite Mersin Üniversitesi iken, enstitüler açısından Sağlık Bilimleri Enstitüsü; anabilim dalı açısından ise Beden Eğitimi ve Spor Anabilim Dalı öne çıkmaktadır. Araştırma yöntemleri açısından, tezlerin tümünde nitel araştırma yöntemi kullanılmıştır. Lisansüstü tezlerin Life Kinetik ile ilgili gelişim alanlarına bakıldığında, motor ve bilişsel gelişim alanında çalışmalar öne çıkmaktadır. Çalışmaların en çok yoğunlaştığı yaş aralığının da 10-14 yaş arası olduğu belirlenmiştir. Sonuç olarak, farklı alanlarda yapılacak çalışmalar ve odaklanılacak gelişim alanları ile okul öncesi dönem kapsamında yapılacak çalışmaların, çocuk gelişimine ve alanyazına önemli katkılar sağlayacağı düşünülmektedir.

**Anahtar Kelimeler:** Life kinetik, Kinetik beyin egzersizleri, Çocuk.

## GİRİŞ

Horst Lutz tarafından 2008 yılında geliştirilen Life Kinetik, fiziksel hareketleri zihinsel zorluklarla birleştiren, yüksek konsantrasyon ve algı becerilerine odaklanan yenilikçi bir eğitim programıdır. Temel prensibi, çapraz el hareketleri, adımlama veya bilişsel komutlar gibi bir hareket becerisi tam olarak öğrenilmeden hemen bir üst seviyedeki karmaşık görevlerle yer değiştirerek beyni sürekli yeni durumlara uyum sağlamaya zorlamaktır. Engelleyici kontrol mekanizmasını tetikleyen ve doğal hareket dürtülerinin aksine tepki vermeyi gerektiren bu egzersizler ile görsel algının, koordinasyonun ve bilişsel esnekliğin artırılması hedeflenir (Grünke, 2011). Özellikle tipik gelişim gösteren çocuklarda, fiziksel yorgunluktan ziyade zihinsel yorgunluğu hedefleyen Life Kinetik ile beynin farklı bölgeleri arasındaki bağlantıların arttığı; bunun sonucunda çocukların hem denge ve koordinasyon gibi motor becerilerinde hem de dikkat, hafıza ve problem çözme gibi bilişsel işlevlerinde ilerleme sağlandığı bilinmektedir (Vural, 2016; Büyüктаş, 2021; Çimen, 2021; Kurt, 2022; Yılmaz, 2022; Aktaş, 2023; Benlikara, 2023; Tapşın, 2023; Aydın, 2024; Boyanmış, 2024; Gökbel, 2024; Koyun, 2024; Şirin, 2024; Taş, 2024; Töraydın, 2025; Yılmaz, 2025). Nitekim, bu çalışmanın bulguları da alanyazındaki bu eğilimi yansıtarak Türkiye’de Life Kinetik alanında yapılan lisansüstü çalışmaların tipik gelişim gösteren çocuklarda en çok motor ve bilişsel gelişim alanlarına odaklandığını ortaya koymaktadır.

Türkiye’de özellikle 2024 yılına gelindiğinde Life Kinetik alanındaki lisansüstü tezlerde bir yoğunlaşma olduğu görülmektedir. Bu durumda Life Kinetik alanının giderek artan bir ilgi alanı olduğu söylenebilir. Konu ile ilgili çalışmaların sayısı artmasına rağmen, bu verileri bir araya getiren ve genel tabloyu ortaya koyan sistematik bir değerlendirmenin olmaması alanyazın açısından önemli bir eksiklik olarak görülmüştür. Bu bağlamda, literatürdeki henüz sentezlenmemiş bulguları ortak bir paydada buluşturmak amacıyla gerçekleştirilen bu çalışma, mevcut eksikliği tamamlamayı hedeflemektedir. Yukarıdaki bilgilerden hareketle bu çalışmanın amacı, Life Kinetik alanında Türkiye’de yapılan lisansüstü tezlerin incelenmesidir.

## MATERYAL VE METOT

### Araştırma Deseni

Bu araştırma, Türkiye’de Life Kinetik alanında çocuk örneklemiyle yapılmış lisansüstü tezlerin yapısal, metodolojik ve içeriksel eğilimlerini ortaya koymayı amaçlayan nitel araştırma yaklaşımlarından doküman analizi modeline göre tasarlanmıştır. Doküman analizi; araştırılması

hedeflenen olgu, olay veya süreçler hakkında bilgi barındıran yazılı belgelerin sistematik olarak taranması, sınıflandırılması ve analitik olarak çözümlenmesi sürecini ifade eder (Creswell, 2002). Bu çalışmada elde edilen veriler nitel bir yöntem olan doküman incelemesi ile toplanmış, ancak sunumunda ve genel eğilimlerin somutlaştırılmasında frekans ve yüzde dağılımları kullanılarak betimsel istatistiklerden yararlanılmıştır.

### **Veri Toplama Süreci**

Araştırmanın verileri Yükseköğretim Kurulu Ulusal Tez Merkezi (YÖKTEZ) veri tabanı kullanılarak toplanmıştır. Veri tabanının sunulduğu ekranda yer alan detaylı arama parametreleri yardımıyla “Life Kinetik” alanında yapılmış, taramalar “life kinetik” ve “kinetik beyin egzersizleri” çerçevesinde; aranacak alan kısmı “tümü” seçilerek ve konunun yeni olması sebebiyle herhangi bir yıl aralığı tercih edilmeden yapılmıştır. Taramanın sonucunda toplam 52 yüksek lisans ve doktora tezine ulaşılmıştır.

Bu çalışmada, sadece çocuklar üzerinden yapılan tezler incelenmiş, ancak gelişim süreçlerinin farklılıkları sebebiyle bulguların genellenebilirliğini artırmak ve veri setinde homojenliği sağlamak amacıyla özel gereksinimli çocuklar hariç tutulmuştur. Çalışma, erişim izni olan ve örnekleme tipik gelişim gösteren çocukları kapsayan toplam 41 lisansüstü ve doktora tezinden oluşmaktadır.

### **Verilerin Analizi**

İnceleme kapsamına alınan yüksek lisans ve doktora tezleri analiz kriterleri doğrultusunda yayın inceleme formu oluşturularak, tezlere ilişkin olarak yayınlanan tür, yayınlanan yıl, üniversite, enstitü, anabilim dalı, gelişim alanları ve çalışma grubu bakımından incelenmiştir. Doküman analizi, araştırmada incelenen olgu veya olaylarla ilişkili bilgiler içeren yazılı belgelerin ayrıntılı olarak taranması ve bu belgelerle ilişkili yeni bir bütünlük oluşturulması olarak adlandırılır (Creswell, 2002). Doküman incelemesine dayalı olarak gerçekleştirilen bu araştırmada içerik analizi yöntemi kullanılmıştır. İçerik analizi, sözel, yazılı ve diğer bilimsel çalışmaların nesnel ve sistematik bir biçimde sınıflandırılmasını ve değerlendirilmesini sağlayan bir yöntem olarak kabul edilmektedir (akt. Sarıgül,2020). Araştırmanın bulguları ise frekans ( $n$ ) ve yüzde (%) gibi betimsel istatistik teknikleri yardımıyla sunulmuştur.



## BULGULAR

Bu araştırma kapsamında elde edilen veriler yayınlanan tür, yıl, üniversite, enstitü, anabilim dalı, çalışma grubu/örneklem, araştırma yöntemi, çalışma konuları ve yöntem bakımından incelenerek aşağıda sunulmuştur.

**Tablo 1.** Lisansüstü Tezlerin Türüne Göre Dağılımı

| Tez Türü      | <i>n</i>  | %           |
|---------------|-----------|-------------|
| Yüksek Lisans | 31        | %75.61      |
| Doktora       | 10        | %24.39      |
| <b>Toplam</b> | <b>41</b> | <b>%100</b> |

Tablo 1 incelendiğinde, yüksek lisans ( $n=31$ , %75.61) programında hazırlanan tez türlerinin doktora ( $n=10$ , %24.39) oranla daha fazla olduğu görülmektedir.

**Tablo 2.** Lisansüstü Tezlerin Yıllara Göre Dağılımı

| Yayınlandığı Yıl | Yüksek Lisans |             | Doktora   |             |
|------------------|---------------|-------------|-----------|-------------|
|                  | <i>n</i>      | %           | <i>n</i>  | %           |
| 2014             | 1             | %3.23       | -         | -           |
| 2016             | 1             | %3.23       | -         | -           |
| 2017             | -             | -           | 1         | %10.00      |
| 2019             | 4             | %12.90      | -         | -           |
| 2021             | 2             | %6.45       | 2         | %20.00      |
| 2022             | 4             | %12.90      | 1         | %10.00      |
| 2023             | 6             | %19.35      | 2         | %20.00      |
| 2024             | 9             | %29.03      | 1         | %10.00      |
| 2025             | 4             | %12.91      | 3         | %30.00      |
| <b>Toplam</b>    | <b>31</b>     | <b>%100</b> | <b>10</b> | <b>%100</b> |

Tablo 2'ye bakıldığında, en fazla yüksek lisans tezinin 2024 yılında ( $n=9$ , %29.03), doktora tezinin ise 2025 yılında ( $n=3$ , %30) yayınlandığı görülmektedir. 2015, 2018 ve 2020 yıllarında konu ile ilgili herhangi bir tezin yayınlanmamış olması dikkat çekici bir bulgudur.

**Tablo 3.** Lisansüstü Tezlerin Üniversitelere Göre Dağılımı

| Hazırlandığı Üniversite                | Yüksek Lisans |       | Doktora  |        |
|----------------------------------------|---------------|-------|----------|--------|
|                                        | <i>n</i>      | %     | <i>n</i> | %      |
| Amasya Üniversitesi                    | 1             | %3.23 | -        | -      |
| Ankara Yıldırım Beyazıt Üniversitesi   | 1             | %3.23 | -        | -      |
| Atatürk Üniversitesi                   | 1             | %3.23 | -        | -      |
| Bayburt Üniversitesi                   | -             | -     | 1        | %10.00 |
| Bitlis Eren Üniversitesi               | 1             | %3.23 | -        | -      |
| Burdur Mehmet Akif Ersoy Üniversitesi. | 1             | %3.23 | 1        | %10.00 |
| Bursa Uludağ Üniversitesi              | 1             | %3.23 | -        | -      |

|                                           |           |             |           |             |
|-------------------------------------------|-----------|-------------|-----------|-------------|
| Çanakkale Onsekiz Mart Üniversitesi       | 1         | %3.23       | -         | -           |
| Çukurova Üniversitesi                     | 1         | %3.23       | 1         | %10.00      |
| Dokuz Eylül Üniversitesi                  | 1         | %3.23       | -         | -           |
| Erzincan Binali Yıldırım Üniversitesi     | 2         | %6.45       | -         | -           |
| Gazi Üniversitesi                         | 2         | %6.45       | 1         | %10.00      |
| Harran Üniversitesi                       | 1         | %3.23       | -         | -           |
| Hitit Üniversitesi                        | 1         | %3.23       | 1         | %10.00      |
| İnönü Üniversitesi                        | 1         | %3.23       | -         | -           |
| İstanbul Arel Üniversitesi                | 1         | %3.23       | -         | -           |
| İstanbul Gelişim Üniversitesi             | 1         | %3.23       | -         | -           |
| Kırşehir Ahi Evran Üniversitesi           | 1         | %3.23       | -         | -           |
| Kocaeli Üniversitesi                      | -         | -           | 1         | %10.00      |
| Kütahya Dumlupınar Üniversitesi           | 1         | %3.23       | 2         | %20.00      |
| Mersin Üniversitesi                       | 3         | %9.68       | 1         | %10.00      |
| Muğla Sıtkı Koçman Üniversitesi           | -         | -           | 1         | %10.00      |
| Ondokuz Mayıs Üniversitesi                | 2         | %6.45       | -         | -           |
| Ordu Üniversitesi                         | 1         | %3.23       | -         | -           |
| Sakarya Uygulamalı Bilimler Üniversitesi. | 1         | %3.23       | -         | -           |
| Selçuk Üniversitesi                       | 1         | %3.23       | -         | -           |
| Trabzon Üniversitesi                      | 1         | %3.23       | -         | -           |
| Trakya Üniversitesi                       | 1         | %3.23       | -         | -           |
| Van Yüzüncü Yıl Üniversitesi              | 1         | %3.23       | -         | -           |
| <b>Toplam</b>                             | <b>31</b> | <b>%100</b> | <b>10</b> | <b>%100</b> |

Tablo 3 incelendiğinde, yüksek lisansta Mersin Üniversitesi ( $n=3$ , %9.68) öne çıkarken, doktora da Kütahya Dumlupınar Üniversitesi ( $n=2$ , %20) öne çıkmaktadır.

**Tablo 4.** Lisansüstü Tezlerin Enstitüye Göre Dağılımı

| Enstitü                                  | Yüksek Lisans |             | Doktora   |             |
|------------------------------------------|---------------|-------------|-----------|-------------|
|                                          | <i>n</i>      | %           | <i>n</i>  | %           |
| Eğitim Bilimleri Enstitüsü               | 6             | %19.35      | 2         | %20.00      |
| Sağlık Bilimleri Enstitüsü               | 13            | %41.94      | 5         | %50.00      |
| Sosyal Bilimler Enstitüsü                | 1             | %3.23       | -         | -           |
| Lisansüstü Eğitim Enstitüsü              | 10            | %32.25      | 3         | %30.00      |
| Kış Sporları ve Spor Bilimleri Enstitüsü | 1             | %3.23       | -         | -           |
| <b>Toplam</b>                            | <b>31</b>     | <b>%100</b> | <b>10</b> | <b>%100</b> |

Enstitü kapsamında bakıldığında hem yüksek lisans ( $n=13$ , %41.94) hem doktora ( $n=5$ , %50) yapılan çalışmaların en fazla Sağlık Bilimleri Enstitüsü'nde yapılmış olduğu görülmektedir.

**Tablo 5.** Lisansüstü Tezlerin Anabilim Dalına Göre Dağılımı

| Anabilim Dalı                       | Yüksek Lisans |             | Doktora   |             |
|-------------------------------------|---------------|-------------|-----------|-------------|
|                                     | <i>n</i>      | %           | <i>n</i>  | %           |
| Antrenman ve Hareket Anabilim Dalı  | 3             | %9.68       | -         | -           |
| Antrenörlük Anabilim Dalı           | 2             | %6.45       | -         | -           |
| Antrenörlük Eğitimi Anabilim Dalı   | 4             | %12.90      | -         | -           |
| Beden Eğitimi ve Spor Anabilim Dalı | 19            | %61.29      | 10        | %100        |
| Psikoloji Anabilim Dalı             | 1             | %3.23       | -         | -           |
| Rekreasyon Eğitimi Anabilim Dalı    | 1             | %3.23       | -         | -           |
| Rekreasyon Yönetimi Anabilim Dalı   | 1             | %3.23       | -         | -           |
| <b>Toplam</b>                       | <b>31</b>     | <b>%100</b> | <b>10</b> | <b>%100</b> |

Tablo 5'teki lisansüstü tezlerin anabilim dalı dağılımına bakıldığında, yüksek lisansta Beden Eğitimi ve Spor Bilim Dalı'nın ( $n=19$ , %61.29) öne çıktığı, doktora ise sadece Beden Eğitimi ve Spor Anabilim Dalı kapsamında çalışma ( $n=10$ , %100) yapıldığı görülmektedir.

**Tablo 6.** Lisansüstü Tezlerin Life Kinetik ile İlişkili Gelişim Alanlarının Dağılımı

| Gelişim Alanı                             | Yüksek Lisans |             | Doktora   |             |
|-------------------------------------------|---------------|-------------|-----------|-------------|
|                                           | <i>n</i>      | %           | <i>n</i>  | %           |
| Motor ve Bilişsel Gelişim                 | 12            | %38.71      | 4         | %40.00      |
| Motor Gelişim                             | 14            | %45.16      | 1         | %10.00      |
| Motor ve Fiziksel Gelişim                 | 3             | %9.68       | -         | -           |
| Motor ve Psikolojik Gelişim               | 2             | %6.45       | 1         | %10         |
| Bilişsel Gelişim                          | -             | -           | 2         | %20         |
| Bilişsel ve Psikolojik Gelişim            | -             | -           | 1         | %10         |
| Nörofizyolojik, Bilişsel ve Motor Gelişim | -             | -           | 1         | %10         |
| <b>Toplam</b>                             | <b>31</b>     | <b>%100</b> | <b>10</b> | <b>%100</b> |

Tablo 6 incelendiğinde, Life Kinetik çalışmalarının en çok çalışılan alanların yüksek lisansta motor gelişim ( $n=14$ , %45.16) ve hemen ardından motor ve bilişsel gelişim ( $n=12$ , %38.71) , doktora ise motor ve bilişsel gelişim ( $n=4$ , %40) alanları olduğu görülmüştür.

**Tablo 7.** Lisansüstü Tezlerde Çalışılan Yaş Aralıkları

| Yaş Aralıkları | Lisansüstü Tezler |       |
|----------------|-------------------|-------|
|                | <i>n</i>          | %     |
| 10-11 Yaş      | 1                 | %2.44 |
| 10-12 yaş      | 2                 | %4.88 |
| 10-14 Yaş      | 3                 | %7.32 |

|               |           |             |
|---------------|-----------|-------------|
| 11-12 Yaş     | 1         | %2.44       |
| 11-13 Yaş     | 3         | %7.32       |
| 11-14 Yaş     | 3         | %7.32       |
| 12 Yaş        | 2         | %4.88       |
| 12-13 Yaş     | 2         | %4.88       |
| 12-14 Yaş     | 2         | %4.88       |
| 12-17 Yaş     | 1         | %2.44       |
| 13-15 Yaş     | 1         | %2.44       |
| 13-17 Yaş     | 1         | %2.44       |
| 13-18 Yaş     | 1         | %2.44       |
| 14-15 Yaş     | 2         | %4.88       |
| 14-16 Yaş     | 1         | %2.44       |
| 14-17 Yaş     | 1         | %2.44       |
| 14-19 Yaş     | 1         | %2.44       |
| 15-18 Yaş     | 1         | %2.44       |
| 17-18 Yaş     | 1         | %2.44       |
| 6-10 Yaş      | 2         | %4.88       |
| 6-12 Yaş      | 1         | %2.44       |
| 6-9 Yaş       | 1         | %2.44       |
| 8-12 Yaş      | 1         | %2.44       |
| 8-17 Yaş      | 1         | %2.44       |
| 9-11 Yaş      | 1         | %2.44       |
| 9-13 Yaş      | 2         | %4.88       |
| 9-16 Yaş      | 1         | %2.44       |
| <b>Toplam</b> | <b>41</b> | <b>%100</b> |

Tablo 7 incelendiğinde, lisansüstü tezlerin farklı yaş aralıkları üzerinde dağılım gösterdiği görülmektedir. Lisansüstü tezlerin yaş aralıklarına bakıldığında, en fazla tercih edilen çocukların 10 yaş ile 14 yaş aralığındaki çocuklar olduğu tespit edilmiştir.

## TARTIŞMA VE SONUÇ

Bu çalışmanın amacı, life kinetik alanında Türkiye’de yapılan lisansüstü tezlerin incelenmesiydi. Çalışmaların yüksek lisans tezlerine oranla doktora düzeyinde oldukça yetersiz olduğu sonucuna varılmıştır (Tablo 1). Araştırmacıların doktora tezi düzeyinde daha derinlemesine ve uzun soluklu çalışma yapması, bu alandaki eksikliğin giderilmesine yardımcı olacaktır. Yapılan çalışmaların 2024 yılında yoğunlaşması (Tablo 2), Life Kinetik konusunun Türkiye literatüründe henüz çok yeni olduğunu ve zaman içerisinde Life Kinetik alanına ilginin giderek artacağını gösterir niteliktedir.

Yapılan sistematik inceleme sonucunda en fazla tezin Mersin Üniversitesi’nde üretildiği görülmektedir (Tablo 3). Çalışılan enstitü ve anabilim dalı kapsamında ise en çok Sağlık

Bilimleri Enstitüsü'nde (Tablo 4) ve Beden Eğitimi ve Spor Anabilim Dalı'nda (Tablo 5) çalışma yapıldığı tespit edilmiştir. Çalışmaların odaklandıkları gelişim alanlarına bakıldığında, en çok motor ve bilişsel gelişim ilişkili gelişim alanında çalışma yapıldığı, bunu takiben motor gelişim alanında çalışmaların olduğu dikkat çekici bir bulgudur (Tablo 6). Bu durum, Türkiye'de yapılan tezlerin Life Kinetik kapsamında çoğunlukla bir "spor ve fiziksel aktivite" disiplini olarak ele alındığını gösterir. Life Kinetik çalışma alanı sadece spor veya fiziksel bir aktivite değil, aynı zamanda bilişsel esneklik, engelleyici kontrol, dikkat ve hafıza gibi bilişsel süreçleri kapsayan psikolojik ve gelişimsel çıktılara sahip bir çalışma alanıdır. Life Kinetik çalışmalarının bilişsel ve psikolojik gelişime de etki etmesi sebebiyle, Eğitim Bilimleri, Psikoloji gibi anabilim dalları ile özellikle Çocuk Gelişimi bilim dalında eksiklik olduğu düşünülmektedir. Farklı alanlara yönelim, eksikliklerin giderilmesi açısından önem arz etmektedir. Bir başka bulgu, çalışmaların en çok 10 yaş ile 14 yaş aralığına yoğunlaşmış olmasıdır (Tablo 7). Motor ve bilişsel gelişimin en hızlı olduğu, beyin plastisitesinin en yüksek olduğu okul öncesi dönem kapsamında yazılmış herhangi bir tezin olmaması, Life Kinetik alanında göze çarpan önemli bir eksikliğin varlığını göstermektedir. Sonuç olarak, farklı alanlarda yapılacak çalışmalar ve odaklanılacak gelişim alanları ile okul öncesi dönem kapsamında yapılacak çalışmaların, çocuk gelişimine ve alanyazına önemli katkılar sağlayacağı düşünülmektedir.

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## EUROPEAN-BASED CARBON REDUCTION METHODS FOR THE CEMENT SECTOR IN ACHIEVING 2050 NET ZERO EMISSION TARGETS: A COMPILATION OF SCENARIOS AND CASES

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### ABSTRACT

The imperative to decarbonize heavy industries is at the forefront of the European Green Deal's net-zero agenda. Accounting for approximately 8% of global anthropogenic CO<sub>2</sub> emissions, the cement sector remains one of the most challenging, yet critical, industries to transform. This study critically analyzes the role, economic viability, and inherent limitations of energy efficiency measures within the European cement manufacturing landscape. By evaluating various efficiency scenarios, the research assesses near-term electricity and fuel saving potentials alongside their corresponding emission reduction rates. The findings indicate that retrofitting existing facilities with modern interventions—such as waste heat recovery systems, high-efficiency grinding mills, and advanced thermal process optimization yields substantial and cost-effective energy savings. However, the study identifies a definitive structural ceiling to these conventional measures. Because the majority of the sector's carbon footprint stems from unavoidable chemical process emissions during the calcination of limestone for clinker production, thermal and electrical efficiency alone cannot deliver absolute carbon neutrality. Consequently, the research underscores the indispensable role of developing and scaling Carbon Capture, Utilization, and Storage (CCUS) technologies to address these residual emissions. The transition is further contextualized within the regulatory pressures of the EU's "Fit for 55" package, highlighting how the revised Emissions Trading System (ETS) and the Carbon Border Adjustment Mechanism (CBAM) serve as primary economic drivers accelerating this industrial shift. Ultimately, the study demonstrates that while energy efficiency is a foundational and financially prudent first step, achieving final climate targets demands a holistic strategy portfolio. This includes the widespread adoption of supplementary cementitious materials, alternative clinker chemistries, and robust circular economy principles. The paper concludes by urging EU policymakers to mitigate investment risks through targeted R&D incentives, cross-border infrastructure development, and cohesive regulatory support.

**Keywords:** Cement; Energy Efficiency; Net Zero; CCS; Green Deal.

### INTRODUCTION

Cement, one of the symbolic materials of industrialization, forms the foundation of modern infrastructure; however, it contributes significantly to global climate change due to the high energy intensity of its production process and chemical emissions. Annual cement production exceeds 4 billion tons (Miller and Myers, 2019). The fact that the resulting carbon dioxide (CO<sub>2</sub>)

emissions constitute approximately 5-8% of total global human-caused emissions (Chen et al., 2022) has made the sector a focal point of climate policies and sustainability research. The 2050 net zero emission targets established under the Paris Agreement mandate urgent and radical measures for energy-intensive and "hard-to-abate" sectors like cement (Watari et al., 2022).

In this context, energy efficiency is one of the first strategies resorted to by the sector, providing a dual benefit by reducing both operational costs and emissions. Historically, improvements in production processes (development of thermal systems, waste heat recovery, etc.) have provided significant savings. However, as the thermodynamic limits of the process are approached, the marginal benefits to be obtained from these measures are expected to decrease. As shown in Figure 1 below, approximately 60-65% of CO<sub>2</sub> emissions in cement production originate from chemical reactions during the calcination of limestone ( $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ ), while the others stem from fuel used in heating and other operational processes (Obrist et al., 2021). These "process emissions" cannot be eliminated simply by changing the energy source or increasing efficiency (Benhelal et al., 2021).

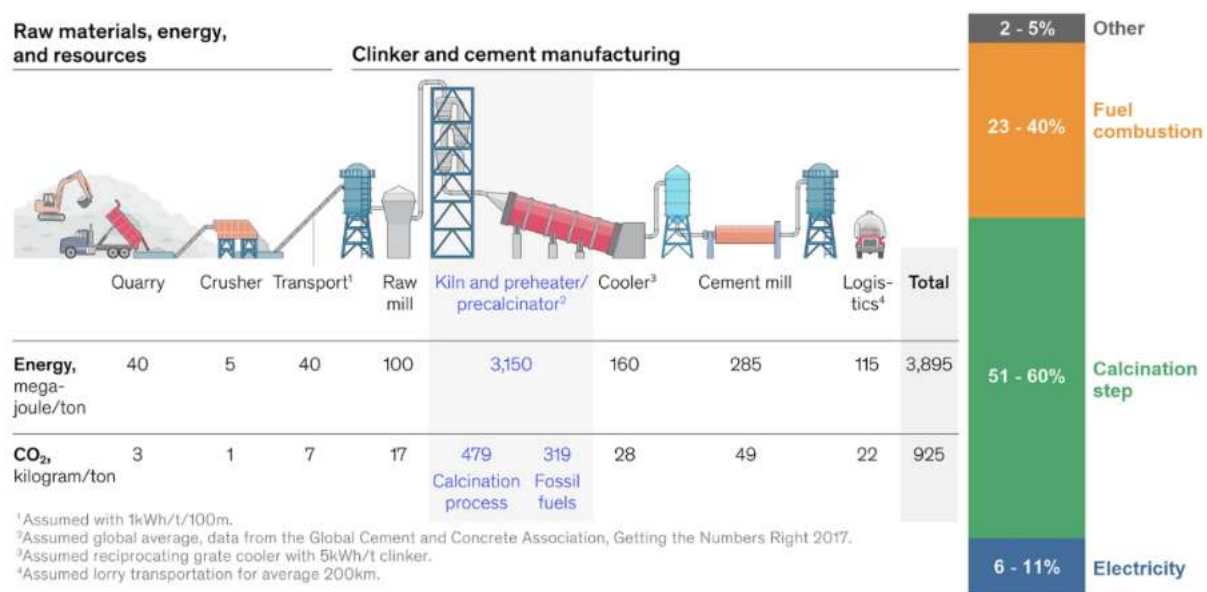


**Figure 1.** Amounts of emissions arising from cement production (Volaity et al., 2025).

This study seeks answers to two fundamental questions by deeply examining energy efficiency scenarios and case studies in the existing literature: First, to what extent do traditional energy efficiency measures contribute to 2030 and 2050 targets in regions with different levels of economic and technological development? Second, at the point where these measures fall short, which complementary and innovative strategies (CCUS, alternative binders, etc.) are

necessary for the sector to reach the net zero target? The study also evaluates the transformative effect of legal regulations such as the European Union's (EU) European Green Deal and the "Fit for 55" package on the sector and points to the importance of global policy transfer (Wurzel et al., 2023).

## **MATERIALS AND METHODS**

This review study covers research articles published in academic indices such as Scopus, Web of Science, and Google Scholar between 2021 and 2025, focusing on energy efficiency, emission reduction scenarios, and decarbonization roadmaps in the cement sector. In the selection of studies, criteria such as establishing a clear link with net zero emission targets, containing quantitative scenario analysis or case studies, and being published in peer-reviewed journals were observed. The examined studies were analyzed comparatively in terms of energy saving potential, CO<sub>2</sub> reduction rate, implementation cost, and regional context; and were supported by roadmaps published by industry associations (CEMBUREAU, GCCA) and international organizations (IEA) (GCCA, 2022).

## **RESULTS AND DISCUSSION**

### **Energy Efficiency Scenarios: Regional Case Analyses**

Current studies in the literature reveal the potential and limits of energy efficiency measures in different geographies. The study by Obrist et al. (2021), a long-term scenario analysis for the Swiss cement industry, demonstrated that with energy efficiency and partial decarbonization strategies, energy consumption could decrease from 3.0 GJ/ton cement in 2015 to 2.3 GJ/ton in 2050, and emission intensity from 579 kgCO<sub>2</sub>/ton to 466 kgCO<sub>2</sub>/ton. However, the study emphasizes that process emissions must be addressed to reach Paris Agreement goals, and at this point, CO<sub>2</sub> capture technologies play a key role (Obrist et al., 2021).

The study by Georgiades et al. (2023) performed a prospective life cycle assessment (prospective LCA) for European cement production, modeling the potential of measures to be applied gradually under different scenarios until 2050. The study revealed that clinker substitution (42%), alternative fuel use (25%), and kiln efficiency improvements (12%) could provide significant reductions on their own. In a scenario where these three measures are applied synchronously, it was calculated that CO<sub>2</sub>-equivalent emissions from cement production could be reduced by 58% in 2050 compared to 2020 levels (Georgiades et al., 2023).

The comprehensive review study by Supriya et al. (2023) systematically examines current and promising low-carbon emission strategies for the cement sector to reach the net zero target. The study focuses on alternative binder systems that go beyond traditional Portland cement chemistry. It is stated that clinkers with low calcium content and produced at lower temperatures (~1200-1350°C), such as Belite-rich cement (BPC) and calcium sulfoaluminate cement (CSA), can provide CO<sub>2</sub> reductions of up to 10% and 30-40%, respectively (Supriya et al., 2023; Kotsay and Jaskulski, 2019). It is emphasized that alkali-activated binders and particularly geopolymers carry a higher reduction potential of up to 70% (Robayo-Salazar et al., 2018). One of the most striking findings of the study is the potential of systems with completely different hardening mechanisms, such as carbonatable calcium silicate cement (Solidia technology) and magnesia cement (Novacem, TecEco), to achieve net negative emissions by permanently trapping CO<sub>2</sub> in the structure through carbonation (Meyer et al., 2018). Furthermore, CO<sub>2</sub> utilization technologies at the commercialization stage (TRL 6-9) such as CarbonCure, Solidia, Carbicrete, and CO<sub>2</sub>-SUICOM, and the integration of these technologies into production processes are discussed in detail (Zajac et al., 2021).

In the study by Cavalett et al. (2022); a comprehensive study examining the sustainable decarbonization of the European cement sector from a life cycle perspective was published in the journal Scientific Reports. The study revealed that the climate impact of current clinker production in European countries varies between 832 and 1,075 kg CO<sub>2</sub>-eq/ton and evaluated 15 different decarbonization options. The findings showed that complementary measures such as alternative fuels and technological improvements could reduce the climate impact by at most 30%, while an ambitious package of measures could only provide a reduction of approximately 50% by 2050. It was emphasized that the rapid and large-scale implementation of carbon capture and storage (CCS) is mandatory to reach climate neutrality. Additionally, it was stated that the use of captured carbon in synthetic fuel (e-fuel) production (CCU) does not provide a significant benefit in terms of climate change, and conversely increases other environmental impacts such as human health and water consumption. The study indicated that oxy-fuel technology, if integrated with biomass fuels, carries a negative emission potential (-24 to -169 g CO<sub>2</sub>eq per 1 kg of clinker) (Cavalett et al., 2022).

The review published by Sherif et al. (2025) addresses the potential of the UK cement sector to reach 2050 net zero targets from a critical perspective. By analyzing the sector's current emission profile, energy, and material flows in detail, the study revealed that its performance

lags behind some global averages. Decarbonization options were systematically evaluated in terms of technology readiness levels (TRL), cost, and impact potentials (Sherif et al., 2025). The graph found in Figure 2 shows the emission reduction rates relative to the reference scenario in the articles summarized above.

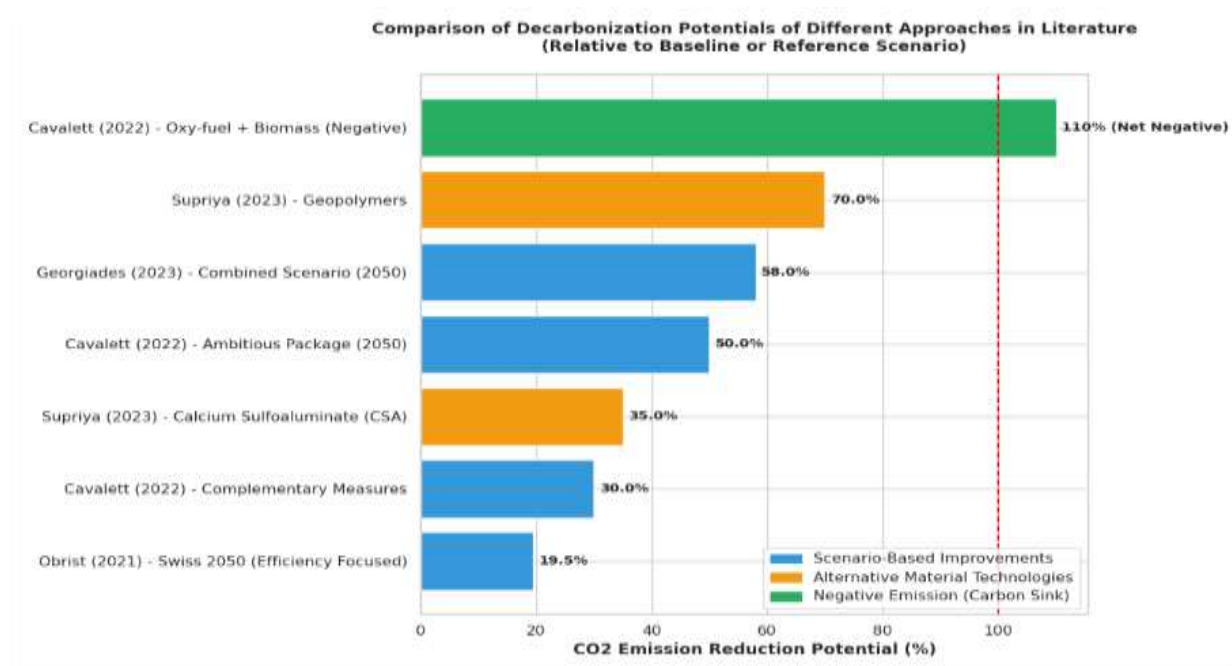


**Figure 2.** Carbon emission reduction rates of the summarized articles relative to the reference scenario.

When the graph is examined, it is seen that there is a distinct hierarchy among the impact levels of the scenarios proposed in the decarbonization roadmap of the cement sector; while energy efficiency and complementary measures presented by Obrist (2021) and Cavalett (2022) provide limited improvement remaining in the 20-30% band, advanced material technologies pointed out by Supriya (2023) such as geopolymers push these limits with a reduction potential of up to 70%. However, the most striking point of the graph is that the only scenario exceeding the Net Zero threshold (100%) is the Cavalett (2022) oxy-fuel and biomass integration; this proves that for the sector to not only zero its emissions but also transform into a "net negative" carbon sink, it is inevitable to go beyond conventional improvements and use CCS (Carbon Capture and Storage) technologies synchronized with biomass.

## Thermodynamic Limits of Energy Efficiency and the Necessity of Transition to Complementary Strategies

The case studies above confirm that energy efficiency is an important starting point. However, the physicochemical realities of cement production delineate the limits of this strategy. While the theoretical minimum energy requirement for clinker production is 1.6-1.76 GJ/ton, with Best Available Techniques (BAT), this value practically goes down to 2.9-3.0 GJ/ton levels (Fennell et al., 2021). Considering that the European average is ~3.6 GJ/ton, it is clear that the progress to be achieved with traditional thermal efficiency measures will become increasingly marginal (Fennell et al., 2021). Therefore, complementary strategies going beyond energy efficiency are inevitable. As shown in Figure 3 put forward by CEMBUREAU, the "5C" approach (Clinker, Cement, Concrete, Construction, Carbon) forms the framework of these holistic strategies (Cembureau, 2020).

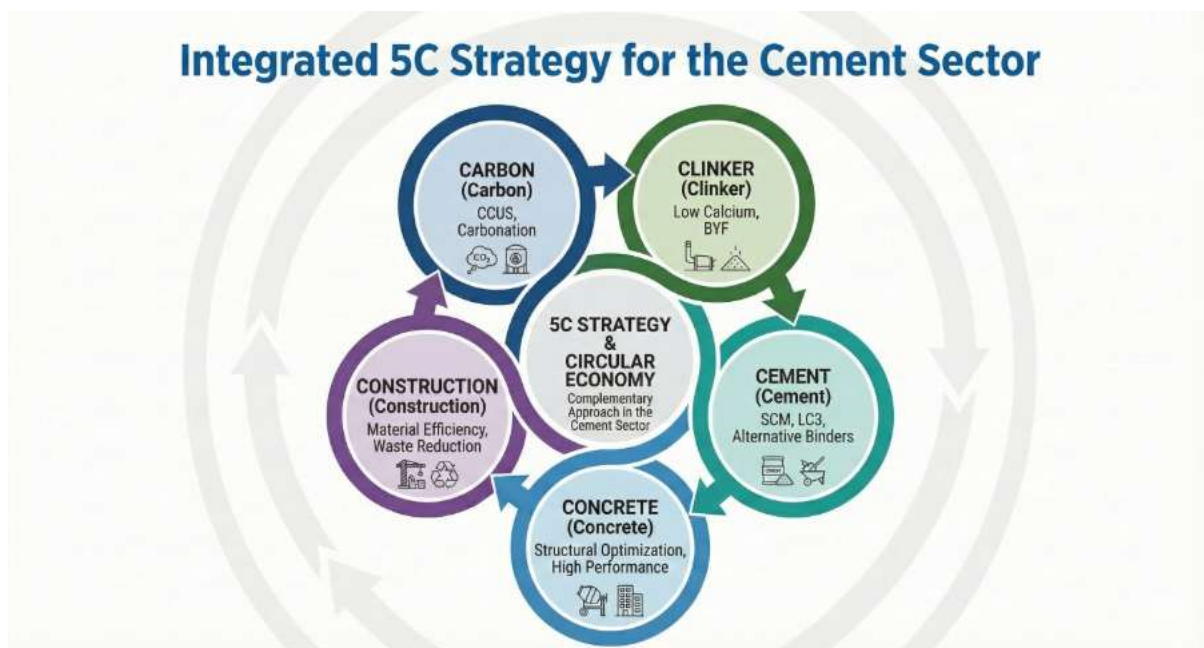


**Figure 3.** CEMBUREAU's "5C" Strategy and Circular Economy

**Clinker:** Reducing the clinker/cement ratio and developing alternative clinkers with low calcium content (e.g., BYF clinker). Belite-Ye'elimite-Ferrite (BYF) clinkers have a 28% lower CO<sub>2</sub> emission factor compared to Portland clinker (Miller and Myers, 2019). **Cement:** Against the bottleneck in the supply of traditional Supplementary Cementitious Materials (SCM) like fly ash and slag, expanding the use of new binder systems such as Limestone Calcined Clay Cement (LC<sup>3</sup>). LC<sup>3</sup> technology can reduce the clinker factor down to 50% and CO<sub>2</sub> emissions by up to 40% (Zunino et al., 2021). **Concrete & Construction:** Reducing material demand



through structural optimization, high-performance concrete, and circular economy principles (Watari et al., 2022). Carbon: Commercialization of Carbon Capture, Utilization, and Storage (CCUS) technologies to address unavoidable process emissions. GCCA and IEA roadmaps predict that a significant portion of the required reduction in 2050 will come from CCUS (IEA, 2018).

### Political and Economic Dynamics: The European Green Deal and Global Repercussions

One of the most important factors determining the sector's transformation speed is the political and economic framework. The EU's European Green Deal and "Fit for 55" package foresee radical changes for the cement sector. The gradual phasing out of free allocations provided to the sector in the Emissions Trading System (ETS) in the 2026-2034 period and the rise in carbon prices will directly affect production costs (Wurzel et al., 2023). In parallel, the Carbon Border Adjustment Mechanism (CBAM) envisages applying a tax to cement imported from outside the EU equal to the carbon costs not paid at the production location (Wurzel et al., 2023). This dual mechanism aims to force producers within the EU to decarbonize while also encouraging global trading partners to adopt similar policies to prevent "carbon leakage."

### CONCLUSION

The findings of this study demonstrate that the cement sector's path to the 2050 net zero emission target is possible not with a one-dimensional solution, but with a multi-layered and complementary portfolio of strategies, as also shown in Figure 4.

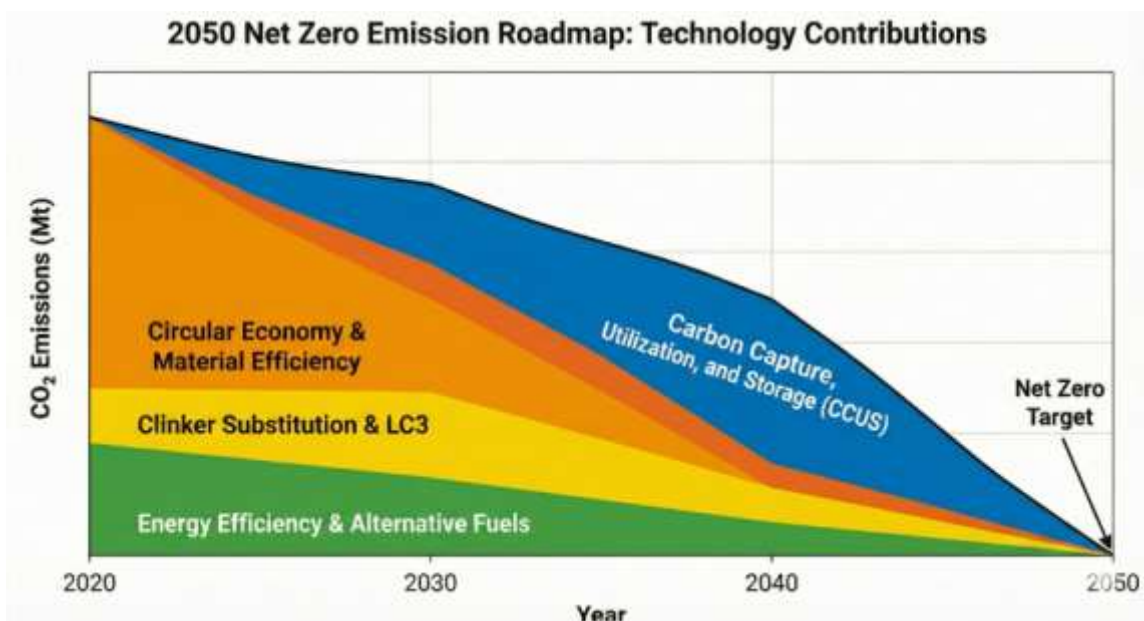


**Figure 4.** 2050 Net Zero Emission Roadmap for the Cement Sector

Energy efficiency is a fundamental and indispensable component of this portfolio, especially with its applicability in existing facilities, short payback periods, and tangible emission reduction potential. However, the existence of process emissions and thermodynamic efficiency limits remove energy efficiency from being a "final solution" and make it the first step of a more comprehensive transformation plan. This transformation requires the industrial-scale commissioning of clinker substitution, alternative binders, material efficiency, and ultimately CCUS technologies. Pilot and commercial-scale CCUS projects such as Brevik (Norway), LEILAC (Germany/Belgium), and Westküste 100 (Germany) prove technological feasibility, but barriers such as high investment costs, energy penalties, and infrastructure deficits need to be overcome (Hills et al., 2017).

Recommendations for policymakers can be listed as follows: Developing Local Scenarios: Energy efficiency potential varies greatly from country to country depending on existing plant stock, energy resources, and SCM availability. Therefore, detailed country-based scenario studies and roadmaps are as vital as global roadmaps (Miller and Myers, 2019). R&D and Initial Investment Support: Financial support mechanisms such as public-private partnerships, grant programs, and Carbon Contracts for Difference (CCfD) should be encouraged, especially for the development and establishment of the first commercial facilities of innovative, high-cost but long-term mandatory technologies like CCUS and LC<sup>3</sup>. Policy Consistency and Global Cooperation: Mechanisms like the EU's ETS and CBAM have the potential to create a global impact. Supporting such policies with technology transfer and capacity-building opportunities for developing countries will ensure a just transition and increase global impact.

In conclusion, the transformation of the cement sector is a complex but unpostponable process. Energy efficiency is the first and logical step to be taken on this long journey, but bolder technological breakthroughs and determined policy support are needed to reach the goal.

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## AGRICULTURAL MECHANIZATION LEVEL OF ALANYA DISTRICT OF TÜRKİYE

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### ABSTRACT

This current study reviews the agricultural mechanization status and characteristics of Alanya district. The number of agricultural machinery and tractors have been obtained from 2024 data of the Turkish Statistical Institute. The total agricultural area of Alanya district consists of 193579.5 da. The total agricultural area of the district is made up of; 72526 da fruit, drink and spice plants area, 81000 da fallow area, 19205 da vegetable area, 51.5 da ornamental plants and 20800 da cereals and other plant products. The total number of tractors in the district is 755 and total tractor power is 18397.5 kW. Tractor power-group distribution is as follows; 35 tractors between 1-5 HP, 190 tractors with over 5 HP+, 90 tractors between 1-10 HP, 95 tractors between 11-24 HP, 95 tractors between 25-34, 155 tractors between 35-50 HP, 90 tractors between 51-70 HP, and 5 tractors with over 70 HP+. Agricultural machinery includes soil tillage machinery, planting machinery, spraying machinery, irrigation machinery, harvesting machinery, crop sorting machinery, and trailers. Mechanization level indicators considered include average tractor power, kW/ha, tractor power/1000 ha, ha/tractor, and machine/tractor values. According to the calculations, average tractor power, kW/ha, tractor power/1000 ha, ha/tractor, and machine/tractor were determined to be 17.93 kW, 0.69 kW/ha, 39 tractor/1000 ha, 25.63 ha/tractor, and 13.71 machine/tractor, respectively.

**Keywords:** Alanya, Mechanization, Tractor.

## ARTIFICIAL INTELLIGENCE–DRIVEN DIGITAL EXERCISE IN TELEREHABILITATION: CLINICAL, BEHAVIORAL, AND SUSTAINABILITY PERSPECTIVES

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### ABSTRACT

This review aims to comprehensively evaluate current evidence on artificial intelligence (AI) analyzed digital exercise content in telerehabilitation from clinical effectiveness, patient adherence, and sustainability perspectives.

A structured literature search was conducted in accordance with PRISMA principles. Studies reporting clinical, behavioral, or system-level outcomes of AI based or digital exercise interventions were included in the analysis. Eligible studies encompassed telerehabilitation applications integrating AI-supported assessment, feedback, and exercise prescription processes.

Current evidence indicates that digital physiotherapy interventions are comparable to conventional rehabilitation in terms of pain reduction and functional improvement, particularly in musculoskeletal conditions. The integration of AI enhances clinical outcomes through real-time movement analysis, adaptive feedback, and personalized exercise prescription. Moreover, AI driven systems appear to improve patient adherence and engagement, which are recognized as key determinants of rehabilitation success. In addition, these approaches contribute to sustainable healthcare systems by reducing costs, minimizing environmental impact, and improving access to care.

AI-analyzed digital exercise content transforms telerehabilitation from a passive service model into an interactive, adaptive, and data-driven rehabilitation ecosystem. This approach not only improves clinical outcomes but also supports the development of more accessible and sustainable healthcare delivery models. However, challenges such as data privacy, digital inequality, and limited long-term evidence remain. Future research should focus on long-term effectiveness and the development of standardized implementation frameworks.

**Keywords:** Telerehabilitation, Digital physiotherapy, Artificial intelligence, Exercise therapy, Patient adherence, Sustainability

### INTRODUCTION

The global burden of musculoskeletal and chronic conditions continues to rise, placing increasing demands on healthcare systems and rehabilitation services. Musculoskeletal

disorders alone affect over 1.7 billion individuals worldwide and represent the leading cause of disability (Lee et al., 2025). Conventional physiotherapy models, which rely predominantly on face-to-face interactions, are often constrained by limited accessibility, workforce shortages, and economic barriers (Lee et al., 2025).

In response to these challenges, digital health technologies, particularly telerehabilitation, have emerged as viable alternatives for delivering rehabilitation services remotely. Telerehabilitation enables home-based interventions, improves access to care, and allows continuous patient monitoring (Sivertsson et al., 2024). Furthermore, digital physiotherapy practice has expanded to include a wide range of technologies such as mobile applications, wearable sensors, and remote monitoring systems (World Physiotherapy, 2019).

Artificial intelligence has further accelerated this transformation by enabling data-driven, personalized, and adaptive rehabilitation approaches. AI systems can analyze movement patterns, predict clinical outcomes, and provide real-time feedback, thereby improving the precision and effectiveness of interventions (Alshami et al., 2025). Despite these advancements, the integration of AI-analyzed digital exercise content within telerehabilitation frameworks remains insufficiently synthesized in the literature. Therefore, this narrative review aims to explore current evidence and provide a physiotherapy-centered perspective on this emerging field.

### **Digital Physiotherapy and Telerehabilitation**

Digital physiotherapy encompasses a broad spectrum of technologies designed to support remote care delivery. Telerehabilitation, as a core component of digital practice, facilitates the provision of rehabilitation services using information and communication technologies while maintaining essential therapeutic principles (World Physiotherapy, 2019).

Evidence suggests that telerehabilitation can achieve clinical outcomes comparable to traditional physiotherapy in musculoskeletal conditions. For instance, a systematic review and meta-analysis reported that digital physiotherapy interventions significantly improve physical function and reduce pain in individuals with knee osteoarthritis (Cheung et al., 2025). Similarly, exercise-based telerehabilitation has demonstrated comparable outcomes to conventional therapy in chronic low back pain (Sivertsson et al., 2024).

However, traditional digital rehabilitation approaches are often limited by the absence of real-time supervision and objective movement assessment. These limitations highlight the need for more advanced and intelligent systems capable of enhancing intervention quality.

### **Role of Artificial Intelligence in Rehabilitation**

Artificial intelligence has emerged as a transformative tool in rehabilitation by enabling personalized and data-driven care models. AI systems are capable of analyzing large datasets, identifying patterns, and adapting interventions based on individual patient characteristics (Alshami et al., 2025).

Applications of AI in rehabilitation include movement analysis, predictive modeling, real-time feedback, and automated monitoring of patient progress. These capabilities allow clinicians to deliver more targeted interventions and improve decision-making processes. Furthermore, AI facilitates continuous monitoring outside clinical settings, addressing a key limitation of traditional rehabilitation models.

By shifting rehabilitation from a reactive to a proactive approach, AI enhances both efficiency and effectiveness in clinical practice.

### **AI-Analyzed Digital Exercise Content**

AI-analyzed digital exercise systems represent a significant advancement over conventional telerehabilitation approaches. Unlike traditional video-based interventions, these systems incorporate technologies such as computer vision, motion tracking, and wearable sensors to evaluate movement quality and provide real-time feedback.

A randomized controlled trial demonstrated that AI-assisted telerehabilitation resulted in significantly greater improvements in pain, disability, and muscle function compared to conventional video-based rehabilitation (Xiao et al., 2025). These findings indicate that AI not only improves accessibility but also enhances clinical outcomes by optimizing exercise performance and personalization.

Such systems enable objective assessment, individualized progression, and continuous feedback, which are essential components of effective physiotherapy.

### **Patient Adherence and Engagement**

Patient adherence is a critical determinant of rehabilitation success, yet adherence rates in conventional rehabilitation programs remain relatively low. Studies have reported adherence rates ranging from 30% to 65% in traditional physiotherapy settings (Lee et al., 2025).

AI-based digital rehabilitation systems address these limitations by incorporating personalized feedback, progress tracking, reminders, and motivational strategies. These features significantly enhance patient engagement and adherence (Mohammad Namdar et al., 2025).

Moreover, AI enables objective monitoring of adherence, reducing reliance on self-reported measures and improving the accuracy of clinical evaluations. Improvements in adherence rates of up to 40% have been reported in digital rehabilitation settings (Lee et al., 2025).

These findings highlight the potential of AI to address one of the most significant challenges in rehabilitation practice.

### **Sustainability in Telerehabilitation**

Sustainability is an increasingly important consideration in healthcare delivery. AI-driven telerehabilitation contributes to sustainability across environmental, economic, and healthcare system domains.

From an environmental perspective, digital healthcare reduces the need for patient travel, thereby lowering carbon emissions. The healthcare sector accounts for approximately 4.4% of global greenhouse gas emissions, underscoring the importance of sustainable healthcare solutions (Usher et al., 2024).

Economically, digital rehabilitation reduces healthcare costs by minimizing in-person visits and optimizing resource utilization. Cost reductions of up to 30–40% have been reported in digital therapeutic models (Lee et al., 2025).

From a healthcare system perspective, telerehabilitation improves access to care, particularly for individuals in rural and underserved areas, and supports more efficient use of healthcare resources.

## **MATERIAL AND METHODS**

### **Study Selection Overview**

This narrative review was conducted using a structured literature search approach to enhance methodological transparency. Electronic databases including PubMed, Scopus, and Web of Science were searched for studies published between 2020 and 2025.

The search strategy combined keywords related to artificial intelligence, digital rehabilitation, and physiotherapy, including “artificial intelligence,” “telerehabilitation,” “digital physiotherapy,” “exercise therapy,” and “adherence.” Studies were included if they met the following criteria:

- (i) involved digital or AI-based rehabilitation interventions,
- (ii) included exercise-based components,
- (iii) reported clinical outcomes, adherence, or system-level impacts,
- (iv) were published in peer-reviewed journals in English.

Studies focusing solely on non-exercise interventions or non-rehabilitation populations were excluded.

A total of 112 records were identified through database searches. After removing 27 duplicates, 85 records were screened based on titles and abstracts. Forty-four records were excluded due to irrelevance to AI or exercise-based rehabilitation. The full texts of 41 articles were assessed for eligibility, and 23 were excluded due to lack of clinical outcomes or insufficient relevance. Finally, 18 studies were included in this narrative synthesis.

## RESULTS

### Characteristics of Included Studies

A total of 112 records were identified through database searching. After removal of duplicates and screening of titles and abstracts, 41 articles were assessed for eligibility. Of these, 18 studies were included in the final synthesis based on relevance to AI-supported digital exercise and telerehabilitation. Although this review does not follow a full systematic review design, elements of PRISMA reporting were adopted to improve transparency and reproducibility.

Data extraction focused on study design, population characteristics, intervention type, and key outcomes, which were synthesized narratively and presented in tabular form.

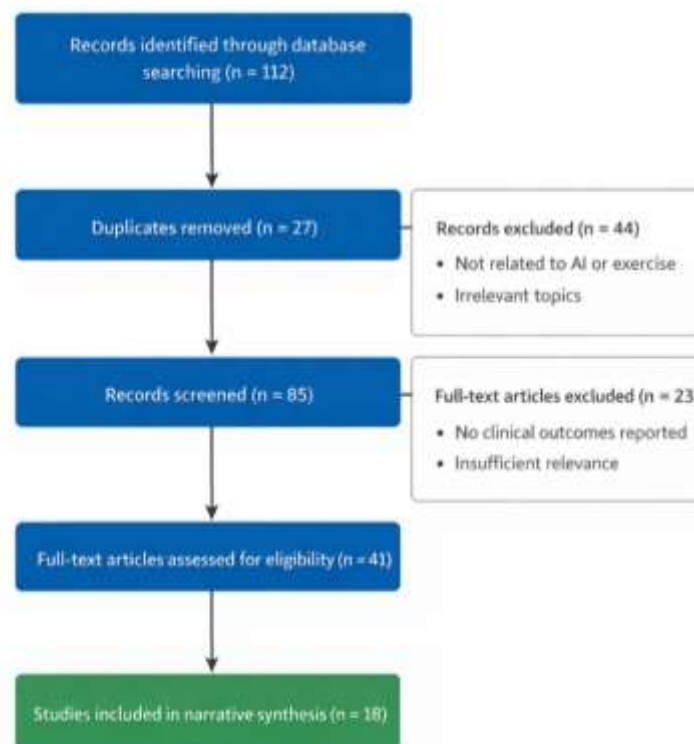


**Figure 1.** PRISMA Flow Diagram of Study Selection for AI-Based Digital Exercise in Telerehabilitation



### **Narrative Synthesis of Findings**

The findings of this review can be categorized into three main domains: clinical effectiveness, behavioral outcomes, and system-level sustainability.

First, in terms of clinical effectiveness, AI-supported telerehabilitation interventions demonstrated improvements comparable to or exceeding those of conventional physiotherapy. These improvements were particularly evident in pain reduction, functional outcomes, and movement quality.

Second, behavioral outcomes, particularly patient adherence and engagement, emerged as a critical mediator of rehabilitation success. AI-based systems enhanced adherence through personalized feedback, real-time monitoring, and motivational strategies.

Finally, at the system level, digital rehabilitation approaches contributed to sustainability by reducing healthcare costs, minimizing environmental impact, and improving access to care. These findings highlight the multifaceted value of AI-integrated rehabilitation systems.

**Table 1.** Characteristics of Included Studies on AI-Based Digital Exercise in Telerehabilitation

| <b>Study</b>                | <b>Design</b>                     | <b>Population</b>         | <b>Intervention</b>            | <b>Key Findings</b>                              |
|-----------------------------|-----------------------------------|---------------------------|--------------------------------|--------------------------------------------------|
| Cheung et al., 2025         | Systematic Review & Meta-analysis | Knee OA                   | Digital physiotherapy          | Improved function and reduced pain               |
| Xiao et al., 2025           | RCT                               | Chronic LBP               | AI-based telerehabilitation    | Superior clinical outcomes vs video-based rehab  |
| MohammadNamdar et al., 2025 | Rapid Review                      | Mixed populations         | AI-driven digital rehab        | Increased adherence and engagement               |
| Sivertsson et al., 2024     | Scoping Review                    | Chronic LBP               | Telerehabilitation             | Comparable outcomes to conventional therapy      |
| Lee et al., 2025            | Narrative Review                  | Musculoskeletal disorders | Digital therapeutics           | Improved adherence and reduced cost              |
| Alshami et al., 2025        | Narrative Review                  | Mixed                     | AI in rehabilitation           | Personalized care and improved outcomes          |
| Rodrigues et al., 2025      | Systematic Review                 | Stroke                    | VR-based telerehabilitation    | Improved engagement and motor recovery potential |
| Usher et al., 2024          | Perspective                       | General healthcare        | Virtual healthcare systems     | Reduced carbon footprint                         |
| World Physiotherapy, 2019   | Report                            | Global                    | Digital physiotherapy practice | Expanded definition of digital care              |

|                                              |               |         |                     |                                                 |
|----------------------------------------------|---------------|---------|---------------------|-------------------------------------------------|
| Additional digital rehab studies (2020–2024) | Mixed designs | Various | App/web-based rehab | Improved accessibility and patient satisfaction |
|----------------------------------------------|---------------|---------|---------------------|-------------------------------------------------|

Based on the included studies summarized in Table 1, the findings of this review can be categorized into three main domains: clinical effectiveness, behavioral outcomes, and system-level sustainability. The included literature consisted of randomized controlled trials, systematic reviews, and narrative reviews, reflecting the multidisciplinary and evolving nature of AI-based digital rehabilitation. Most studies focused on musculoskeletal conditions, particularly chronic low back pain and osteoarthritis, while others explored neurological populations such as stroke. Across studies, AI-supported interventions demonstrated consistent improvements in clinical outcomes, including pain reduction, functional performance, and movement quality. Additionally, enhanced patient adherence and engagement were among the most frequently reported benefits. From a system-level perspective, digital and AI-driven rehabilitation approaches contributed to improved accessibility, cost-efficiency, and environmental sustainability.

## DISCUSSION

This narrative review highlights the emerging role of artificial intelligence–analyzed digital exercise systems in transforming telerehabilitation into a more interactive, adaptive, and personalized model of care.

Compared to conventional rehabilitation approaches, AI-supported systems provide enhanced capabilities in real-time feedback, objective movement analysis, and individualized progression, which may explain the observed improvements in clinical outcomes. Previous evidence indicates that digital physiotherapy interventions can achieve comparable improvements in pain and functional outcomes to traditional therapy, particularly in musculoskeletal conditions such as knee osteoarthritis and chronic low back pain (Cheung et al., 2025; Sivertsson et al., 2024). The integration of AI appears to further strengthen these effects by optimizing exercise execution and personalization (Alshami et al., 2025; Xiao et al., 2025). Importantly, the benefits of digital and AI-based rehabilitation are not limited to musculoskeletal populations. Studies involving neurological populations, such as stroke patients, suggest that technology-supported interventions, including virtual reality–based telerehabilitation, may enhance motor recovery and patient engagement (Rodrigues et al., 2025). This indicates that AI-driven rehabilitation has the potential to be applied across a wide

range of clinical conditions. One of the most significant findings of this review is the central role of patient adherence as a mediator of rehabilitation success. Poor adherence remains a major limitation of conventional physiotherapy, with reported compliance rates as low as 30–65% (Lee et al., 2025). AI-based systems address this challenge by incorporating real-time monitoring, personalized feedback, and motivational strategies, which have been shown to significantly improve adherence and engagement (Mohammad Namdar et al., 2025). These findings suggest that the effectiveness of AI-supported rehabilitation is not solely driven by technological advancements but also by behavioral mechanisms that enhance patient participation. From a broader perspective, the findings of this review align with the global shift toward digital and sustainable healthcare models. Digital physiotherapy practice, as defined by international frameworks, encompasses a wide range of technologies aimed at improving access, efficiency, and quality of care (World Physiotherapy, 2019). AI-driven rehabilitation approaches contribute to this transformation by enabling scalable and accessible care delivery. In addition, sustainability emerges as a key advantage of digital rehabilitation systems. AI-supported telerehabilitation has been associated with reduced healthcare costs and improved system efficiency (Lee et al., 2025). Furthermore, virtual healthcare technologies have demonstrated the potential to reduce carbon emissions by minimizing patient travel, highlighting their environmental benefits (Usher et al., 2024). These findings reinforce the role of AI-driven rehabilitation not only as a clinical tool but also as a component of sustainable healthcare systems. Despite these promising findings, several challenges remain. The heterogeneity of interventions, variability in study designs, and lack of standardized outcome measures limit the comparability of results. Additionally, many studies focus on short-term outcomes, and evidence regarding long-term effectiveness and real-world implementation remains limited. Concerns related to data privacy, digital literacy, and clinician training also represent important barriers to widespread adoption (Alshami et al., 2025).

Future research should focus on large-scale randomized controlled trials, long-term follow-up, and the development of standardized frameworks for AI-based rehabilitation systems. Moreover, integrating behavioral science with technological innovation may further enhance adherence and clinical effectiveness. AI-driven telerehabilitation is not merely a technological innovation but represents a paradigm shift toward sustainable, patient-centered, and data-driven rehabilitation models.

## **Challenges and Limitations**

Despite its potential, AI-driven telerehabilitation faces several challenges. These include data privacy concerns, digital inequality, lack of clinician training, and the absence of standardized protocols (Alshami et al., 2025).

Additionally, variability in study designs and outcome measures limits the generalizability of findings. Long-term effectiveness and real-world implementation remain insufficiently explored, highlighting the need for further research.

## **Future Directions**

Future developments in AI-based rehabilitation are expected to focus on advanced technologies such as digital twin models, predictive analytics, and integration with wearable biosensors (Lee et al., 2025). These innovations have the potential to enable fully personalized and adaptive rehabilitation programs. However, high-quality studies are required to establish standardized frameworks and evaluate long-term outcomes.

## **CONCLUSION**

Artificial intelligence-analyzed digital exercise content represents a paradigm shift in physiotherapy by transforming telerehabilitation into an interactive, personalized, and data-driven care model. While current evidence supports improvements in adherence and clinical outcomes, successful implementation requires addressing challenges related to equity, regulation, and long-term sustainability. AI-driven telerehabilitation has the potential to redefine rehabilitation services, making them more accessible, efficient, and sustainable.

This review, supported by a structured search strategy, highlights the emerging role of AI-analyzed exercise systems not only as technological tools but as integral components of future sustainable rehabilitation models.

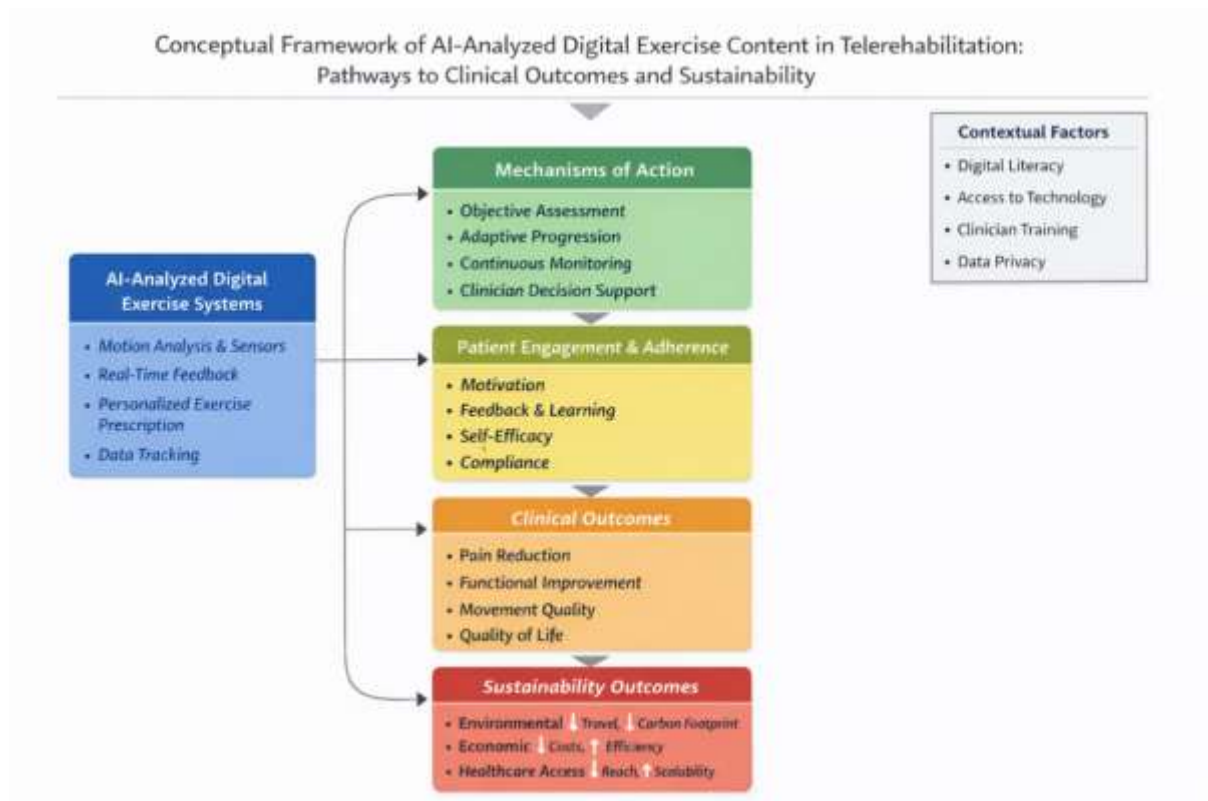


**Figure 2.** Conceptual framework illustrating the role of artificial intelligence–analyzed digital exercise content in telerehabilitation.

AI-driven systems enhance rehabilitation through real-time movement analysis, personalized feedback, and adaptive progression. These mechanisms improve patient engagement and adherence, which act as key mediators influencing clinical outcomes such as pain reduction and functional improvement. At the system level, these effects contribute to sustainability through improved accessibility, cost-efficiency, and reduced environmental impact. Contextual factors such as digital literacy, access to technology, and clinician training may influence the effectiveness of this framework.

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## TOWARD SUSTAINABLE PHYSIOTHERAPY: CLINICAL UTILITY, LIMITATIONS AND FUTURE DIRECTIONS OF WEARABLE TECHNOLOGIES IN REHABILITATION

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### ABSTRACT

Wearable technologies are increasingly integrated into physiotherapy and rehabilitation, offering real-time monitoring, personalized feedback, and opportunities for remote care delivery. Despite their widespread adoption, their long-term clinical effectiveness and sustainability remain insufficiently understood. Existing studies predominantly focus on short-term outcomes, while key aspects such as long-term adherence, real-world integration, and underlying mechanisms remain underexplored.

This study was conducted as a narrative review based on literature identified through PubMed, Scopus, and Web of Science. Systematic reviews, meta-analyses, and high-quality clinical studies published within the last decade were prioritized. The analysis was structured using a multi-dimensional sustainability framework encompassing clinical effectiveness, behavioral adherence, technological validity, and system-level integration.

Wearable technologies were found to increase physical activity levels and support rehabilitation adherence, particularly in home-based settings. However, important limitations were identified, including variability in measurement accuracy, lack of algorithm transparency, and challenges in maintaining long-term behavioral engagement. Evidence suggests that wearable technologies are more effective when integrated into structured rehabilitation programs rather than used as standalone interventions. Their impact appears to be mediated by behavioral feedback mechanisms, which are insufficient to sustain long-term motor learning and adherence without clinician guidance. Additionally, barriers related to data security, interoperability, and economic feasibility limit large-scale implementation.

Wearable technologies represent a promising but context-dependent approach in physiotherapy. Their effectiveness relies on integration within clinician-guided, mechanism-based rehabilitation models. This review proposes a sustainability-oriented framework that links clinical, behavioral, and system-level factors, providing a basis for

future intervention design. Future research should focus on standardized validation, long-term effectiveness, and personalized digital rehabilitation strategies.

**Keywords:** Physical Therapy Modalities; Rehabilitation; Exercise Therapy; Telemedicine; Patient Compliance; Motor Activity; Wearable Technology; Digital Health

## **INTRODUCTION**

The increasing prevalence of chronic diseases, sedentary lifestyles, and aging populations has created a growing demand for sustainable and scalable healthcare solutions worldwide (World Health Organization [WHO], 2021). The growing burden of physical inactivity further exacerbates this global health challenge, necessitating innovative approaches that can be effectively integrated into modern healthcare systems. In this context, physiotherapy plays a central role in promoting physical activity, improving functional independence, and enhancing quality of life. However, conventional rehabilitation models remain constrained by limited accessibility, high costs, and suboptimal patient adherence, limiting their long-term effectiveness (Peek et al., 2019).

In recent years, wearable technologies have gained significant attention as innovative tools capable of addressing these limitations. These technologies—including smartwatches, fitness trackers, biosensor patches, and smart textiles—enable continuous monitoring of physiological and biomechanical parameters such as heart rate, physical activity levels, energy expenditure, and movement patterns (De Fazio et al., 2023). Through real-time feedback and data-driven insights, wearable devices facilitate self-management, enhance patient engagement, and support more individualized rehabilitation processes (Patel et al., 2012). Consequently, wearable technologies have emerged as promising tools capable of transforming rehabilitation delivery, particularly within home-based and remote care models.

From a sustainability perspective, wearable technologies offer several potential advantages, including reduced healthcare utilization, improved remote monitoring, and enhanced continuity of care. These technologies support decentralized healthcare models by enabling home-based rehabilitation and reducing the burden on healthcare facilities (Piwek et al., 2016). However, despite their growing adoption, concerns persist regarding their clinical validity, reliability, and long-term effectiveness. Issues such as measurement inaccuracies, lack of algorithm transparency, and challenges in integrating wearable-generated data into clinical decision-making processes highlight important limitations that must be addressed (Li et al., 2025).



Importantly, a critical gap remains in the current literature: the sustainability of wearable technologies in physiotherapy is insufficiently understood. While existing studies predominantly focus on short-term outcomes, key dimensions such as long-term adherence, real-world clinical integration, cost-effectiveness, and underlying mechanistic pathways remain underexplored. This gap limits the ability to fully evaluate the long-term value and scalability of wearable technologies in rehabilitation settings.

Therefore, the present study aims to address this gap by providing a comprehensive evaluation of wearable technologies in physiotherapy through a multi-dimensional sustainability framework. Specifically, this review integrates clinical, behavioral, and system-level perspectives to better understand the potential and limitations of wearable technologies in supporting sustainable rehabilitation practices.

## **MATERIALS AND METHODS**

This study employed a narrative review methodology to synthesize current evidence on wearable technologies in physiotherapy (Green et al., 2018). Narrative reviews are particularly suitable for integrating findings across diverse study designs and providing a comprehensive overview of emerging topics.

Relevant studies were identified through searches in PubMed, Scopus, and Web of Science using predefined keywords related to wearable technology, physiotherapy, and rehabilitation. Inclusion criteria prioritized systematic reviews, meta-analyses, and high-quality clinical studies published in English within the last decade, consistent with established recommendations for narrative and integrative review methodologies (Green et al., 2018; Snyder, 2019).

A structured literature search was conducted focusing on systematic reviews, meta-analyses, and high-quality observational and experimental studies published in recent years. The included studies investigated wearable technologies used in rehabilitation, physical activity promotion, and health monitoring.

To advance beyond descriptive evaluation, this study adopts a four-domain sustainability framework:

1. Clinical sustainability → effectiveness and outcomes
2. Behavioral sustainability → adherence and engagement

3. Technological sustainability → validity and reliability

4. System sustainability → scalability and integration

This framework allows a more comprehensive interpretation of wearable technologies beyond isolated outcomes.

## **RESULTS**

### **Clinical Effectiveness**

Wearable technologies have demonstrated significant potential in improving physical activity and rehabilitation outcomes. Evidence from systematic reviews indicates that wearable activity trackers can increase daily step counts by approximately 1800 steps and extend walking duration by nearly 40 minutes per day (Ferguson et al., 2022). These improvements are associated with enhanced cardiovascular health and functional performance.

In rehabilitation contexts, wearable devices support patient recovery by facilitating remote monitoring and providing continuous feedback. This is particularly relevant in post-operative rehabilitation and neurological conditions, where adherence to prescribed exercise programs is critical (Latif et al., 2024). Additionally, wearable-based interventions have been shown to improve physical function and body composition in older adults (Li et al., 2025).

### **Data Validity and Reliability**

Despite their clinical advantages, wearable technologies present notable limitations regarding data accuracy. Studies have shown that while step count measurements are relatively reliable under controlled conditions, their accuracy decreases significantly in real-life environments (Fuller et al., 2020; Li et al., 2025). Another major limitation is the lack of transparency in proprietary algorithms used by commercial devices. These algorithms are often not accessible for scientific validation, making it difficult to assess the accuracy of measurements such as energy expenditure and heart rate variability (Piwek et al., 2016). This issue raises concerns regarding the clinical applicability of wearable-derived data.

### **Behavioral Adherence and Sustainability**

Wearable technologies play an important role in promoting physical activity by enhancing motivation and engagement. Features such as real-time feedback, goal setting, and progress tracking contribute to improved adherence (Ferguson et al., 2022).

However, maintaining long-term behavioral change remains challenging. While short-term improvements are frequently observed, adherence tends to decline over time without continuous support or structured intervention programs (Peek et al., 2019). This highlights the importance of integrating wearable technologies with behavioral strategies and clinician guidance.

### **System-Level Sustainability**

From a healthcare systems perspective, wearable technologies contribute to more efficient and sustainable service delivery by enabling remote monitoring and reducing the need for in-person visits (De Fazio et al., 2023). The integration of artificial intelligence (AI) and Internet of Things (IoT) technologies further enhances the capabilities of wearable devices by enabling personalized and predictive healthcare approaches (Antarsih et al., 2025). However, several barriers limit their widespread implementation, including data privacy concerns, lack of standardization, and economic constraints.

## **DISCUSSION**

This review provides a comprehensive evaluation of wearable technologies in physiotherapy through a sustainability-oriented framework, integrating clinical, behavioral, technological, and system-level perspectives. Overall, the findings indicate that while wearable technologies offer substantial advantages, their effectiveness is highly context-dependent and strongly influenced by how they are implemented within rehabilitation processes (De Fazio et al., 2023; Latif et al., 2024).

Wearable technologies have clear potential to transform physiotherapy practice by enabling continuous monitoring, real-time feedback, and more personalized rehabilitation strategies. These features support patient-centered care and facilitate remote and home-based interventions, aligning with contemporary healthcare models (De Fazio et al., 2023; Piwek et al., 2016). Notably, such technologies may enhance accessibility and continuity of care, particularly in populations with limited access to traditional rehabilitation services. However, the present findings emphasize a critical conceptual shift: wearable technologies are not inherently effective; rather, their effectiveness emerges when they are embedded within structured, clinician-guided rehabilitation programs (Patel et al., 2012; Peek et al., 2019). This challenges the prevailing assumption that technology alone can drive meaningful rehabilitation outcomes and highlights the indispensable role of clinical expertise and intervention design.

Critically, several limitations continue to restrict the clinical utility of wearable technologies. Among these, the lack of standardized validation protocols and the widespread use of proprietary algorithms represent major barriers. These issues limit transparency and reduce confidence in the accuracy and reproducibility of wearable-derived data (Fuller et al., 2020; Li et al., 2025). Consequently, clinicians should interpret wearable data with caution, prioritizing longitudinal trends over single-point measurements and integrating these data with clinical assessments to ensure appropriate decision-making (Piwek et al., 2016).

Behavioral sustainability represents another key challenge. Although wearable devices are effective in initiating behavior change through feedback, goal setting, and self-monitoring, maintaining long-term engagement remains problematic (Ferguson et al., 2022). Importantly, evidence suggests that sustained adherence is unlikely without structured intervention frameworks, behavioral support strategies, and ongoing clinician involvement (Peek et al., 2019). This indicates that wearable technologies function most effectively as facilitators of behavior change rather than independent drivers.

From a broader sustainability perspective, wearable technologies align well with the goals of modern healthcare systems by supporting remote care delivery, reducing resource utilization, and enhancing continuity of care (De Fazio et al., 2023). Nevertheless, their large-scale implementation is constrained by several systemic barriers, including data privacy concerns, lack of interoperability, economic limitations, and insufficient clinician training (Antarsih et al., 2025). Addressing these barriers is essential to ensure equitable and sustainable integration into clinical practice.

Taken together, the findings of this review support a mechanism-based interpretation of wearable technology use in physiotherapy. Rather than functioning as standalone solutions, wearable technologies should be conceptualized as components of a comprehensive rehabilitation ecosystem. Their true value lies in their capacity to augment clinical decision-making, enhance patient engagement, and support long-term rehabilitation strategies when integrated into evidence-based and clinician-supervised care models (Latif et al., 2024; Ferguson et al., 2022).

This framework extends previous literature by integrating clinical effectiveness, behavioral adherence, technological validity, and system-level scalability into a unified sustainability model, providing a structured basis for future intervention design and evaluation.

## **LIMITATIONS**

This study has several limitations. First, as a narrative review, it does not include a systematic search strategy or quantitative synthesis, which may introduce selection bias. Second, the included studies vary in design, population, and intervention characteristics, limiting the generalizability of findings. Third, many wearable technologies evaluated in the literature rely on proprietary algorithms, restricting transparency and independent validation. Additionally, long-term outcomes and cost-effectiveness analyses remain insufficiently explored in current research. Future studies should focus on high-quality randomized controlled trials, standardized validation protocols, and long-term follow-up data to strengthen the evidence base.

Importantly, the lack of high-quality randomized controlled trials and standardized outcome measures limits the strength of current evidence.

## **CONCLUSION**

Wearable technologies represent a promising approach for enhancing sustainable physiotherapy and rehabilitation. They improve physical activity, support home-based interventions, and promote patient engagement.

However, their widespread adoption requires improvements in data accuracy, algorithm transparency, and integration into clinical workflows. A multidisciplinary, evidence-based approach is essential to maximize their potential in sustainable healthcare systems. Future physiotherapy models should not adopt wearable technologies as isolated tools, but rather embed them within integrated, mechanism-driven rehabilitation systems.

## **FUTURE DIRECTIONS**

Future research should focus on:

- Standardized validation protocols
- AI-driven personalized rehabilitation
- Long-term adherence studies
- Cost-effectiveness analyses
- Integration into clinical decision-making systems

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## **STUDY OF VARIABLES IN THE RATIO OF CREATINE IN THE BLOOD OF SHORT, MEDIUM AND LONG DISTANCE FOR RUNNERS**

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### **ABSTRACT**

The study of the effect of training on jogging on serum creatine levels is important to identify the level of developmental and functional development, as well as understanding the process of developing appropriate training programs for short, medium and long term effectiveness.

Creatine is an important indicator in the human body by calculating the blood quantities in the day following the race or training in order to know the work of the kidneys or any damage in them, and to establish a sound path and right to our coaches and our players relying on the analysis that helps them in the development of their achievement.

The aim of the study was to study the variables in the ratio of creatine in the blood of short, medium and long distances of 10 players. The experimental approach - equal groups due to its relevance to the subject of the research.

The researchers concluded:

The presence of effects of significant significance for the athletes in the various energy systems in the ratio of creatine in the blood of the players and according to the high intensity and effort in the functional work of the two kidneys.

Short-range athletes were more susceptible to high blood creatinine, as they needed higher voltage than medium and short hips.

**Keywords:** Creatine, blood and distance

### **INTRODUCTION**

The study of the effect of training on different types of jogging on the blood creatine ratio is important and necessary to know the level of development and functional as well as the understanding of the development of training programs suitable for the events of short, medium and long, which has received great attention by researchers and trainers in the world, where the largest number of The medals in the games because the awards are characterized by individuality in addition to attracting large numbers of athletes and the public because of the skill, excitement and suspense. Laboratory analysis has been used to determine changes in creatine levels of short-, medium- and long-term athletes due to the effect of exercise with different training doses on them. It is therefore necessary to identify the physiological and chemical laws on which functional changes occur during sporting events and which help to improve the body's response when controlling and working on them.

In view of the specificity of jogging by regulating the production of different energy and the development of the physical and functional capabilities of the players in order to achieve

advanced achievements, the importance of research in the study of the impact of jogging the various energy production systems in the proportion of creatine in the blood according to modern scientific bases in order to raise the level of players to reach their achievements to reach the level of players in developed countries in this important and vital.

Creatine is an important indicator of the metabolism of proteins in the human body. This is done by calculating its quantity and its value in the blood because it is one of the energy-rich chemical compounds to measure the metabolic remains that indicate tiredness and recovery. However, some trainers did not give enough importance to this vital and influential aspect. The development of training curricula that are affected by the type of effort given to the short, medium and long distance runners who need proper nutrition, especially the quality of the meat and the quantity of power generation according to the type of intensity and training load of each and the impact of this on the proportion of creatine ratio in the blood in order to develop a sound track and true in front of our coaches and players by relying on sound scientific results that are useful in the development of their achievement.

Research aims:

1. Knowledge of the effects of energy systems at different levels of creatine blood in the players.
2. Knowledge of the differences in the ratio of creatine blood runners according to the energy systems used in each of the variables investigated.

Research hypotheses:

1. The short, medium and long circuits of different energy systems have a real effect on the blood creatine ratio of the players.
2. There are differences in the proportion of creatine blood between the groups of the research sample in the variables investigated.

## **MATERIALS AND METHODS**

The experimental method is used as an equal group due to its relevance to this research. Experimental approaches examine the problems and phenomena based on the experimental method or the scientific research method based on observations, hypotheses and precise experiments to verify hypotheses (Mahmood Al-Rubaie et al. 2018, p. 30)

The research sample:

The research sample consisted of 10 (10) advanced runners in the field and the field were chosen by random method and those who practice activities ran (100 m and 3-1500m and the



number of (4 – 5000 m and the number 3) distributed to three groups and depending on the type of game. In order to identify the characteristics of the sample members and the extent of their representation in the research community, the researcher found some variables as shown in Table 1.

**Table 1.** Represents the computational circles, standard deviations and percentages of the distribution of the members of the research sample according to the type of effectiveness in some variables

| Activity   | Number of Players | percentage | Variables    | Units | Mean   | SD   |
|------------|-------------------|------------|--------------|-------|--------|------|
| 100 meter  | 3                 | %30        | Age          | Year  | 26.58  | 3.34 |
|            |                   |            | Training age | Year  | 5      | 2.47 |
|            |                   |            | Weight       | Kg    | 70.25  | 2.66 |
|            |                   |            | Length       | cm    | 170.75 | 4.9  |
| 1500 meter | 4                 | %40        | Age          | Year  | 25.13  | 3.54 |
|            |                   |            | Training age | Year  | 4      | 2.51 |
|            |                   |            | Weight       | Kg    | 67.80  | 4.51 |
|            |                   |            | Length       | cm    | 170.90 | 4.01 |
| 5000 meter | 3                 | %30        | Age          | Year  | 23.73  | 3.24 |
|            |                   |            | Training age | Year  | 5      | 2.31 |
|            |                   |            | Weight       | Kg    | 61.67  | 5.22 |
|            |                   |            | Length       | cm    | 172.67 | 5.11 |

#### Pilot study:

For the purpose of adjusting variables for the main experiment, the researcher conducted a reconnaissance experiment on 15/2/2024, the purpose of which was to:

1. Ensure that the task force can apply duties.
2. Identify the time of the experiment to benefit from the main experiment.
3. Identify the requirements of conducting the main experiment in terms of materials used and others.

#### Field research procedures

##### Measurements and tests:

1. Anthropometric measurements (length, weight, age, training age)
2. Measurement of some biochemical variables (measuring the concentration of urea in the blood)

##### Method of testing:

The assistant team drew blood samples from the eye in order to conduct tests on them and to identify some biochemical variables (serum creatin concentration). The blood was withdrawn

after the athlete had been out of food for at least six hours. The laboratory temperature (37 degrees).

### **The main experience:**

The assistant team drew blood samples from the resting position, six minutes before the race and for all the sample of the research during the first day of the official championship period corresponding to 18/2/2024. On 20/2/2018, another sample was drawn from the blood of runners running 100 m After the official race for them, and draw the blood for the contestants 1500 m, 5000 m on 21/2/2024 also after the completion of the race immediately after the transfer of a special portfolio to the laboratory where the measurements there until 3/3/2024 were processed statistically, as stated in the door the fourth.

## **RESULTS**

**Table 2.** Show pretests for the three groups in creatine test, (t) value and significance level

| Groups              | Pretest |        | Posttest |        | (t) value  |           | Type of significance |
|---------------------|---------|--------|----------|--------|------------|-----------|----------------------|
|                     | Mean    | SD     | Mean     | SD     | Calculated | Tabulated |                      |
| 100 meter (short)   | 125.33  | 45.74  | 136      | 45.177 | 32         | 4.352     | Sig.                 |
| 1500 meter (Medium) | 98.650  | 17.05  | 109.175  | 18.821 | 3.985      | 3.182     | Sig.                 |
| 5000 meters (long)  | 92.766  | 18.917 | 94.000   | 20.952 | 0.196      | 4.352     | Non sig.             |

The first group (ran 100 m) shows that (2) for the creatinine test, Phosphokinase, the mean (125.333) and the standard deviation (45.742) in the pretest, the mean (136) and the standard deviation (45.177), (2), which indicates that the difference is significant between the pre and post tests and for the benefit of the post-test

The mean of the calculation of creatine phospho-kinase was (98.650) with a standard deviation (17.051) in the pretest. In the post-test, the mean (109.175) and the standard deviation (18.821), the calculated value (t) (3.985), which is the largest of the value of the table (3.182) by line (0,05) and the degree of freedom (3), indicating that the difference is significant between the pre-test and the post-test and for the post-test

(5000) meter Table (2) shows that the computation of the test creatine phosphokinase (92.766) and the standard deviation (20.952) in the post-test. The calculated value (t) is 0.196, which is smaller than the total value of (4.352) and a score of error (0.05) and degree of freedom (2), which indicates that the difference is not significant between the tests pre and post.

Knowledge and the difference between the groups in the post tests the researcher sought to test the analysis of variance as in the following table?

**Table 3.** Shows the results of variance of the three groups in the post-test creatine test

| Source of variation | Total squares deviations | df | Average square deviations | (f) value calculated | (f) value Tabulated | Indication of difference |
|---------------------|--------------------------|----|---------------------------|----------------------|---------------------|--------------------------|
| Between groups      | 2727.433                 | 2  | 1363.717                  | 1.585                | 4.74                | Non sig.                 |
| Within groups       | 26022.768                | 7  | 860.395                   |                      |                     |                          |
| Total               | 8750.201                 | 9  | 2224.112                  |                      |                     |                          |

Table (3) shows that the calculated value of (f) is (1.585), which is smaller than the (f) tabular value of (4.74) and by mistake (0.05) and freedom degree (7.2). This indicates that the differences between the averages Groups are not significant.

## DISCUSSION

Creatine is an important indicator of the metabolism of proteins in the human body. This is done by calculating the quantity and value of blood in the day following the race or training to measure the residual metabolism following the race or training, which indicates tiredness, recovery and removal of metabolic residues.

In the three groups (short-, medium- and long-term), the ratio of creatine in the blood was normal, where it was limited to (1-2-6), as shown in Table 2. Although the ratio increases during short- May lead to a relative increase even though they are within the normal range. In our observation of Table (2) we find that after the effort there is an increase in the ratio of creatine in the blood for the spindles (100) m, which can be explained by the high effort in this sport and reliance on the phosphate creatinine stored muscle in burning energy, which leads to increase the proportion of blood availability and delay The rate of removal by the kidneys due to the relative discontinuation of kidney function, as is the case in runners (1500 and 5000), since the dependence on phosphogensic storage is not the burning of energy (Divix-1988- p. 59)

Table (2) shows that the results are significant for the three groups in the post tests in the pre. The researcher attributed this to the fact that the rider of these events controlled the rate of effort through the appropriate speed, which makes the creatine phosphate and the metabolism is not exhausted before the time, indicating that it allows the most efficient use of phosphate metabolism and creatine during the full competition.

On this basis, we did not see any significant differences between the three tests of the three groups as shown in Table (2). The reason is that the metabolic process is responsible for the energy used during these activities, but it is emptied less quickly than the phosphate creatine during these activities and during the physical effort, Because the metabolic process is done by other devices, so the impact of the exercise of sporting events will be delivered on all the organs of the body, which shows us that the body and its functional mechanism works as a unit.

## **CONCLUSIONS**

1. The long range (5000 m) group was less affected by the high blood creatinine ratio because it required more long-term training than short and medium training.
2. Effect of kidney function towards elimination of excess creatinine due to delay in removal rate by kidneys in running (100 m)
3. There is an increase in creatine in the blood for spasticity (100 m) due to high stress and dependence on muscle creatine phosphate in the muscle to burn energy
4. Do not rely on the reservoirs in the burning energy (1500 m) and (5000 m), which leads to removal by the kidneys
5. Control the runners in the rate of effort through the appropriate speed makes phosphate creatine and the metabolism is not exhausted before the ozone
6. No significant differences of the three groups because the metabolism is responsible for the energy used during the pharmacology, to be discharged less quickly than phosphate creatine.

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## DO YOGA PRACTICES AFFECT YOGIS' LEVEL OF NUTRITIONAL KNOWLEDGE AND THEIR ADHERENCE TO THE MEDITERRANEAN DIET?

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### ABSTRACT

Yoga has been gaining increasing attention in recent years as a holistic approach that supports physical and mental health through its teachings. However, the effect of the duration of yoga practice on individuals' nutritional knowledge and adherence to the Mediterranean diet (AMD) has not yet been fully clarified. The aim of this study was to determine the relationship between yoga practices of varying durations and the nutritional knowledge levels, dietary quality, and AMD among women yoga practitioners. This cross-sectional correlational study included 181 female yoga practitioners aged 18–50 living in the province of Antalya. The questionnaire includes general and nutrition-related information, anthropometric measurements, the Mediterranean Diet Adherence Scale, the Nutrition Knowledge Level Scale, and a 24-hour dietary recall. Approval for the study was obtained from the Ethics Committee (date: 13.05.2025, decision number: 2025/03). According to the study results, women who have been practicing yoga for more than one year are older and have a higher level of nutritional knowledge ( $p<0.001$ ). There is no significant difference in MEDAS or DQI-I scores based on the duration of yoga practice. A positive correlation was found between nutrition knowledge and AMD among yoga practitioners ( $r=0.252$ ,  $p<0.001$ ). Additionally, a negative correlation was found between nutritional knowledge and the number of snacks consumed and sleep duration (respectively:  $r=-0.183$ ;  $-0.173$ ,  $p<0.05$ ); a positive correlation was found between the DQI-I and age ( $r=0.233$ ,  $p<0.05$ ). The findings indicate that the duration of yoga practice is not directly associated with

diet quality or AMD, but is associated with individuals' level of nutritional knowledge. In this context, incorporating nutrition education into yoga practices may be an effective approach to improving individuals' diet quality and promoting healthy eating behaviors.

**Keywords:** Mediterranean diet, nutrition, level of nutrition knowledge, MEDAS, yoga

## INTRODUCTION

The adoption of healthy lifestyle behaviors is important for the prevention of chronic diseases and the improvement of quality of life, and healthy eating habits are among the key factors determining individuals' overall health status (Watts et al., 2018). Yoga, which fundamentally means unity, connection, and continuity, is an ancient form of meditation that originated in the Indian subcontinent but whose philosophy has spread worldwide. It involves a mind and body practice that enhances individuals' overall health and well-being (Büssing et al., 2012). It is also stated that yoga supports maintaining mental and emotional balance, as well as healthy lifestyle changes such as improved sleep and weight control (Cramer et al., 2016). Yoga practices, which aim at lifestyle change and are considered a mind–body intervention, are thought to have an impact on eating behavior, food choices, and healthy eating practices; however, our knowledge regarding the effects of yoga on nutrition knowledge (NK), attitudes, and behaviors, as well as its potential to promote healthy eating behavior, remains limited (Braun et al., 2012). In a study evaluating the combined effects of yoga practice and the Mediterranean diet on the nutritional status and functional capacity of community-dwelling older adults, it was found that the Mediterranean diet and yoga intervention improved individuals' health and functional capacities (Carcelén-Fraile et al., 2024).

Changes in eating behaviors primarily occur through an increase in NK. NK encompasses understanding of nutrition- and health-related concepts and processes, including how diet is linked with health and disease, the role of foods as sources of essential nutrients, as well as dietary guidelines and nutritional recommendations (Miller & Cassady, 2015). Level of NK is a critical determinant of individuals' ability to make healthy food choices. In this context, the Dietary Quality Index (DQI), which is used to assess individuals' nutritional quality, is an important indicator that provides a holistic evaluation of various components of the diet. It has been reported that a higher DQI is associated with healthier dietary patterns (Najibi et al., 2023).

The Mediterranean diet is a sustainable eating pattern widely practiced in Mediterranean regions, characterized by a high intake of vegetables, fruits, whole grains, olive oil, and fish, along with a low consumption of red meat and processed products. It is one of the most

prevalent dietary models in these countries and has been associated with a reduced risk of chronic diseases (Guasch-Ferré & Willett, 2021). Adherence to the Mediterranean diet (AMD) is influenced not only by cultural factors but also by individuals' NK (Aridi et al., 2022). It is known that individuals with higher NK show greater AMD pattern and have a lower risk of obesity (Bonaccio et al., 2013). It has been reported that an increase in NK among adults significantly improves healthy and balanced eating behaviors as well as AMD (Öngün Yilmaz et al., 2025). Considering the potential effects of yoga practice on individuals' lifestyle behaviors, it becomes important to evaluate its impact on NK, AMD, and overall diet quality. However, there is limited research in the literature that jointly examines the relationships between the duration of yoga practice and these nutritional indicators (Braun et al., 2012; Yadav et al., 2020). Accordingly, this study sought to investigate how the length of yoga practice influences NK, AMD, and the DQI-I among individuals engaged in yoga.

## **MATERIALS AND METHODS**

This cross-sectional, correlational study was conducted between August 2025–March 2026 with individuals aged 18–50 who practice yoga and are registered at YogaKioo centers and branches located in Antalya province. The sample size was calculated using G\*Power analysis as 180 participants, based on a medium effect size ( $d = 0.25$ ), a 5% margin of error ( $\alpha = 0.05$ ), and 80% power ( $1 - \beta = 0.80$ ). Between the study dates, 181 adult yogis who were registered at this center and had been practicing yoga for at least 6 months with a minimum of 1 hour per week were included in the study.

### *Inclusion criteria*

- Having been attending the YogaKioo center for at least six months.
- Actively practicing yoga for at least one hour per week on a regular basis.
- Not having any chronic disease that requires a special diet
- Being willing to participate in the study voluntarily.
- Being literate
- 18-50 years of age

### *Exclusion criteria*

- Being pregnant
- Not regularly participating in yoga activities.



The research data were collected through face-to-face interviews. The questionnaire included participants' general information, anthropometric measurements, a 24-hour dietary recall, Diet Quality Index-International (DQI-I) calculated using dietary intake data, the Mediterranean Diet Adherence Screener (MEDAS), and the Nutrition Knowledge Level Scale (NKLS). Ethical approval for the study was obtained from the Non-Interventional Clinical Research Ethics Committee of Alanya Alaaddin Keykubat University, dated 13.05.2025 and decision numbered 2025/03. The study was conducted in accordance with the Declaration of Helsinki, and informed consent was obtained from all participants.

### **Questionnaire form**

The general information section of the questionnaire included questions on participants' demographic characteristics such as age, education, occupation, etc., as well as the number of main meals and snacks, meal skipping status, sleep duration, and use of dietary supplements.

### **Anthropometric measurements**

Participants' height was measured without shoes, with feet together and in the Frankfort plane, on a flat surface with the head, back, hips, and legs touching the surface at four points. The distance from the highest point of the head to the ground was measured using a TARTI brand telescopic stadiometer (Pekcan, 2020). Body weight and body composition were assessed using a Tanita BC-730 body composition analyzer, following standard procedures. A non-stretch Seca measuring tape was used to measure waist circumference, and the waist-to-height ratio was calculated. A waist circumference of  $\geq 102$  cm in men and  $\geq 88$  cm in women was considered to indicate a high health risk (Pekcan, 2020), while body mass index (BMI) ( $\text{kg}/\text{m}^2$ ) was calculated using height and body weight measurements. The World Health Organization classification was used in the evaluation of BMI (WHO, 2025).

### **24-hour dietary recall**

The dietary intake of yogis was assessed by recording all foods and beverages consumed over a retrospective 24-hour period. The portion sizes of foods consumed by participants were determined using the Food and Nutrition Photograph Catalog (Rakıcıoğlu et al., 2017), and the nutrient content of one portion of foods consumed outside the home was calculated using the Standard Food Recipes book (Merdol, 2016). The energy and nutrient content of each food item

was analyzed using the full version of the Nutrition Information System (BEBIS 9) software package.

### **Diet Quality Index-International (DQI-I)**

Diet quality was evaluated based on the results of the 24-hour dietary recall records. The index focuses on four main dimensions of a high-quality and healthy diet: adequacy, variety, moderation, and overall balance. Each dimension includes various nutrient components for evaluation. The scores of each component are summed separately to obtain a total score ranging from 0 to 100. The minimum possible score is 0, and the maximum score is 100. It has been stated that diet quality is associated with the total score, and as the total score obtained from the index increases, the quality of the diet improves (Kim et al., 2003).

### **Mediterranean Diet Adherence Screener (MEDAS)**

The scale, developed by Martínez-González et al. (2012) and adapted into Turkish by Pehlivanoglu et al. (2020), consists of 14 items evaluating individuals' AMD. Participants receive 1 or 0 points for each question based on their consumption status, and a total score is calculated. It is stated that individuals scoring below 7 have low AMD, those scoring 7 or above have an acceptable level of adherence, and those scoring 9 or above have a high level of AMD.

### **Nutrition Knowledge Level Scale (NKLS)**

Participants' level of nutrition knowledge was assessed using the NKLS developed by Gündoğdu and Ünüsan (2009). The scale consists of 25 multiple-choice questions. In scoring, 1 point is given for correct answers and 0 points for incorrect answers. When evaluated, individuals can score a minimum of 0 and a maximum of 25 points on the scale. Accordingly, scores of 0–6 are classified as “very poor,” 7–12 as “poor” 13–17 as “moderate,” 18–21 as “good” and 22–25 as “very good NK.” In order for individuals to be considered as having adequate NK, they must correctly answer at least 18 questions.

### **Statistical Analysis**

Data analyses were conducted using SPSS Statistics version 27.0. The distribution of quantitative variables was evaluated through histogram and probability plots. For independent group comparisons, normally distributed variables were analyzed using the independent samples t-test, whereas the Mann–Whitney U test was performed when the assumption of normality was not satisfied. Relationships between categorical variables were examined using

the chi-square test. Pearson correlation was performed for variables with normal distribution, whereas Spearman correlation was used for non-parametric data. A commonly used level of statistical significance was set at  $p < 0.05$ .

## RESULTS AND DISCUSSION

Table 1 presents the general characteristics of the participants according to the duration of yoga practice. The median age of individuals practicing yoga for  $\geq 1$  year is higher compared to those practicing yoga for  $< 1$  year ( $p < 0.001$ ). Across the duration of yoga practice, groups showed similar distributions in education level, income status, number of main and intermediate meals, meal-skipping behavior, sleep duration, and dietary supplement use ( $p > 0.05$ ).

**Table 1.** General Characteristics of Participants According to Duration of Yoga Practice (n = 181)

| Variables                          | Duration of yoga practice |                  | p                   |
|------------------------------------|---------------------------|------------------|---------------------|
|                                    | <1 year (n=93)            | ≥1 year (n=88)   |                     |
| Age                                | 27.0 (20.0-48.0)          | 32.5 (23.0-50.0) | <0.001 <sup>a</sup> |
| Education level                    |                           |                  |                     |
| High school                        | 11 (11.8)                 | 5 (5.7)          | 0.068 <sup>b</sup>  |
| University                         | 68 (73.1)                 | 59 (67.0)        |                     |
| Postgraduate                       | 14 (15.1)                 | 24 (27.3)        |                     |
| Income                             |                           |                  |                     |
| Moderate                           | 64 (68.8)                 | 56 (63.6)        | 0.461 <sup>b</sup>  |
| High                               | 29 (31.2)                 | 32 (36.4)        |                     |
| Number of main meals               |                           |                  |                     |
| 1                                  | 4 (4.3)                   | 6 (6.9)          | 0.168 <sup>b</sup>  |
| 2                                  | 52 (55.9)                 | 37 (42.0)        |                     |
| 3                                  | 37 (39.8)                 | 45 (51.1)        |                     |
| Number of snacks                   |                           |                  |                     |
| None                               | 9 (9.7)                   | 16 (18.2)        | 0.374 <sup>b</sup>  |
| 1                                  | 30 (32.2)                 | 29 (33.0)        |                     |
| 2                                  | 53 (57.0)                 | 42 (47.7)        |                     |
| 3                                  | 1 (1.1)                   | 1 (1.1)          |                     |
| Meal skipping                      |                           |                  |                     |
| Yes                                | 36 (38.7)                 | 29 (33.0)        | 0.420 <sup>b</sup>  |
| No                                 | 57 (61.3)                 | 59 (67.0)        |                     |
| Supplement use                     |                           |                  |                     |
| Yes                                | 44 (47.3)                 | 53 (60.2)        | 0.082 <sup>b</sup>  |
| No                                 | 49 (52.7)                 | 35 (39.8)        |                     |
| Sleep duration                     | 8.0 (4.0-10.0)            | 8.0 (5.0-12.0)   | 0.145 <sup>a</sup>  |
| Body mass index (BMI)              | 22.1±2.2                  | 22.2±2.0         | 0.680 <sup>c</sup>  |
| BMI Classification                 |                           |                  |                     |
| Normal                             | 83 (89.2)                 | 78 (88.6)        | 0.896 <sup>b</sup>  |
| Overweight                         | 10 (10.8)                 | 10 (11.4)        |                     |
| Waist circumference                | 69.0 (56.0-91.0)          | 68.0 (58.0-94.0) | 0.592 <sup>a</sup>  |
| Waist circumference classification |                           |                  |                     |

|                              |                  |                  |                    |
|------------------------------|------------------|------------------|--------------------|
| Normal/No risk               | 81 (87.1)        | 74 (84.1)        | 0.564 <sup>b</sup> |
| Risky / high risk            | 12 (12.9)        | 14 (15.9)        |                    |
| <b>Waist-to-height ratio</b> | 0.4 ± 0.0        | 0.4 ± 0.0        | 0.418 <sup>c</sup> |
| <b>Body fat (%)</b>          | 27.4 (11.0-37.7) | 26.9 (12.5-39.7) | 0.100 <sup>a</sup> |

BMI: Body mass index

<sup>a</sup>: Mann-Whitney U Testi   <sup>b</sup>: Chi-square test   <sup>c</sup>: Independent Samples T Test

Table 2 presents the MEDAS, NKLS, and BMI scores according to the duration of yoga practice. When participants' total MEDAS scores and their classifications were examined according to the duration of yoga practice, the groups did not differ significantly ( $p>0.05$ ). When evaluated in terms of NKLS, it was found that individuals who had been practicing yoga for  $\geq 1$  year had higher NKLS compared to those who had been practicing yoga for  $<1$  year ( $p=0.001$ ). Similarly, a significant difference was found between the groups in terms of NKLS classifications ( $p<0.001$ ), and it was determined that individuals who had been practicing yoga for  $\geq 1$  year had a higher proportion of moderate and good levels of NK.

**Table 2.** MEDAS, NKLS, and DQI-I Scores According to Duration of Yoga Practice

| Variables                              | Duration of yoga practice |            | p                   |
|----------------------------------------|---------------------------|------------|---------------------|
|                                        | <1 year                   | ≥1 year    |                     |
| MEDAS total score                      | 5.5 ± 1.5                 | 5.3 ± 1.6  | 0.394 <sup>b</sup>  |
| MEDAS classification                   |                           |            |                     |
| Low adherence                          | 70 (75.3)                 | 67 (76.1)  | 0.892 <sup>a</sup>  |
| Acceptable adherence                   | 23 (24.7)                 | 21 (23.9)  |                     |
| NKLS total score                       | 12.9 ± 3.3                | 14.6 ± 3.6 | 0.001 <sup>b</sup>  |
| NKLS classification                    |                           |            |                     |
| Poor NKLS (7-12)                       | 52 (55.9)                 | 19 (21.6)  | <0.001 <sup>a</sup> |
| Moderate NKLS (13-17)                  | 27 (29.0)                 | 48 (54.5)  |                     |
| Good NKLS (18-21)                      | 14 (15.1)                 | 21 (23.9)  |                     |
| DQI-I total score                      | 52.6 ± 7.6                | 52.7 ± 8.5 | 0.940 <sup>b</sup>  |
| DQI-I classification                   |                           |            |                     |
| Poor diet quality (≤49)                | 39 (41.9)                 | 33 (37.5)  | 0.742 <sup>a</sup>  |
| Diet quality needs improvement (50-59) | 35 (37.6)                 | 38 (43.2)  |                     |
| Good diet quality (≥60)                | 19 (20.5)                 | 17 (19.3)  |                     |
| DQI-I sub-dimensions                   |                           |            |                     |
| Variety                                | 14.3 ± 2.2                | 14.2 ± 2.5 | 0.857 <sup>b</sup>  |
| Moderation                             | 13.5 ± 4.9                | 14.1 ± 5.3 | 0.437 <sup>b</sup>  |
| Adequacy                               | 21.7 ± 3.5                | 21.3 ± 3.5 | 0.403 <sup>b</sup>  |
| Overall balance                        | 3.1 ± 1.9                 | 3.0 ± 1.9  | 0.977 <sup>b</sup>  |

MEDAS: Mediterranean Diet Adherence Screener, NKLS: Nutrition Knowledge Level Scale, DQI-I: Diet Quality Index-International

<sup>a</sup>Chi-square   <sup>b</sup>Independent samples T test

Table 3 presents correlations between MEDAS, NKLS, and DQI-I according to selected participant characteristics. Age showed significant positive associations with NKLS, total DQI-

I score, and the moderation subdimension (respectively  $r=0.263$ ;  $0.300$ ;  $0.233$ ; all  $p<0.001$ ). In contrast, age was negatively correlated with the number of snacks ( $r=-0.225$ ;  $p<0.001$ ) and sleep duration ( $r=-0.327$ ;  $p<0.001$ ). A positive relationship was identified between the number of snacks and sleep duration, whereas snack frequency was negatively associated with NKLS (respectively  $r=0.173$ ;  $-0.183$ ; all  $p<0.05$ ). Sleep duration also demonstrated a negative correlation with NKLS ( $r=-0.173$ ;  $p<0.05$ ). MEDAS was positively correlated with NKLS ( $r=0.252$ ;  $p<0.001$ ).

Furthermore, strong positive associations were observed among all DQI-I subdimensions and the total score ( $p<0.001$ ). Within these subdimensions, variety was positively correlated with adequacy ( $r=0.257$ ;  $p<0.001$ ), while a negative association was observed between variety and overall balance ( $r=-0.171$ ;  $p<0.05$ ). Additionally, both moderation and adequacy showed positive correlations with overall balance ( $p<0.05$ ). This study examined the effect of yoga practice duration on individuals' AMD, NK level, and diet quality. The findings indicated that the duration of yoga practice was associated with NK level; however, it had no significant effect on AMD or diet quality. The higher median age among individuals who had been practicing yoga for  $\geq 1$  year suggests that yoga practice may be a sustainable lifestyle behavior, and previous studies have shown that as age increases, the daily duration of yoga practice tends to be shorter, but its long-term sustainability is greater (Grabara, 2025; Ward et al., 2025). In the literature, it has been reported that as age increases, individuals' health awareness improves and their tendency toward healthy lifestyle behaviors strengthens (Kalyoncuo & Kartın, 2025). This may explain the longer duration of yoga practice among older age groups.

The positive relationship between age and the moderation dimension of the DQI-I suggests that portion control and balanced eating behaviors are more commonly adopted in older age. Wang et al. (2023) also found that healthy eating behaviors increase with age and that individuals tend to consume smaller, more frequent meals. In addition, a negative correlation was observed between age and both the number of snacks and sleep duration in our study, which may be influenced by lifestyle factors. It is known that younger individuals, in particular, tend to have irregular eating and sleep habits (Najata et al., 2021). In addition, the negative correlation between the number of snacks and NK level suggests that individuals who consume more snacks do not always exhibit conscious eating behaviors. However, our understanding of the negative relationship between sleep duration and nutritional knowledge level is limited. In the

literature, it has been stated that the relationships between sleep and eating behaviors are complex and multidimensional, and are influenced by multiple factors (Dashti et al., 2015). In our study, no significant differences were found in anthropometric measurements according to the duration of yoga practice. In a systematic review and meta-analysis examining the effects of yoga on anthropometry, quality of life, lipid profile, and obesity, no beneficial effect of yoga practices on body weight and BMI was observed, and it was reported that it is not possible to conclude that yoga significantly improves anthropometric parameters (Asiah et al., 2023). However, the literature also reports that yoga practices may have positive effects on body composition. It has been observed that the practice of Bikram yoga for 6 months reduced body fat percentage in women (Zoila et al., 2026). In a study comparing the effects of yoga and walking on anthropometric measurements in overweight and obese adults, both yoga and walking were found to significantly reduce BMI, waist circumference, hip circumference, fat-free mass, body water, and total cholesterol (Telles et al., 2014). Although it has been reported that yoga practices may have positive effects on body composition, these effects are generally influenced by other lifestyle factors such as the duration and intensity of physical activity, as well as dietary habits (Shetty et al., 2018). In this context, it may be considered that the duration of yoga practice alone may not be sufficient to change anthropometric indicators. In addition, the lack of a significant relationship between anthropometric measurements and yoga duration may be due to the fact that most of the yoga practitioners in our study had BMI and waist circumference values within the normal range.

**Table 3.** Correlations Between Participants' General Characteristics, MEDAS, NKLS, and DQI-I

| Variables                | 1                   | 2              | 3                   | 4                   | 5                | 6              | 7                | 8              | 9                | 10               | 11               | 12               | 13               | 14               | 15               |
|--------------------------|---------------------|----------------|---------------------|---------------------|------------------|----------------|------------------|----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 1.Age                    | 1                   | 0.078          | -<br><b>0.225**</b> | -<br><b>0.327**</b> | 0.099            | 0.122          | 0.135            | -0.017         | 0.065            | <b>0.263**</b>   | <b>0.233**</b>   | 0.019            | <b>0.300**</b>   | 0.101            | 0.072            |
| 2.Number of main meals   | 0.078               | 1              | -0.057              | -0.011              | -0.098           | 0.022          | -0.044           | -0.013         | -0.026           | -0.010           | 0.041            | <b>0.203**</b>   | -0.075           | 0.089            | 0.016            |
| 3. Number of snacks      | -<br><b>0.225**</b> | -0.057         | 1                   | <b>0.173*</b>       | -0.108           | -0.057         | -0.088           | -0.022         | -0.033           | <b>-0.183*</b>   | 0.019            | -0.053           | -0.077           | 0.126            | 0.033            |
| 4.Sleep duration         | -<br><b>0.327**</b> | -0.011         | <b>0.173*</b>       | 1                   | 0.014            | -0.029         | -0.009           | 0.001          | 0.051            | <b>-0.173*</b>   | -0.007           | 0.044            | -0.104           | 0.076            | -0.032           |
| 5. BMI                   | 0.099               | -0.098         | -0.108              | 0.014               | 1                | <b>0.700**</b> | <b>(0.779**)</b> | <b>0.406**</b> | <b>(-0.129)</b>  | <b>(0.032)</b>   | <b>(-0.112)</b>  | <b>(0.032)</b>   | <b>(-0.134)</b>  | <b>(-0.018)</b>  | <b>(-0.113)</b>  |
| 6. Waist circumference   | 0.122               | 0.022          | -0.057              | -0.029              | <b>0.700**</b>   | 1              | <b>0.932**</b>   | <b>0.355**</b> | -0.101           | -0.023           | -0.054           | -0.031           | -0.093           | 0.068            | -0.067           |
| 7. Waist-to-height ratio | 0.135               | -0.044         | -0.088              | -0.009              | <b>(0.779**)</b> | <b>0.932**</b> | 1                | <b>0.356**</b> | <b>(-0.123)</b>  | <b>(-0.031)</b>  | <b>(-0.066)</b>  | <b>(-0.046)</b>  | <b>(-0.052)</b>  | <b>(0.006)</b>   | <b>(-0.090)</b>  |
| 8. Body fatt (%)         | -0.017              | -0.013         | -0.022              | 0.001               | <b>0.406**</b>   | <b>0.355**</b> | <b>0.356**</b>   | 1              | -0.087           | -0.004           | -0.114           | -0.009           | -0.099           | -0.042           | -0.118           |
| 9. MEDAS total score     | 0.065               | -0.026         | -0.033              | 0.051               | <b>(-0.129)</b>  | -0.101         | <b>(-0.123)</b>  | -0.087         | 1                | <b>(0.252**)</b> | <b>(0.097)</b>   | <b>(0.083)</b>   | <b>(0.074)</b>   | <b>(0.008)</b>   | <b>(0.092)</b>   |
| 10. NKLS total score     | <b>0.263**</b>      | -0.010         | <b>-0.183*</b>      | <b>-0.173*</b>      | <b>(0.032)</b>   | -0.023         | <b>(-0.031)</b>  | -0.004         | <b>(0.252**)</b> | 1                | <b>(0.045)</b>   | <b>(0.053)</b>   | <b>(0.038)</b>   | <b>(0.041)</b>   | <b>(-0.053)</b>  |
| 11. DQI-I total score    | <b>0.233**</b>      | 0.041          | 0.019               | -0.007              | <b>(-0.112)</b>  | -0.054         | <b>(-0.066)</b>  | -0.114         | <b>(0.097)</b>   | <b>(0.045)</b>   | 1                | <b>(0.311**)</b> | <b>(0.784**)</b> | <b>(0.635**)</b> | <b>(0.549**)</b> |
| 12. Variety              | 0.019               | <b>0.203**</b> | -0.053              | 0.044               | <b>(0.032)</b>   | -0.031         | <b>(-0.046)</b>  | -0.009         | <b>(0.083)</b>   | <b>(0.053)</b>   | <b>(0.311**)</b> | 1                | <b>(-0.078)</b>  | <b>(0.257**)</b> | <b>(-0.171*)</b> |
| 13. Moderation           | <b>0.300**</b>      | -0.075         | -0.077              | -0.104              | <b>(-0.134)</b>  | -0.093         | <b>(-0.052)</b>  | -0.099         | <b>(0.074)</b>   | <b>(0.038)</b>   | <b>(0.784**)</b> | <b>(-0.078)</b>  | 1                | <b>(0.136)</b>   | <b>(0.446**)</b> |
| 14. Adequacy             | 0.101               | 0.089          | 0.126               | 0.076               | <b>(-0.018)</b>  | 0.068          | <b>(0.006)</b>   | -0.042         | <b>(0.008)</b>   | <b>(0.041)</b>   | <b>(0.635**)</b> | <b>(0.257**)</b> | <b>(0.136)</b>   | 1                | <b>(0.166*)</b>  |
| 15. Overall balance      | 0.072               | 0.016          | 0.033               | -0.032              | <b>(-0.113)</b>  | -0.067         | <b>(-0.090)</b>  | -0.118         | <b>(0.092)</b>   | <b>(-0.053)</b>  | <b>(0.549**)</b> | <b>(-0.171*)</b> | <b>(0.446**)</b> | <b>(0.166*)</b>  | 1                |

BMI: Body mass index, MEDAS: Mediterranean Diet Adherence Screener, NKLS: Nutrition Knowledge Level Scale, DQI-I: Diet Quality Index-International

Without parentheses: Spearman correlation

(with parentheses): Pearson correlation

\* $p < 0.05$ \*\* $p < 0.001$

One of the key findings of the study is that individuals who had been practicing yoga for  $\geq 1$  year had higher levels of nutritional knowledge. This may be explained by the possibility that yoga practice increases awareness levels and contributes to individuals becoming more conscious about nutrition. In a study evaluating the nutritional status and health behaviors of women who had received yoga training and engaged in exercise, women who regularly participated in yoga exercises were found to have healthier eating habits, indicating that yoga practitioners have a higher level of awareness regarding health and nutrition (Gogojewicz et al., 2024). In a study examining the potential of yoga to promote healthy eating and physical activity behaviors among young adults, regular yoga practice was found to increase motivation toward healthy eating habits characterized by higher fruit and vegetable consumption, lower intake of sugary beverages and snacks, and less frequent fast food consumption (Watts et al., 2018). In light of all these findings, it may be suggested that regular yoga practice can positively influence individuals' NK by increasing their level of awareness. In our study, the lack of a significant difference in MEDAS and DQI-I according to yoga practice duration indicates that an increase in knowledge level does not always translate into behavioral change. It has been stated that eating behaviors are influenced by numerous factors such as socioeconomic status, cultural factors, and environmental determinants; therefore, even when individuals have a high level of nutritional knowledge, this knowledge does not necessarily promote healthy eating behaviors (Kucharska et al., 2025; Orhan et al., 2026). It is suggested that NK should be supported by training that includes motivation and self-regulation skills in order for it to translate into healthy eating behaviors.

In this study, the observed positive relationship between age and NK level and diet quality supports the idea that awareness of healthy eating increases with age (Spronk et al., 2014). Although the literature on the relationship between MEDAS and NKLS in yoga practitioners is limited, the positive association found in our study between MEDAS and NKLS is consistent with previous findings (Bonaccio et al., 2013; Aridi et al., 2022; Aureli & Rossi, 2022), indicating that higher NKLS are associated with greater adherence to a healthy dietary pattern. In our study, the weak positive correlation between MEDAS and NKLS also suggests that NK is a multidimensional construct influenced by socioeconomic status, education, and cultural factors, and that knowledge alone is not sufficient to determine AMD. Overall, our findings indicate that in yoga practitioners, there is a relationship between NK level, AMD, and diet



quality; however, this relationship is not fully reflected in behavior, and lifestyle factors may play a determining role in this process. It is therefore considered important that future studies conducted among yoga practitioners include interventions that support the translation of NK into behavior.

### **Challenges and Limitations**

This study has several limitations. First, due to its cross-sectional design, causal relationships could not be established; therefore, the findings regarding the effect of yoga practice duration on NKLS should be interpreted only at a correlational level. In addition, the use of self-reported data may have introduced potential measurement biases, such as recall bias and social desirability bias. The fact that the sample consisted of yoga practitioners enrolled in yoga schools in Antalya and was not selected randomly limits the generalizability of the findings. Finally, potential confounding variables such as stress level, psychological status, and health literacy were not examined in this study; these factors may influence both NK level and diet quality and could therefore have affected the study results.

### **CONCLUSION**

Our study results indicate that the duration of yoga practice has a positive effect on NKLS; however, it has no significant effect on MEDAS scores or DQI-I. These findings suggest that an increase in nutritional knowledge alone is not sufficient to induce behavioral change. Integrating nutritional education interventions into yoga practices may help improve both individuals' awareness levels and healthy eating behaviors. Future studies planned with yoga practitioners are recommended to include intervention-based and longitudinal designs.

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## WHAT IS NEW IN CRYOTHERAPY?

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### ABSTRACT

Contemporary cryotherapy is evolving from simple cold therapy toward advanced technologies supporting regeneration, biological regeneration, and aesthetic medicine. New trends focus on increasing safety, precision, and combining treatments with other physiotherapy methods.

Here are the key innovations and trends in cryotherapy:

- modern cryochambers (cryosaunas): New devices offer faster cooling (up to -140°C or lower with liquid nitrogen) with increased safety. Computer-controlled systems allow for precise adjustment of treatment temperature and duration to the patient's individual needs.
- local cryotherapy in a new guise: In addition to the classic application of cold, advanced local cryotherapy devices (cryoprobes, nitrogen applicators) are used to precisely freeze tissue, which is particularly useful in sports medicine for injuries (e.g., bruises, sprains).
- combining with other methods: A new innovation is the synergy of cryotherapy with other physical treatments. Studies show that combining cryotherapy with laser therapy produces significantly better therapeutic results in the treatment of injuries than using these methods separately.
- cryotherapy in aesthetic medicine: Cryotherapy is gaining importance in reducing cellulite and firming the skin. By stimulating microcirculation and improving tissue metabolism, these treatments leave the skin looking healthier and firmer.
- supporting wellness and mood: A new approach emphasizes the impact of whole-body cryotherapy not only on pain but also on the release of endorphins (happiness hormones), which helps reduce stress and improve well-being.
- proctological cryotherapy: The use of low temperatures to treat hemorrhoids is a modern, less invasive method that improves patient comfort.

**Keywords:** cryotherapy, local cryotherapy, whole-body cryotherapy.

## COMPUTATIONAL STRATEGIES FOR DESIGNING 3D POROUS CARBON ANODES FOR SODIUM-ION BATTERIES: A MINI REVIEW

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### ABSTRACT

Sodium-ion batteries (SIBs) offer a potential alternative for large-scale clean energy storage owing to sodium's abundance and low cost. However, the conventional graphite and hard carbon anodes suffer from limited storage capacity and sluggish kinetic diffusion, hindering their practical application. To address this challenge, the design of three-dimensional (3D) porous carbon anodes using graphene, biphenylene, and doped carbon-based structures have been being recently explored to improve electronic conductivity, storage capacity, and ion mobility. The unique porous architecture of the nonbenzenoid biphenylene sheet and sulfur incorporation in the graphene ribbons can offer superhigh storage capacity and improve the overall electrochemical properties of the battery cell. The fundamental properties of these nanostructures have been evaluated by applying density functional theory and deep potential molecular dynamic. This review highlighted the recent trend in designing advanced SIB anodes using quantum mechanical-based computational techniques, contributing to the development of low-cost and sustainable clean energy storage systems for future applications.

**Keywords:** 3D porous carbon; Sodium-ion batteries; First-principles calculations; Machine learning

### INTRODUCTION

One of the most widely used clean energy storage technologies that is transforming our daily life is lithium-ion batteries (LIBs) [1,2]. Because lithium is expensive and scarce in the earth's crust, sodium-ion batteries (SIBs) have emerged as a viable LIB substitute [3,4]. Thus, SIBs can be used in large-scale applications such as electric vehicles due to its availability and low-cost. The electrochemical performance of LIBs and SIBs is comparable and primarily relies on the appropriate choice of anode and cathode materials. In charging, sodium ions are deintercalated from the cathode (made of transition metal oxides) and passed by an electrolyte, approach into the anode (made of carbonaceous materials). The oxidation reaction on the anode, which is caused by the sodium ions leaving the structure of the negative electrode and reaching into the cathode layers, causes the battery to discharge spontaneously when current flows in an external circuit [5]. Figure 1 illustrated of the SIBs' operational principle. Therefore, utilizing

SIBs instead of LIBs has a number of benefits (i) A NIB cell is safer to operate than a LIB because sodium is less reactive and prone to thermal runaway reactions; (ii) the Na/Na<sup>+</sup> potential reduction (−2.71 V) is only 300 mV higher than that of Li (−3.04 V); (iii) sodium is the fourth most abundant element on Earth with a wide range of sodium precursors and low cost; and (iii) sodium is ideal when a massive amount of alkali metals is used for large-scale applications [6].

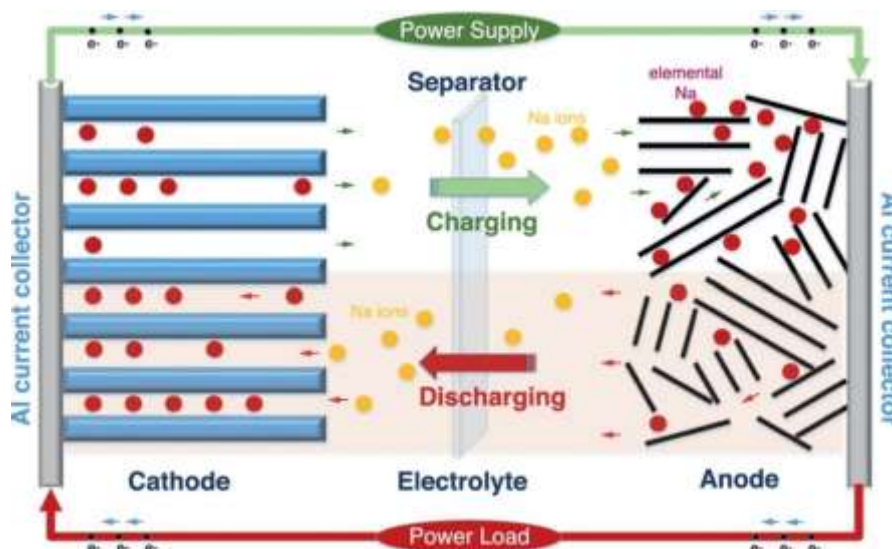


**Figure 1.** Working principle of sodium-ion batteries [7].

SIBs are competitive with LIBs and practically possible because to the variety of sodium-based electrolytes and the well-developed cobalt-free high voltage cathodes. [8] Sodium is cheap and abundantly available in nature which can be used as an alternative to LIBs to power the electric vehicles. However, the major bottleneck in advancing SIB cells is the anode part. With a storage capacity of 35 mAh g<sup>−1</sup>, graphite, the commonly utilized anode component in LIBs, is unable to store Na<sup>+</sup> because of the large ionic radius of sodium. Intensive research has been done on the anode part to find the most suitable materials that can accommodate a high amount of sodium, at least comparable to that of graphite in LIBs. To solve this issue, hard carbon (HC) with lots of voids is utilized. [9,10] However, the main obstacles to utilizing HC anode are still the low storage capacity (250 mAh g<sup>−1</sup>), hazardous average voltage (0.01-0.30 V), slow ionic diffusion (0.76 eV), poor electrical conductivity and cycling stability, and substantial volume variations. [11,12]

To address some of the issues noted above, a variety of porous carbonaceous materials have been used as anodes for SIBs in addition to traditional graphite and HC. [13] However, the electrical conductivity and Na-kinetic diffusion are directly impacted by the uneven distribution of the pores. [14,15] Hence, controlling porosity is key to developing more efficient carbonaceous-based anode materials. [16] For instance, three-dimensional (3D) structures including organized porosity and promising electrochemical performance have effectively included graphene nanoribbons. [17] Additionally, doping carbon lattices with heteroatoms has been regarded as a possible tactic to adjust the electrodes' electrical conductivity, expand storage capacity, and accelerate the ions' kinetic diffusion. [18,19] Sulfur is particularly interesting for battery applications among the different nonmetal dopants (B, P, and N), [20-22] because it can react with Na ions in an active manner. [23] The storage mechanism in 3D porous carbon and sulfur-doped carbon needs to be revealed. Sulfur's huge ionic radius can degrade the structure and greatly expand the porous channels, causing rapid ionic diffusion. [24,25] Additionally, an asymmetric charge distribution and the development of more active adsorption sites could result from such a significant lattice distortion. [26] However, the doping sites of S are not well-defined, which could result in a shuttle effect during the sodiation and desodiation process. For instance, Xu et al. [13] reported a 3D porous reduced graphene foam, and their outcomes presented that the studied material stores a high amount of sodium ions of  $836.2 \text{ mAh g}^{-1}$ . Additional computational study showed that defective C-honeycomb provide a theoretical capacity of  $711 \text{ mAh g}^{-1}$ , but with volume change (15%). Yuan et al. [27] also reported that sulfur doping could enhance the performance of hard carbon anode. The sulfurized hard carbon shows a storage capacity of  $520 \text{ mAh g}^{-1}$  at  $100 \text{ mA g}^{-1}$  and rate capability of  $257 \text{ mAh g}^{-1}$  at a high current density of  $2 \text{ A g}^{-1}$ . Also, Imran et al. [28] studied 3D porous sulfurized graphdiyne and applied density functional theory to evaluate the electrochemical performance of this material as anode for SIB. The results unveil a storage capacity of  $913.8 \text{ mAh g}^{-1}$  and energy barrier of  $0.41 \text{ eV}$ . Thus, materials discovery and optimization are key areas of research. Our goal is to design carbon electrode materials that can offer well-distributed porous channels and well-defined sulfur doping sites to enhance the storage capacity, diffusion kinetics, and cycling stability during the charge and discharge process.



### Recent advances in designing 3D porous carbon-based anodes

Carbon atoms are highly flexible in chemical bonding where different carbon allotropes with different dimensionality can be synthesized. [29] 3D porous carbon materials have been experimentally synthesized using chemical vapor deposition. [30] Graphene nanoribbons can be used as basic building blocks to construct these 3D porous structures. [31] Still, these assembled materials lack high electronic conductivity and ordered porosity. Therefore, we are looking for 3D ordered porous carbon allotropes that can provide the following: (i) small volume change during charge and discharge process, (ii) high storage capacity of sodium ions, and (iii) ionically and electronically conductivity, (iv) high-rate performance and safety as shown in Figure 2. The first two criteria (i) and (ii) can be achieved by designing highly porous structures with abundant inequivalent sites for sodium ion adsorption. To prevent mechanical failure and capacity decline, the ordered porosity may serve as a buffer to reduce the strain brought on by the injection of a large sodium ionic radius. [32-34] The porous channels are favorable for fast ionic diffusion kinetic. However, most interpenetrated porous carbon-based anode suffers from poor conductivity. [35] Designing a porous anode structure with high electrical conductivity combined with ordered porosity is key to achieving high performance SIB anodes. Doping is another strategy to satisfy these criteria.

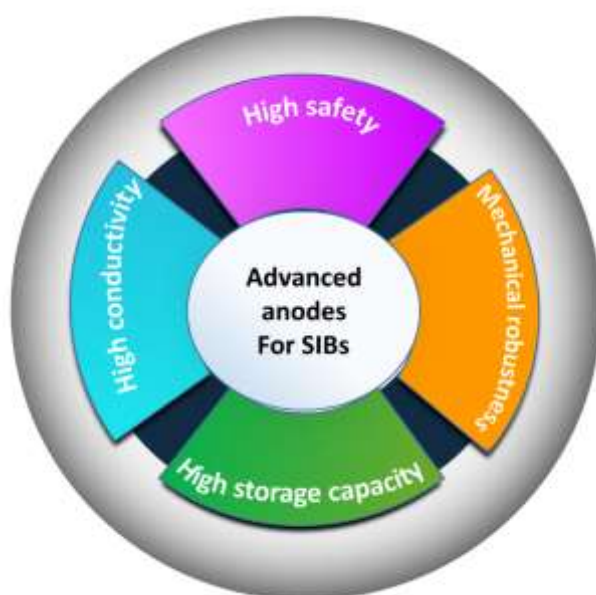


**Figure 2.** Criteria for designing advanced SIB anodes.

With the recent developments in supercomputers and computational procedures like first-principle calculations, structure search methods based on artificial intelligence, and machine learning, [36] high-performance materials can be predicted and reveal their basic properties such as electronic properties, thermal, mechanical and dynamical stability, synthesizability, and much more, which are vital for designing advanced battery cells and other fields. [37-41] Thus, these computational techniques are powerful tools for generating and evaluating new class of 3D porous carbon materials. [42-43] Researchers have successfully integrated graphene nanoribbons into three-dimensional porous structures with high electronic conductivity applicable for high performance SIB anode. (Figure 3) [34] Na ions can diffuse easily in these designed materials that have homogeneous pores distribution compared with the heterogeneous distribution of the pores in conventional hard carbon. However, theoretical storage is still minimal ( $\leq 300 \text{ mAh g}^{-1}$ ), which raises a concern about the efficiency of these materials as anode materials for SIBs. This is simply attributed to the use of a hexagonal carbon lattice that can accommodate a single sodium ion in one hexagon ring. Table 1 lists the electrochemical performance of several carbon-based anodes for SIBs. One can see that the 3D porous carbon-based structures overcome the electrochemical performance of the commercialized graphite and hard carbon structures.

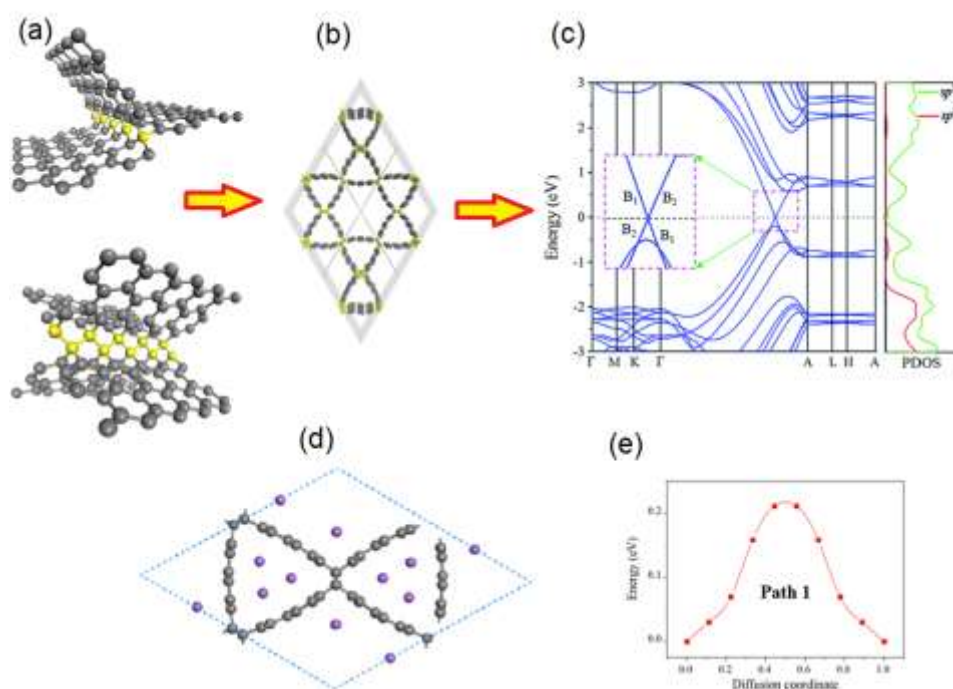


**Figure 3.** The construction high electronic conductivity 3D porous carbon by using graphene nanoribbons as building blocks and its application as SIB anode. [34]

**Table 1.** Comparison of gravimetric capacity (mAh g<sup>-1</sup>), volumetric capacity (mAh mL<sup>-1</sup>) activation energy (eV), open-circuit voltage OCV (V), volume expansion (%) of several anodes for NIBs.

| System                          | gravimetric capacity | Volumetric capacity | Activation energy | OCV    | Volume expansion% |
|---------------------------------|----------------------|---------------------|-------------------|--------|-------------------|
| tC <sub>24</sub> <sup>17</sup>  | 232                  | 353.62              | 0.05-0.13         | 0.54   | 0.94              |
| Doped C-honeycomb <sup>19</sup> | 711                  | 855.5               | 0.17-0.24         | 0.0075 | 15                |
| hC2844                          | 717                  | 946.44              | 0.08-0.17         | 0.36   | 2.30              |
| Bco-C2445                       | 495.9                | 778.5               | 0.02-0.14         | 0.42   | 5.60              |
| bct-C5633                       | 478.2                | 728.1               | 0.07-0.12         | 0.45   | 0.02              |
| HZGM-4234                       | 318.5                | 442.71              | 0.08-0.21         | 0.43   | 1.85              |
| Hard carbon <sup>12,46,47</sup> | 300                  | 465                 | 0.76              | 0.30   | 30                |
| Graphite <sup>48</sup>          | 35                   | 79                  | 0.40              | -      | -                 |

‘-’ means data unavailable.

Furthermore, stoichiometric 3D porous SiC<sub>4</sub> structures have been generated by particle swarm optimization method implemented CALYPSO code. [49] The generated structures are metallic in nature and have been studied as potential candidates for battery applications. The interactions of nonmetal elements like N, P, B, and S with carbon could improve the physical and chemical properties of the pristine 3D porous carbon structures. [18] Several studies show that dopants can improve structural stability due to the creation of strong covalent bonds. Furthermore, metallic nature has been achieved in 3D porous BPC<sub>2</sub> compound, revealing the contribution of the dopants in improving the electronic properties of carbon. [50] Sulfur doping in carbon lattice is rarely studied and signifies a developing research field. [51] Very recently, a 3D porous sulfurized carbon has been theoretically predicted, where the S atom is bonded with six butadiyne linkages. [28] The predicted compound shows excellent electrocatalytic and energy storage performance.

To improve the efficiency and storage capacity of these novel materials and overall electrochemical properties, one must care about controlling the design and synthesis strategy, using building blocks that have different carbon rings such as biphenylene, or applying the heteroatom doping strategy (Figure 4). Because of its uniform distribution of tetragonal, hexagonal, and octagonal carbon rings across two dimensions (2D), biphenylene offers sodium ions nonequivalent adsorption sites. [52] This 2D material has been rarely integrated into 3D porous structures, which could be suitable for hosting novel properties. Further, sulfur has a

large ionic radius, which distorts the structure and enlarges the porous channels, which could facilitate high electronic conductivity, increase the storage capacity, and improve the ionic diffusivity. However, the exact doping site of sulfur are not well defined yet, and designing carbon structure with well-defined porosity and sulfur doping sites are of importance. Hence, the best candidate anode should be a 3D metallic material with ordered porous channels for high  $\text{Na}^+$  storage and rapid diffusion. Hence, designing low-cost 3D porous carbon-based materials with electronic conductivity could allow us to improve the anode part of SIBs. Furthermore, finding novel preparation methods as well as theoretical modeling techniques is an urgent task to expedite the discovery of new carbon-based materials that fulfill this purpose. This broad picture motivates us to explore more carbon-based anode materials by using biphenylene as building blocks and sulfur doped porous carbon structures by evaluating their fundamental properties as well as electrochemical performance as anode for sodium-ion batteries using density functional theory (DFT), particle swarm optimization search method, and machine learning based on deep potential molecular dynamic method.

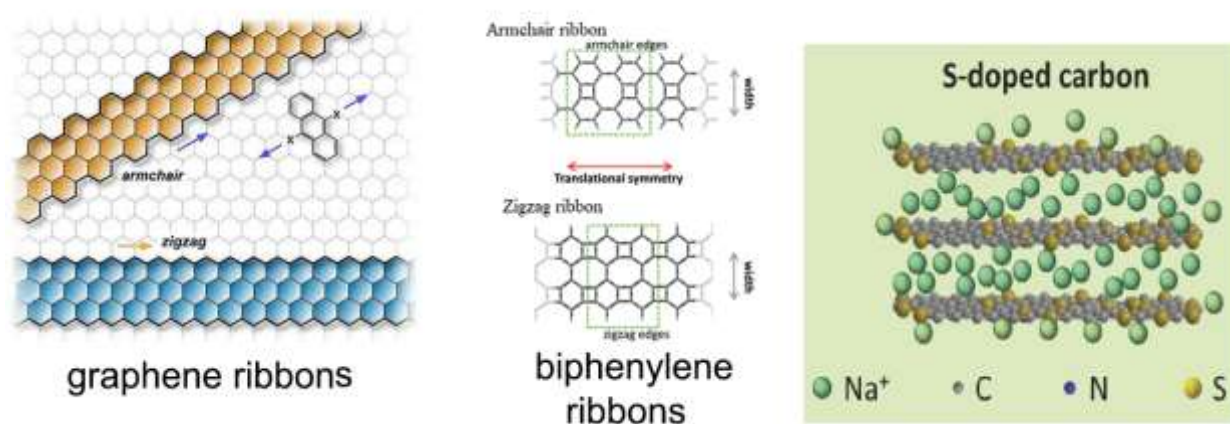


**Figure 4.** The basic building blocks of graphene, biphenylene, and sulfur doped hard carbon.  
[24,53,54]

### Scientific challenges and possible solutions

To design high performance anode material for SIBs, the material must be metallic with ordered porosity and high structural stability. However, it is difficult to find these properties in one material. Therefore, finding a universal anode material consider a hot topic in the field. Assembling graphene or biphenylene nanoribbons and their doping strategy into 3D porous

structures is still immature. Hence, there are several challenges that need to be addressed, which could crack the potential use of the broad family of carbon-based materials for battery applications. The current scientific challenges and research directions in this subject are summarized as follows:

- (1) Finding preparation or assembling methods to integrate low-dimensional graphene and biphenylene building blocks into 3D structures with metallicity and ordered porosity is an urgent task in advancing SIB cells.
- (2) Should the doping strategy with sulfur start from graphene/biphenylene nanoribbons and then assembled into 3D structure? If this is not the case, should we assemble the nanoribbons into 3D structures and then start the doping with sulfur?
- (3) Limited precursors availability to get the basic building blocks of 4-,6-,8-membered carbon rings for synthesizing biphenylene nanoribbons.
- (4) Because the computational cost of density functional theory (DFT)-based first-principles computations rises exponentially with the number of atoms in the unit cell, it takes longer for porous structures. Therefore, machine learning will expedite the discovery and characterization of these materials.
- (5) Most materials are designed by hand, which will take time to find suitable anode materials. In order to close this gap, the CALYPSO code's intelligent particle-swarm optimization search approach will be used.

For this purpose, we draw a path for future guidelines to design advanced 3D porous structures by assembling biphenylene building blocks and sulfur doping graphene nanoribbons by following the steps below:

- (1) Designing stable 3D porous structures: Since biphenylene sheets and its nanoribbons are synthesized, they can be used as building blocks with/without linkers to design stable SIBs anodes. Direct assembly of these building blocks can be done by gluing the armchair biphenylene nanoribbons through the interaction of the available valence electrons. Carbon nanotube can be used and selected as a linker to build these 3D porous structures. Further, sulfur can interact with zigzag graphene nanoribbons to form highly stable structure.
- (2) After obtaining a stable 3D porous structure, we intend to study the fundamental properties of the designed electrodes including their structural, thermal, electronic, and mechanical properties at ambient conditions.

(3) Finally, we will conduct theoretical calculations to evaluate the performance of the designed electrodes as anodes for sodium-ion batteries. The theoretical storage capacity, voltage profile, diffusion energy barriers, diffusion coefficient, and volume changes during sodiation/desodiation process must be studied.

Very recently, our group have successfully designed a series of 3D porous architectures by applying biphenylene nanoribbons and doped graphene ribbons as basic building blocks [10,55]. The designed structure shows excellent performance as anodes for SIBs with superhigh storage capacity and fast kinetic diffusion as shown in Figure 5. The C8S, for instance, has a substantial reversible storage capacity of 465 mAh g<sup>-1</sup>, a low diffusion barrier of 0.06 eV, and a small volume change of 3.3% during the charging and discharging operation. Moreover, the average open circuit voltage (0.64 V) ensures good safety during fast charging rates (Figure 5a). On the other hand, the storage capacity of graphite and hard carbon anodes is thirty times lower than that of HexC28, which has a volumetric capacity of 1109 mAh mL<sup>-1</sup> and a gravimetric capacity of 956 mAh g<sup>-1</sup>. Furthermore, its average potential equals to 0.47 V and negligible volume change (3.60%), and low diffusion energy barrier (0.20-0.36 eV), ensuring fast charging (Figure 5b).

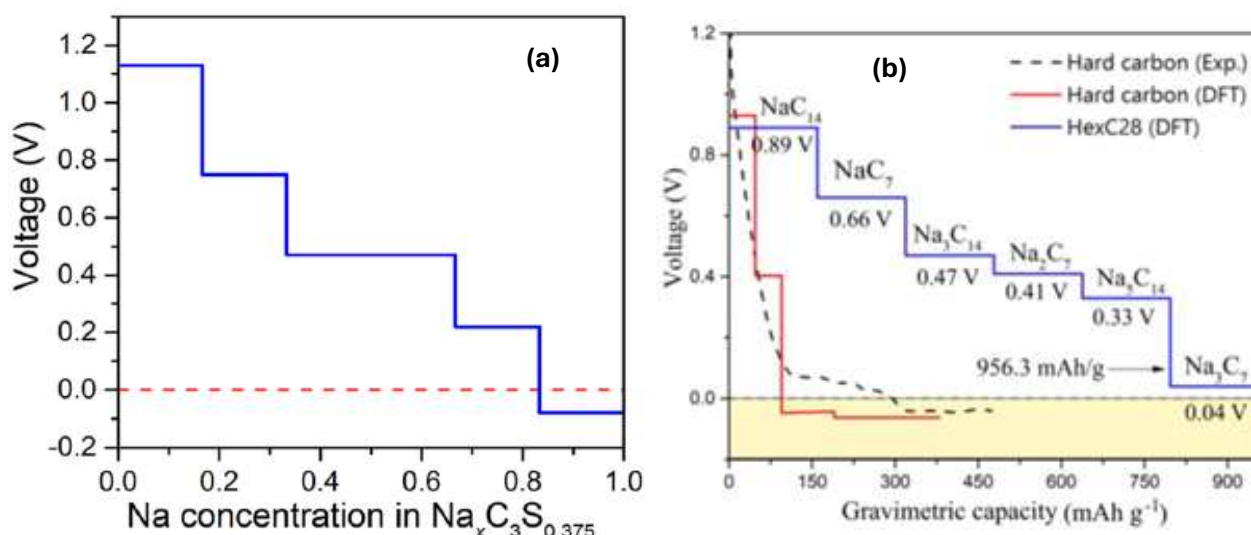


**Figure 5.** The voltage profile of sodiated (a) sulfurized carbon C<sub>8</sub>S and (b) 3D porous biphenylene network HexC28 [9,45].

## Computational methods

### Packages and codes

The electrochemical characteristics of recently developed anode materials are frequently assessed using first-principles calculations based on density functional theory. (DFT) [40] The



mechanical properties, electrical structure, thermal stability, and energetic stability of 3D porous materials that will be used as improved SIB anodes can all be accurately predicted using this technology. Furthermore, the obtained ground state energy from DFT can be used to further evaluate the gravimetric and volumetric capacities, energy barriers of the diffused ions, voltage profile, and volume changes of the designed electrode materials. [37,39,56] Vast number of DFT codes have been employed to do this purpose, but Vienna Ab initio Simulation Package (VASP) [57], a plane wave-based code to perform first-principles calculations using projected augmented wave (PAW) pseudopotentials, has been extensively utilized. Furthermore, CALYPSO can be used to search for stable 3D porous structures by providing the chemical composition only. Due to the heavy element of sulfur and time-consuming NEB computation to get the energy barrier, deep potential molecular dynamic method can be used to assess the diffusivity of sodium with less time consuming and DFT-level accuracy (Figure 6). This method will allow us to deeply understand the diffusion behavior of sodium along different environments. Pymatgen can be used to enumerate the configurations and help to analyze the obtained data.

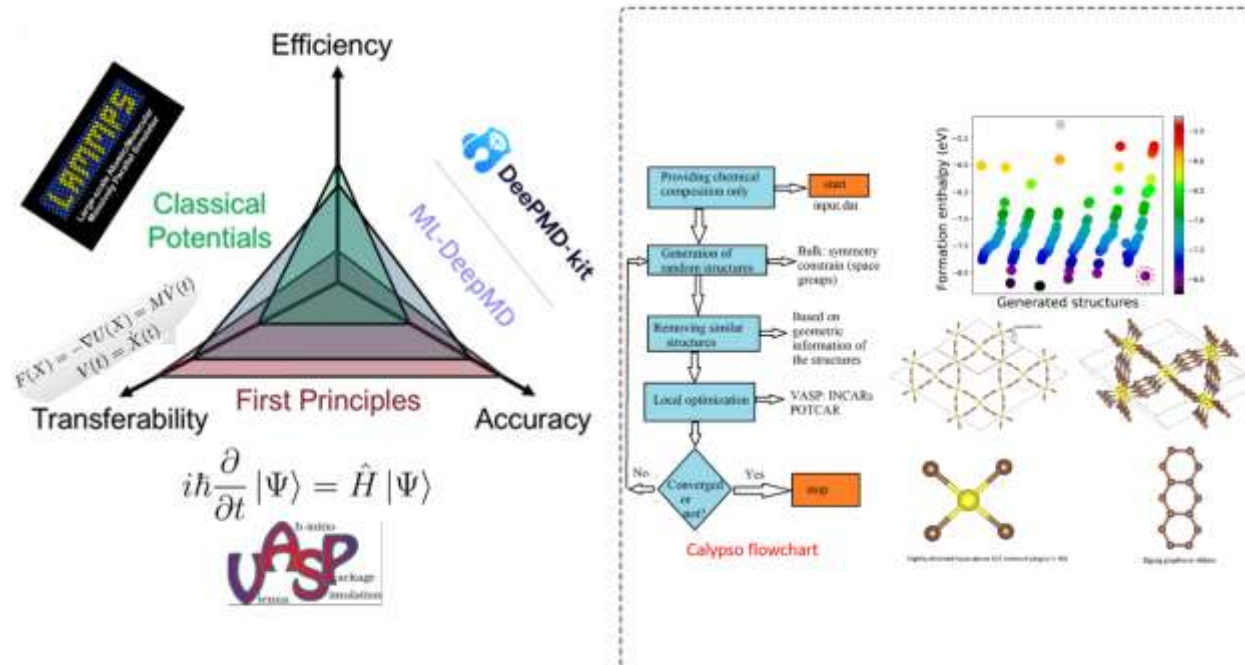


**Figure 6.** Sketch illustrating the use of DFT, DeepMD, and CALYPSO codes to search and characterize anode materials for sodium-ion batteries.

### **Stability of the electrodes**

Confirming the stability of the designed anode materials is the first toward evaluating their electrochemical properties. The ground state energy of the optimized electrodes can be used to obtain the total energy from DFT calculations, which are further used to derive all necessary parameters. In this case, there are four parameters that need to be evaluated in order to assess the stability of the designed 3D porous materials. These parameters can be summarized as follows:

#### **(a) Energetic stability**

The cohesive energy and/or formation enthalpy of the assembled 3D porous structures must be high enough to indicate the synthesizability of the designed materials. The stability of the relaxed structures using DFT is inversely proportional to total energy, where lower energies give high structural stability and indicates that the obtained structure is a local minimum.

#### **(b) Dynamic stability**

The lattice vibration of the assembled geometries can be determined by calculating phonon spectrum, which must be positive in the whole Brillouin zone; otherwise, the designed material is supposed to be dynamically unstable, where the acoustic or optical modes show negative frequencies. This step can be done by displacement of the atoms according to the symmetry of the designed materials.

#### **(c) Thermal stability**

Ab initio molecular dynamics AIMD simulations can be employed to confirm the thermal stability of the structures over a wide range of temperatures by obtaining the atomic forces in the unit cell. The evaluation of designed structures as a function of temperature is necessary for many applications, where intact structures are needed to maintain the safety of the assembled devices. This can be further used to evaluate the diffusivity of the sodium ions using deepMD-kit.

#### **(d) Mechanical stability**

Born-Huang criterion must be satisfied to confirm that the electrode materials are mechanical stability. Strain-energy method has been widely employed to evaluate the mechanical properties of different materials, where strain energy is used as a function of lattice distortion. According



to the lattice symmetry of materials, there are different formulas that can be used to evaluate the mechanical stability of these materials based on the calculation of their elastic constants.

### **Properties to be studied**

#### **Structural properties**

Biphenylene sheet has different carbon rings, which may show different bonding environments among tetragonal, hexagonal, and octagonal rings. Understanding the bonding characteristic of these rings will contribute to the stability of assembled 3D porous structures. Furthermore, the interaction of sulfur with graphene ribbons is a must for further characterization. Thus, calculating the bond lengths, bond angles, hybridization behaviors and atomic positions of these materials will help to shed more light on the structural stability of these porous geometries.

#### **(a) Mechanical properties**

Another important consideration in SIBs is the mechanical behavior of the electrode materials; poor electrode mechanical characteristics can either reduce battery life or cause cell failure during charge and discharge procedures. Due to the large ionic radius of sodium ions, it is necessary to evaluate the mechanical properties of the designed structures. Thus, evaluating the mechanical stability, Young's modulus, bulk modulus, ductility, and shear modulus are necessary to be calculated to confirm the suitability of the electrode materials for batteries.

#### **(b) Electronic band structure**

It is interesting to use metallic anode materials, which can deliver electrons efficiently to the current collector. This can be done by calculating and studying the electronic band structure of these materials using PBE/HSE06 methods. The interaction of *p* orbitals of the biphenylene nanoribbons in the 3D structures could lead to good electronic conductivity. Further, it has been confirmed that sulfur doping significantly improves the electronic conductivity of hard carbon.

#### **(c) Electrochemical properties**

Here, it is essential to calculate the electrochemical properties of the designed structures during charge/discharge process. In this sense, we have to test the anode performance by evaluating its capacity, voltage, diffusivity, and structural stability, which can be predicted as follows:

- I. Binding energy and formation energies of sodiated structures. Negative values indicate the stability of the sodiated structures, otherwise, phase separation could occur. As discussed above, the ground state energies of the DFT total energies of the sodiated structure, pristine structure, and bulk sodium are used to obtain the stability of the sodiated anode.
- II. Charge transfer: Bader charge analysis can be used to evaluate the charge transfer from sodium ions to the pristine geometry. More charge transformation leads safer anode by preventing clustering.
- III. Diffusion energy barriers can be used to evaluate the transport of the ions during sodiation and desodiation operations. Using the nudged elastic band (NEB) approach, this parameter can be computed. The initial and final migration points are well guessed and then intermediate images are generated and optimized to evaluate the total energies of these intermediate images. Due to the large consumption of computational resources using NEB, machine learning could provide accurately predicted values for the diffused ions with less time consuming.
- IV. Voltage profile of the sodiated structures. It is important to unveil the voltage profile of the designed anodes during sodiation, where positive values through the profile must be achieved, which indicates the reversible storage capacity. We can use the ground state total energy of the system to calculate the voltage profile of the anode which can be simply expressed as follows:

$$V \approx \frac{E_{M_{x_1-C}} - E_{M_{x_2-C}} + (x_2 - x_1)E_M}{(x_2 - x_1)e} \quad (1)$$

Where  $E_M$  is the energy of the metallic sodium phase and  $E_{M_{x_1-C}}, E_{M_{x_2-C}}$  are the total energies of the intercalated structures at various concentrations.

- V. Storage capacity and energy density of the designed anodes. The storage capacity of the anode is proportionally related to the number of adsorbed Na ions, where large numbers of adsorbed ions mean high storage capacity, which is inversely proportional to the molecular weight of the anode. Thus, lightweight anodes (carbonaceous electrodes) are expected to increase the storage capacity compared to transition metal oxides. The storage capacity ( $Q$ ) determined by using the expression below:

$$Q = nF/M_w \quad (2)$$

where  $M_w$  is the molecular weight of the active ingredients ( $\text{g mol}^{-1}$ ),  $F$  is the Faraday constant ( $26801 \text{ mA h mol}^{-1}$ ), and  $n$  is the number of monovalent adsorption ions. Thus, light element active materials could be used to reach a high potential storage capacity.

VI. Volume changes of the sodiated structures. This parameter can be evaluated by obtaining the volumes of the pristine and sodiated structures which can be measured by:

$$\Delta V = \frac{M_{M_xC_y} - M_C}{M_C} \times 100\% \quad (3)$$

1. The volumes of fully sodiated and virgin structures are denoted by  $M_{M_xC_y}$  and  $M_C$  respectively

## CONCLUSION

The review aims to shed light on the importance of designing high-performance carbon-based anodes for sodium-ion batteries. Graphite and hard carbon anodes are failed to intercalate the large sodium ions with storage capacity and fast diffusion kinetics. Therefore, the current research field moves to a new paradigm of designing high electronic and ionic conductivity electrodes with ordered porosity. Graphene nanoribbons have been widely used to assemble these porous structures. However, the theoretical storage capacity is still limited due to the presence of only one hexagonal ring for sodium adsorption. Therefore, our recent trend provides the following innovative ideas, as follows:

- (1) Compared with conventional anodes like graphite, hard carbon, and other 3D porous graphene-based electrodes, designing 3D porous biphenylene-based network anodes composed of 4-,6,8-membered carbon rings could provide high electrical conductivity and high storage capacity.
- (2) 3D porous sulfurized carbon electrodes assembled from graphene nanoribbons could enhance the ionic diffusion of sodium.
- (3) The designed 3D porous structures could be highly stable and experimentally realized, which comes from the high flexibility of carbon atoms during chemical bonding.

- (4) Due to the abundant inequivalent adsorption sites, 3D porous biphenylene-based anodes and sulfur doping can offer high storage capacity compared with conventional carbon electrodes.
- (5) The ordered porous channels and good electrical conductivity are suitable for high-rate performance, which is of high importance for high safety and short-time recharging of the cell.
- (6) The 3D porous network could be used as a buffer to alleviate the strain that comes from the large ionic radius of sodium.

For future studies in this direction by computation and simulation, the following aspects are worthy of more attention:

- (1) Developing algorithms to automatically create 3D porous metallic carbon materials composed non-benzenoid 3D porous carbon-based structures. Such Algorithms will help to expedite the discovery of novel 3D porous carbon-based metallic anode materials applicable for sodium ion-battery applications.
- (2) Finding new synthesis strategies to expand the family of 3D carbon-based structures with ordered porosity and metallicity. The broad availability of carbon precursors will help to synthesize graphene and its low-dimensional building blocks, which are necessary for the assembly of 3D structures with ordered porosity. However, only a few preparation methods such as template method, polymerization method, and vacuum sublimation method are available for this purpose. One can apply and follow similar preparation procedures to achieve 3D porous biphenylene-based structures with ordered porosity but with more sophisticated procedures due to the presence of defects.
- (3) A high-performance battery as a whole need to operate synergistically between its individual parts, so investigating the compatibility between the 3D porous carbon-based anode, cathode, and electrolyte is crucial for overall battery performance. More attentions are requested in this direction in future research.

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## ENDODONTIC TREATMENT OF A MANDIBULAR MOLAR TOOTH WITH A BROKEN FILE

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### ABSTRACT

Management of separated instruments during root canal treatment remains a significant clinical challenge, particularly in mandibular molars with complex canal anatomy. The presence of a fractured instrument may limit effective cleaning and shaping, potentially affecting endodontic treatment outcomes. This case report presents the management and follow-up of a mandibular molar with a separated instrument in the mesiobuccal canal associated with a periapical lesion. A patient presented with pain in a mandibular molar previously treated at another clinic, where an instrument fracture had occurred. Clinical and radiographic examination revealed pulpal necrosis and a periapical radiolucency. Despite attempts using different retrieval techniques, the separated instrument could not be removed. Therefore, the treatment was continued by focusing on effective chemo-mechanical preparation of the accessible canal space. Irrigation and canal shaping were completed, followed by single-cone obturation using a bioceramic sealer. Postoperative radiographs confirmed adequate root canal filling. At the 1-year follow-up, a reduction in the periapical lesion was observed with no clinical symptoms. At the 2-year follow-up, radiographic evaluation demonstrated significant healing of the lesion. Successful healing can be achieved even in the presence of a separated instrument when adequate disinfection and obturation are provided. Long-term follow-up is essential to confirm treatment success.

**Keywords:** Apical periodontitis, nonsurgical endodontic treatment, periapical healing, separated instrument

### KIRIK ALET BULUNAN MANDİBULAR MOLAR DIŞİN ENDODONTİK TEDAVİSİ

#### ÖZET

Kök kanal tedavisi sırasında kırık aletlerin yönetimi, özellikle kompleks kanal anatomisine sahip mandibular molar dişlerde önemli bir klinik zorluk oluşturmaktadır. Kırık alet varlığı, etkin temizleme ve şekillendirmeyi sınırlayarak tedavi sonuçlarını olumsuz etkileyebilir. Bu olgu sunumu, mesiobukkal kanalında kırık alet bulunan ve periapikal lezyon ile ilişkili bir mandibular molar dişin tedavi süreci ve takibini sunmaktadır. Hasta, tedavisi başka bir klinikte başlanmış ve işlem sırasında alet kırığı olmuş alt molar dişte ağrı şikâyeti ile başvurmuştur. Klinik ve radyografik incelemede pulpa nekrozu ve periapikal radyolüsen si tespit edilmiştir. Farklı alet çıkarma teknikleri denenmesine rağmen mesiobukkal kanaldaki kırık alet uzaklaştırılamamıştır. Bu nedenle tedavi, ulaşılabilir kanal alanının etkin kemo-mekanik preparasyonuna odaklanılarak sürdürülmüştür. İrrigasyon ve kanal şekillendirme tamamlandıktan sonra tek kon tekniği ile biyoseramik patla obture edilmiştir. Postoperatif radyografiler yeterli kanal dolumunu

doğrulanmıştır. Bir yıllık takipte klinik semptomlar ortadan kalkmış ve periapikal lezyonda azalma gözlenmiştir. İki yıllık takipte ise radyografik olarak belirgin iyileşme saptanmıştır. Yeterli dezenfeksiyon ve obturasyon sağlandığında, kırık alet varlığında dahi başarılı iyileşme elde edilebilir. Bu tür olgularda uzun dönem takip tedavi başarısının doğrulanması açısından önemlidir.

**Anahtar Kelimeler:** Apikal periodontitis, kırık alet, noncerrahi endodontik tedavi, periapikal iyileşme

## INTRODUCTION

Root canal treatment is a highly predictable and successful procedure for preserving teeth affected by pulpal and periapical diseases. The primary objective of treatment is the complete elimination of microorganisms and infected tissue from the root canal system, followed by adequate shaping, disinfection, and three-dimensional obturation.(Burns et al., 2022) However, despite advances in endodontic instruments and techniques, procedural complications may still occur during treatment. Among these, instrument separation within the root canal system remains one of the most challenging and clinically significant complications.(Madarati, Hunter, & Dummer, 2013) Separated instruments are more frequently encountered in teeth with complex root canal anatomy, particularly mandibular molars. These teeth often present with narrow, curved, and anatomically variable canals, especially in the mesial roots, which increase the risk of cyclic fatigue and torsional stress on endodontic files.(Piasecki, Makowka, & Gambarini, 2020) Such anatomical challenges not only predispose the instrument to fracture but also complicate subsequent management procedures.(Assaf, Seoud, Kataia, & Saber, 2024)

The presence of a fractured instrument within the canal may obstruct access to the apical third, thereby limiting effective cleaning, shaping, and irrigation of the entire canal system. This may compromise microbial control by preventing adequate chemo-mechanical debridement of the infected canal space. Consequently, residual bacteria and necrotic debris may remain in the inaccessible portion of the canal, potentially leading to persistent periapical inflammation and adversely affecting the prognosis of treatment.(Jaiswal, Gupta, Saxena, Tyagi, & Verma, 2025; Madarati et al., 2013) The clinical impact of a separated instrument depends on multiple factors, including the location and length of the fragment, the degree of canal curvature, the stage of instrumentation at which the fracture occurred, and whether a pre-existing periapical lesion is present. Although several management options have been described in the literature, including ultrasonic retrieval, bypass techniques, and magnification-assisted procedures, complete removal is not always feasible.(Ikhab Weboko, Kiptoo Kiptiony, & Wandera, 2024; Shaik et al., 2022) In some cases, aggressive retrieval attempts may increase the risk of excessive dentin

removal, root weakening, or perforation. When safe retrieval is not possible, nonsurgical endodontic treatment may still result in successful healing if adequate disinfection and obturation of the accessible canal space can be achieved.(Dioguardi et al., 2024) In such cases, long-term clinical and radiographic follow-up is of critical importance to monitor periapical healing, confirm the absence of symptoms, and evaluate the long-term success of treatment.(Turan Gökduman, Çanakçı, Arili Öztürk, & Er, 2025) Therefore, clinical decision-making should be individualized, balancing the potential benefits of instrument retrieval against the risks associated with the procedure.(Madarati et al., 2013) The present case report describes the nonsurgical management and long-term radiographic follow-up of a mandibular molar tooth with a separated instrument in the mesiobuccal canal associated with a periapical lesion.

## CASE PRESENTATION

A 37-year-old systemically healthy female patient was referred to our clinic with the chief complaint of persistent pain in a second mandibular molar tooth that had previously undergone endodontic treatment at another dental center. According to the patient's history, an instrument fracture had occurred during the initial root canal treatment procedure. The initial panoramic radiograph obtained at the referring clinic is shown in Figure 1.



**Figure 1.** Initial panoramic radiograph obtained at the referring clinic before presentation to our department.

Clinical examination revealed tenderness associated with the affected tooth. Radiographic assessment demonstrated a separated instrument located in the mesiobuccal canal together with a distinct periapical radiolucency, suggestive of apical periodontitis. Based on the clinical and

radiographic findings, the tooth was diagnosed with pulpal necrosis associated with a periapical lesion.

After administration of local anesthesia and rubber dam isolation, the temporary restoration was removed, and the access cavity was re-prepared. The working length was initially determined using a #15 K-file (Mani, Tochigi, Japan) and confirmed with an electronic apex locator Woodpex III (Woodpecker, Guangxi, China). An attempt was first made to retrieve the fractured instrument from the mesiobuccal canal. For this purpose, ultrasonic retrieval was performed using a TD2 ultrasonic tip (Woodpecker, Guangxi, China) under  $\times 5.5$  magnification with a dental loupe (Admetec, Haifa, Israel). Despite careful ultrasonic activation and multiple retrieval attempts, the fractured instrument could not be safely removed because of its location and the complex canal anatomy. Considering the risk of excessive dentin removal and possible perforation, further retrieval procedures were discontinued. The treatment was then continued by focusing on effective chemo-mechanical preparation of the accessible canal space. All accessible canals were instrumented using EndoArt rotary files (EndoArt, İstanbul, Türkiye) up to size 30/.04. In the mesiobuccal canal containing the separated instrument, canal preparation was carried out up to the level of the fractured fragment with a size 40/.04 file. Throughout the preparation procedure, copious irrigation was performed to enhance canal disinfection. Following chemo-mechanical preparation, calcium hydroxide intracanal medication was placed, and the tooth was temporarily restored. The patient was recalled two weeks later for reassessment.

At the second appointment, a clear improvement in clinical symptoms was observed, with the patient reporting relief of pain and no tenderness on examination. The calcium hydroxide dressing was then completely removed from the canals through irrigation and reinstrumentation. Following the master cone radiograph (Fig. 2), the final irrigation protocol was performed using 5 mL of 17% ethylenediaminetetraacetic acid, followed by 5 mL of sterile saline and 5 mL of 2.5% sodium hypochlorite.

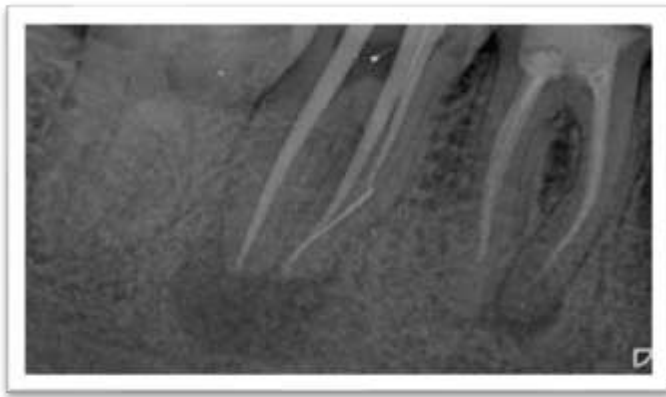


**Figure 2.** Master cone radiograph

Irrigants were ultrasonically activated to enhance canal debridement and improve penetration into the accessible canal space. Subsequently, obturation was completed using the single-cone technique with a bioceramic sealer (MTA Cem, Meta Biomed, Cheongju, South Korea). Postoperative radiographs confirmed satisfactory root canal filling and adequate obturation quality. (Fig 3.)



**Figure 3.** Postoperative radiograph

After completion of the endodontic treatment, the access cavity was permanently restored with composite resin (Filtek Z250, 3M ESPE, St. Paul, MN, USA). The patient was then scheduled for periodic follow-up examinations. At the 1-year follow-up, the tooth was asymptomatic, and radiographic evaluation demonstrated a reduction in the size of the periapical radiolucency. (Fig. 4)



**Figure 4.** One-year follow-up radiograph

At the 2-year follow-up, the tooth remained clinically asymptomatic, and radiographic assessment revealed significant healing of the periapical lesion, indicating a favorable long-term treatment outcome. (Fig. 5)

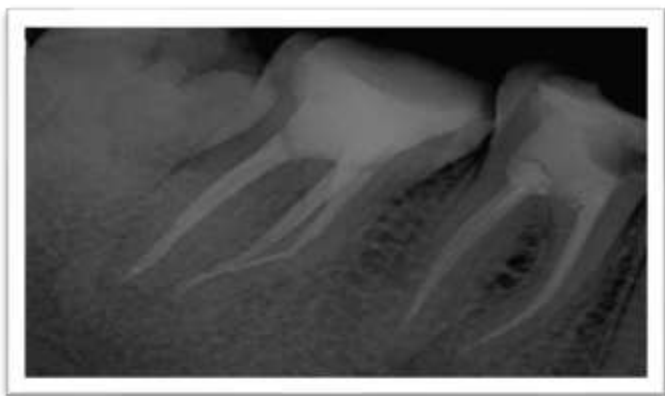


**Figure 5.** Two-year follow-up radiograph showing marked periapical healing

## DISCUSSION

Management of separated instruments remains one of the most challenging complications in endodontic treatment, particularly in mandibular molars where complex canal anatomy limits visibility, accessibility, and safe retrieval. (Panitvisai, Parunnit, Sathorn, & Messer, 2010) In the present case, the fractured instrument was located in the mesiobuccal canal of a mandibular molar, a region frequently characterized by narrow and curved canal morphology. Such anatomy not only increases the risk of instrument fracture but also significantly reduces the likelihood of safe removal without excessive dentin loss. (Turan Gökdoğan et al., 2025)

The location of the fractured fragment is an important prognostic factor. Instruments separated in the apical or middle third of curved mesial canals are generally associated with lower retrieval success and a greater risk of weakening the root structure during ultrasonic procedures.(Portela, Rech, Marchionatti, & Barasuol, 2022) In the present case, although ultrasonic retrieval was attempted under  $\times 5.5$  magnification, further attempts were discontinued to avoid excessive dentin removal, perforation, and potential root weakening. These findings agree with previous reports in the literature. Spili et al. demonstrated that teeth with retained fractured instruments may exhibit favorable long-term healing, particularly when adequate cleaning and obturation of the accessible canal system are achieved.(Spili, Parashos, & Messer, 2005) Similarly, Panitvisai et al. concluded that the presence of a separated instrument alone does not necessarily reduce the success rate of endodontic treatment.(Panitvisai et al., 2010) In the present case, despite the presence of an initial periapical lesion, marked healing was observed at the 2-year follow-up, further supporting these findings.

Another critical factor affecting prognosis is the stage at which the fracture occurs during instrumentation. If instrument separation occurs after substantial canal cleaning and shaping, the microbial burden may already be significantly reduced, thereby increasing the likelihood of healing.(Cujé, Bargholz, & Hülsmann, 2010) In contrast, fractures occurring during the early stages of treatment may prevent adequate debridement of the apical canal space and worsen the prognosis. In the present case, preparation of the mesiobuccal canal could be continued up to the level of the fractured fragment, which likely contributed to successful microbial control.(Portela et al., 2022)

The presence of a pre-existing periapical lesion is generally considered a negative prognostic factor in teeth with separated instruments.(Madarati et al., 2013) Previous studies, including that of Crump and Natkin, have demonstrated that treatment success is strongly influenced by the presence of apical pathology at baseline.(Crump & Natkin, 1970) However, despite the initial periapical radiolucency observed in this case, progressive healing was evident at both the 1-year and 2-year follow-up examinations. This finding further supports the importance of adequate disinfection and sealing of the accessible canal space.

Intracanal calcium hydroxide medication may also have contributed significantly to the favorable outcome by reducing residual bacterial load in areas inaccessible to mechanical

instrumentation.(Siqueira & Lopes, 1999) Ultrasonic activation of the final irrigation solutions may have played a critical role in the favorable outcome of this case.(Jaiswal et al., 2025) In the presence of a retained fractured instrument, mechanical instrumentation beyond the fragment is not possible; therefore, effective chemical debridement becomes even more important. Passive ultrasonic irrigation enhances irrigant penetration, acoustic streaming, and debris removal, particularly in anatomically complex areas and inaccessible portions of the canal system.(Portela et al., 2022) This may have contributed significantly to microbial reduction and subsequent periapical healing in the present case.

Regarding the need for surgical intervention, endodontic surgery was not considered necessary in the present case because the tooth became clinically asymptomatic and radiographic healing progressed during follow-up. Surgical treatment should generally be reserved for cases with persistent symptoms, non-healing lesions, or progression of apical pathology despite adequate nonsurgical management.(Kim & Kratchman, 2006) Therefore, the favorable healing observed in this case supported continuation of a conservative follow-up approach rather than surgical intervention.

## **CONCLUSION**

Overall, this case demonstrates that successful long-term healing can be achieved even in the presence of a retained fractured instrument when appropriate disinfection, intracanal medication, and adequate obturation are provided, highlighting the importance of individualized clinical decision-making and long-term follow-up.

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## EXPERIMENTAL HEAT TRANSFER STUDY IN CYLINDRICAL SYSTEM OF DIFFERENT ARRANGEMENT IMMERSSED IN POROUS MEDIA

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### ABSTRACT

Many industrial applications and processes heavily rely on heat exchangers to enhance heat transfer efficiency. To achieve a larger heat transfer surface while maintaining a smaller heat exchanger size or improving its efficiency without increasing its size, porous media are utilized. Additionally, underground pipes are used for transporting steam, oil, and other fluids, and their heat transfer can be enhanced by selecting the appropriate type and configuration of the surrounding porous medium. In this study, an experiment was conducted using four cylinders placed inside a square duct. Two scenarios were tested: the first without using any porous medium, and the second using gravel as a porous medium with a porosity of 0.44. The cylinders were arranged in two configurations: an inline arrangement and a staggered arrangement. The study focused on analysing the effect of the spacing between the cylinders (3, 3.5, 4, 4.5, and 5 cm) using both numerical and experimental approaches, at a constant Reynolds number of 28,397 and a constant heat flux of 20,700 W/m<sup>2</sup>. The objective was to determine the optimal system performance (performance factor  $\eta$ ). The results showed that the optimal spacing for achieving the best performance was 5 cm in the staggered arrangement, where the performance factor was 2.88% higher in the numerical study and 2.24% higher in the experimental study compared to the inline arrangement. Furthermore, the heat transfer coefficient ( $h$ ) was found to increase with the spacing between the cylinders, and its value was higher in the staggered arrangement than in the inline arrangement. Additionally, the use of porous media improved the heat transfer coefficient by 20% compared to the case without any porous medium.

**Keywords:** Cylindrical system; Porous media, Reynolds number; Experimental work; Staggered arrangement

### INTRODUCTION

Heat transfer in cylindrical systems embedded in porous media is critical in applications like packed-bed heat exchangers, geothermal energy systems, and thermal insulation design. When one or more heated cylinders are surrounded by porous material (e.g. glass beads, ceramic granules), the combined effects of geometry, arrangement, porosity, and flow regime significantly influence convective and conductive heat transport. Experimental studies often report enhanced Nusselt numbers ( $Nu$ ) relative to pure-fluid environments, resulting from increased surface area, obstruction-induced mixing, and porous media conduction pathways.

Various experimental configurations have been explored: isolated cylinders placed at different positions, tandem or staggered arrays, concentric setups, and inclined orientations. Key parameters include Reynolds (Re), Rayleigh (Ra), Peclet (Pe) numbers, porosity ( $\phi$ ), bead size, and cylinder spacing ratios. Results typically quantify both local and average Nu values and generate empirical correlations for design use. For instance, Aamer & Abd-hameed (2020), [1] experimentally placed a heated cylinder within glass-bead packing and observed an up to 67% increase in Nu with increasing Re. They also provided correlations relating Nu to Re and heat flux. Tahseen (2007 and 2011), [2,3] studied mixed convection in horizontal and inclined cylinders filled with porous media and presented experimental Nu-Ra-Pe relationships across inclination angles  $0^\circ$ – $60^\circ$ . Hussain & Jabbar (2013), [4] investigated natural convection in a cylindrical enclosure filled with porous media under varying inclination and transient boundary conditions, experimentally correlating Nu with Ra and geometry. Al-Sammarraie, (2013), [5] studied experimentally natural convection heat transfer from two parallel horizontal cylinders embedded in a porous media inside a horizontal cylindrical enclosure under constant surface temperature boundary condition and the effects of media Rayleigh number ( $Ra = Gr \times Pr$ ), rotation angle of cylinders and spacing between them on their heat loss ability. The experiments were done at the range of media Rayleigh numbers between ( $1.6 \leq Ra \leq 18.1$ ), cylinders rotation angles ( $\theta = 0^\circ, 45^\circ, 90^\circ$ ) and spacing ratios ( $S/D = 2, 2.5, 3$ ). The study had clearly showed that the heat loss ability was a function of media Rayleigh number, cylinders rotation angle and spacing between them. It was noticed that this ability increased with increase of the media Rayleigh number and reaches the maximum value at the first and second cylinder ( $\theta +, \theta -$ ) at spacing ratio ( $S/D=3$ ) and minimum value at spacing ratio ( $S/D=2$ ) at rotation angle ( $\theta = -45^\circ, -90^\circ$ ) for the first and ( $\theta = 0^\circ, +90^\circ$ ) for second cylinder. Layeghi and Borujerdi, (2008), [6] investigated numerically analysis of forced convective heat transfer from a staggered tube bundle with various low conductivity wooden porous media inserts at maximum Reynolds numbers 100 and 300, Prandtl number 0.7, and Darcy number 0.25. The tubes were at constant temperature. The extended Darcy–Brinkman–Forchheimer equations and corresponding energy equation were solved numerically using finite volume approach. Three different porous media with various solid to fluid thermal conductivity ratios 2.5, 5, and 7.5 were used in the numerical analysis. The results were compared with the numerical data for tube bundles without porous media insert and showed that the presence of wooden porous media can increase the heat transfer from a tube bundle significantly (more than 50% in some cases). Younis, (2010), [7]

studied numerically the cross-flow and heat transfer from a bundle of staggered cylinders embedded in a porous media. The effects of Reynolds number within the laminar flow regime, permeability, and thermal conductivity of the porous material on the fluid flow and heat transfer from the cylinders in the cross flow were examined. Prandtl number was fixed to 1.0 for gases. It was found that the porous media may enhanced the rate of heat transfer if the permeability of the porous material is high and the Darcy number is greater than  $10^{-3}$ . Also, increasing the thermal conductivity of the porous material has a positive effect on enhancing the rate of heat transfer from the single column of cylinders or from the cylinders in the first column of a multicolumn heat exchanger. However, the porous media may have a negative effect on the rate of heat transfer from downstream cylinders, where the temperature gradient decreases because of the enhanced rate of heat transfer from the upstream cylinders. Alvandifar, et al, (2017), [8] studied numerically the heat transfer and pressure drop for a tube bank with 5 rows of tubes wrapped by metal foam layers. Use air as work fluid. The results show that covering the tubes with a thin metal foam layer could result in substantial heat transfer enhancement in comparison to the bare tube bank. Pressure drop could be regarded as the main drawback of the metal foam wrapped tube banks. Approximately the same Nusselt number can be achieved compared to the fully wrapped tubes and at the same time the pressure drop reduces by 60%, area goodness factor increases by 33% and the amount of the foam usage decreases by 50% with respect to the fully wrapped foam tubes. H. Sayehvand, et al, (2018), [9] analysed numerically forced convection heat transfer over three isothermal circular cylinders in staggered configuration in isotropic packed bed. The laminar 2-D incompressible steady-state equations of momentum and energy were solved numerically by finite volume method. Simulation was done in three Reynolds numbers of 80, 120, and 200. Also, heat transfer characteristics of them in empty channel and porous channel were compared. The results indicate that, using porous media enhanced Nu. When increasing Reynolds number, heat transfer increased in both channel but the growth rate of it in porous media is larger. Also, the results of simulation in porous channel shown that when increasing Peclet number, the heat transfer increased for each of cylinders. Layeghi and Nouri, (2006), [10] investigated the steady-state laminar and incompressible fluid flow and forced-convection heat transfer from a circular cylinder for an array of circular cylinders in the presence and absence of porous media. The cylinders were at constant temperature and the analysis was restricted to the low and intermediate Peclet number regimes ( $Pr = 1$ ,  $Re \leq 40$  for a single cylinder and  $Re \leq 300$  for an array of cylinders), and Darcy numbers

( $10^{-4} \leq Da \leq 10^{-2}$ ). The first-order upwind and power-law schemes and also the QUICK scheme is used in the numerical solutions. Al-Sumaily, (2014), [11] investigated numerically the influences of longitudinal and transverse spacing of four heated cylinders in two staggered and in-line arrangements. The effect of porous media thermal conductivity and Reynolds number on the flow and heat transfer characteristics around the cylinders had been studied. The spacing parameter SF (the space between cylinder centres is 1.5 and 3.0) affected on the local and average heat transfer from the cylinders at three different solid-to-fluid thermal conductivity ratios,  $kr$  (1.725, 57.5 and 248), and ( $Re D$ ) range (1- 250) for both arrangements. The results showed that both the average and local  $Nu$ , are dependent strongly on  $Re$ , SF, and the cylinder arrangement. However, it was found that the trend of the variations of average  $Nu$  with SF was not considerably altered by  $kr$  in both cylinders' configurations. The results also showed that the thermal performance of the staggered arrangement was higher than that for the in-line one, with less occupied space. Numerical studies complement experiments by exploring forced convection around tandem and staggered arrays of cylinders immersed in isotropic packed beds. Sayehvand et al. (2016) [12] simulated forced convection over three isothermal cylinders in staggered arrangement, showing significant  $Nu$  enhancement in porous media versus empty flow. Similarly, Sayehvand et al. (2017) [13] analysed two tandem cylinders embedded in packed beds, illustrating the effects of inter-cylinder spacing on wall heat flux and  $Nu$ . Other studies include concentric cylinder configurations: Ali (2011) [14] experimentally and numerically studied natural convection between two concentric inclined cylinders with glass beads medium, deriving  $Nu$ – $Ra$  correlations for various inclinations. El-Kady (2021) [15] numerically investigated forced convection in a cylindrical packed bed exposed to a constant wall heat flux, finding about 21% higher  $Nu$  in non-Darcy regimes compared to Darcy-only models. Foundational numerical and theoretical works provide context: Liu et al. (2020) [16] examined RB convection in porous media composed of circular obstacles, showing non-monotonic  $Nu$ – $\phi$  behaviour. Recently, Srikanth & Kuznetsov (2025) [17] discovered symmetry-breaking turbulent flow around cylinder arrays at intermediate porosities ( $\phi \approx 0.8$ – $0.9$ ), enhancing heat transfer. In addition, classical studies on forced convection around arranged cylinders (in air) by Ashjaee & Yousefi (2011) [18] provide experimental insight on spacing effects for vertical and inclined arrays, though not in porous media—they establish baseline trends for array flow–heat transfer interactions. Together, these works offer a strong experimental foundation and theoretical context for studying heat transfer around cylinders in

porous media with various arrangements. The present study can build upon them by focusing on experimental configurations under forced, natural, and mixed convection, measuring Nu and temperature fields for different cylinder layouts, porosities, and flow conditions.

The aim of the present work is enhancing heat transfer by using gravels as porous media with change cylinders' arrangement such as in-line and staggered arrangements. The following is the plan of the present work:- 1-To studying numerically and experimentally the effect of spaces (3, 3.5, 4, 4.5, 5) cm between cylinders on heat transfer to reach the best performance factor at a constant Reynolds Number (28397) and constant heat flux (20700 W/m<sup>2</sup>) 2- To investigate numerically of heat transfer at the space (5 cm) that achieves the best performance factor at a variable Reynolds number and a constant heat flux and other at a variable heat flux and constant Reynolds number. 3- To find numerically the effect of change the working fluid (air and water) on heat transfer characteristic with different porosity.

## **Experimental work**

### **The experimental apparatus**

Several experiments were planned and performed forced convection over a bank of cylinders in different arrangement within the test using the in line and staggered arrangement, the study is done with and without porous medium, the porosity is ( $\epsilon = 0.44$ ). All the steps of building and preparing the experimental device and the specifications of each part are explained, as well as taking readings and explaining the governing equations and assumptions. The test model is manufactured from simple materials available in the local markets. The model consists of the following parts, which are shown in Fig. (1).

|    |              |   |                 |    |                   |
|----|--------------|---|-----------------|----|-------------------|
| 1  | Air blower   | 5 | Heaters         | 9  | Anemometer        |
| 2  | Honeycombs   | 6 | Blower switch   | 10 | Digital manometer |
| 3  | Test section | 7 | Voltage setting | 11 | Multimeter        |
| 4  | Porous media | 8 | Selector switch | 12 | Thermocouples     |
| 13 | Pitot tube   |   |                 |    |                   |



**Figure 1.** Schematic diagram of the test model

### Test section

The figure below shows the cross section studied. The steel plate test section has a cross-sectional area similar to airflow ducts. The length of the test section is 40 cm. Three sides of the test section were installed in the channel, while the upper side was movably used to fill and empty the porous element (gravel) and change the arrangement of the heating element. A mesh wire each cells  $(9 \times 9) \text{ mm}^2$  was used to close both ends of the test section and to prevent the gravels from seeping out of the test section and fix them in place. Holes are made in the plate in the required order and then a thermal insulator was placed inside the holes and heating elements are placed inside these insulators to prevent heat transfer. The duct is sealed with a thermal silicon to prevent any air leakage. The thermocouples are distributed to each heater and



upon entry and exit. A digital anemometer is placed before entry to measure air speed, and a digital manometer with Pitot tube is placed to measure the pressure difference between inlet and outlet as shown in figure (2).

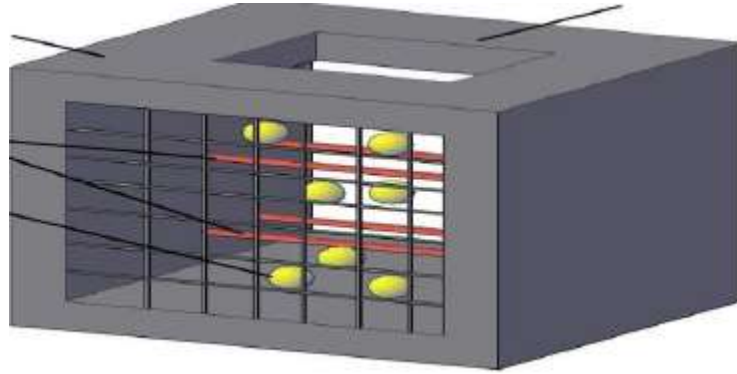


**Figure 2.** Test section of the model

### Measuring Devices

#### Vane Anemometer

Wind speed is a major factor affecting the mechanical power output of a wind turbine. As a result, wind speed must constantly be measured when evaluating a wind turbine. Vane anemometry is employed in this search to determine the wind speed as illustrated in Fig. (3).



**Figure 3.** Anemometry device

#### Power measuring device

A watt meter is used to measure the output power of the developed wind turbine (voltage and current) generated by the turbine after the model is exposed to a different wind speed, as illustrated in Fig. (4).



**Figure 4.** A watt meter

**Temperature measurement:**

In the test section, 16 thermocouples are used to measure the surface temperature of the heater ( $T_w$ ), with 4 thermocouples placed on each heater surface. These thermocouples are distributed evenly around the perimeter of the circular heater at  $90^\circ$  intervals, with a spacing of 7.5 cm between each. Additionally, six more thermocouples are employed: three to measure the inlet air temperature of the test section, and the remaining three to measure the outlet temperature, as illustrated.



**Figure 5.** Temperature measurement distribution

Thermocouples: This HTM 208 B digital LCD Type K Temperature Meter with Probe is rather practical and convenient to measure their surface temperature. The temperature range ( $-50^\circ\text{C}$  to  $1300^\circ\text{C}$ ), made high-quality material, this temperature probe is durable for long-term use. For professional design, it features stable and reliable performance that it will offer accurate measurement. Also, this temperature probe is easy to use for its simple design as shown in Figure (6).



**Figure 6.** Temperature measurement distribution

**Selector board:** The selection panel consists of four switches to control the heat source (heater) and a switch to control the fan speed as shown in Figure (7).



**Figure 7.** Selector board

### **Heater element embedded in porous media**

**Porosity:** Porosity is defined as the ratio of void space, commonly called pore volume, to bulk volume and is reported either as a fraction or a percentage, and can be defined as the pores among the parts of solid material containing the fluid passing through it. In this research use gravels as porous media See Figure (8).



**Figure 8.** porous media (gravels)

Mathematically from porosity equations:

$$\phi = 0.3754 + 4.744 d_p \quad \dots\dots 1$$

Where  $d_p$ : gravel diameter.

-Mean surface temperature calculation

$$T_H = \frac{TH1+TH2+TH3+TH4}{4} \quad \dots\dots 2$$

$T_H$ : Heater temperature

-Heat transfer amount calculation

$$Q_{air} = M \times c_p (T_{out} - T_{in}) \quad \dots\dots 3$$

-Reynolds number calculation

$$Re = \frac{\rho D H U}{\mu}$$

-Heat transfer coefficient calculations

$$h = \frac{QT}{TH - T_m}$$

## RESULTS AND DISCUSSION

The experimental results are illustrated graphically, highlighting the flow field and thermal behavior under various conditions. In the first case, the Reynolds number and heat flux were kept constant while varying the spacing between cylinders. The second case maintained a constant heat flux and cylinder spacing, with a different Reynolds number. In the third case, the Reynolds number and cylinder spacing remained fixed, while the heat flux was varied. The fourth case involved constant Reynolds number, heat flux, and cylinder spacing, but different levels of porosity were tested under air flow. In the fifth case, the same parameters were held constant, but porosity was varied under water flow conditions.

### Distribution of average surface temperatures of each cylinders:

The average temperature of each cylinder in the inline arrangement depends on the location of the cylinder in relation to the air flow. Where the average temperature in the third and fourth cylinders is less by 20 °k than the average temperature in the first and second cylinders, because of the third and fourth cylinders are exposed to air flow directly in contrast to the first and second cylinders, as shown in the figure (9) experimentally.

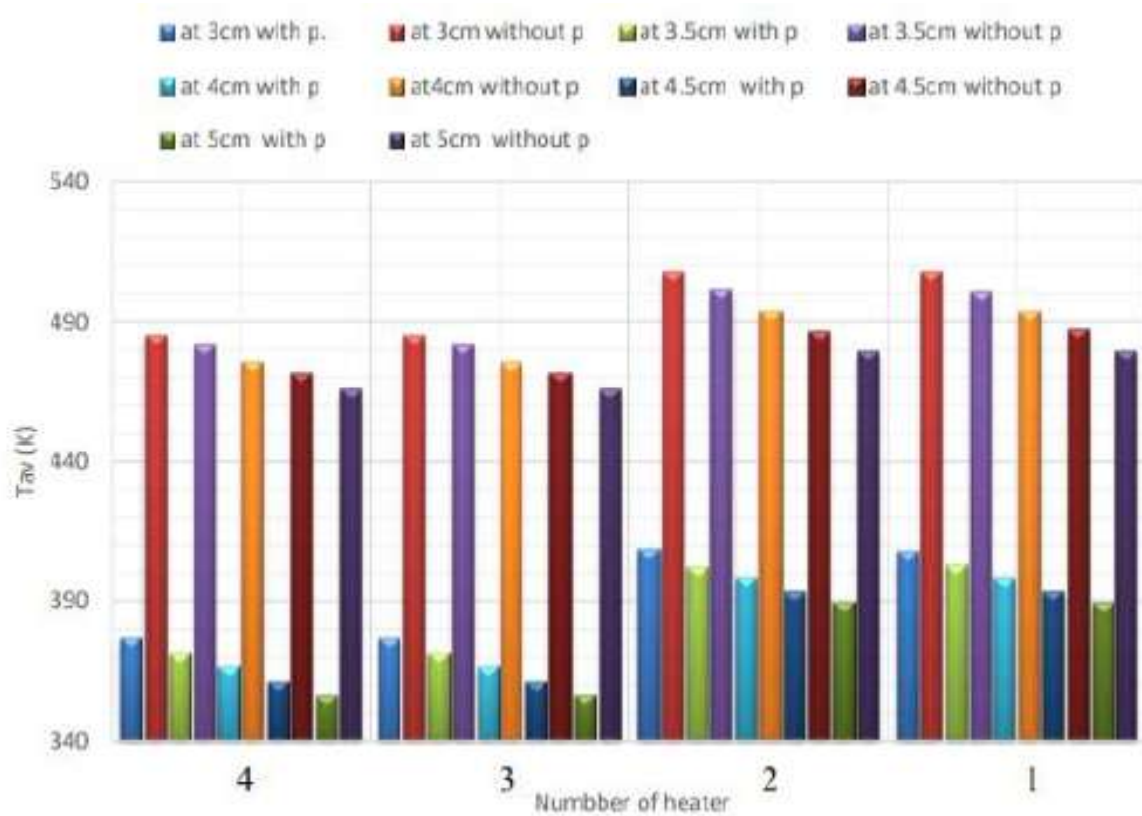


**Figure 9.** Experimental inline average surface temperature distribution at  
( $Re=28397$ , heat flux= $20700 \text{ W/m}^2$ )

#### Average surface temperature with space:

The average surface temperature at staggered arrangement is lower by  $10 \text{ }^\circ\text{K}$  than inline arrangement this indicates the heat transfer in staggered arrangement is higher than inline arrangement, also the average surface temperature in porous media is lower by  $98 \text{ }^\circ\text{K}$  than average surface temperature without porous media, that indicate the heat transfer in porous media is higher than heat transfer without porous medias.

#### Average heat transfer coefficient with space:

The average heat transfer coefficient in the porous media is higher by  $196.98 \text{ W/m}^2 \cdot \text{K}$  than the average heat transfer coefficient without porous media, at staggered arrangement average heat transfer coefficient is higher by  $18.3 \text{ W/m}^2 \cdot \text{K}$  than inline arrangement with porous media and higher by  $3.83 \text{ W/m}^2 \cdot \text{K}$  without porous media. Because of the heat transfer coefficient has an inverse relationship with the temperature difference between the average surface temperatures of cylinders and the mean temperature of the fluid, the heat transfer coefficient increases. Table (1).

**Table 1.** Average heat transfer coefficient and space between cylinders

| Space (cm) | Inline experimental        |                            | Staggered experimental     |                            |
|------------|----------------------------|----------------------------|----------------------------|----------------------------|
|            | hav<br>W/m <sup>2</sup> .K | hav<br>W/m <sup>2</sup> .K | hav<br>W/m <sup>2</sup> .K | hav<br>W/m <sup>2</sup> .K |
|            | Without porous             | With porous                | Without porous             | With porous                |
| 3          | 61.68                      | 206.8                      | 59.5                       | 242.8                      |
| 3.5        | 57.94                      | 212.7                      | 56.37                      | 244.5                      |
| 4          | 55.61                      | 213.8                      | 45.14                      | 249.8                      |
| 4.5        | 53.95                      | 215.5                      | 52.55                      | 252.02                     |
| 5          | 52.74                      | 217.2                      | 51.21                      | 252.7                      |

**Relation heat flux with average surface temperature:**

It is normal for the average surface temperature to decrease with the increase in

the Reynolds numbers. The average surface temperature in the inline arrangement with a porous media is (147.23 °k) lower than without porous media. Also, in a staggered arrangement, the average surface temperature with a porous media is (152.61 °k) lower than surface temperature without a porous media. This indicates that the presence of the porous medium increases heat transfer due to turbulence and high heat transfer area which corresponds to heat flux as shown in figure (9).

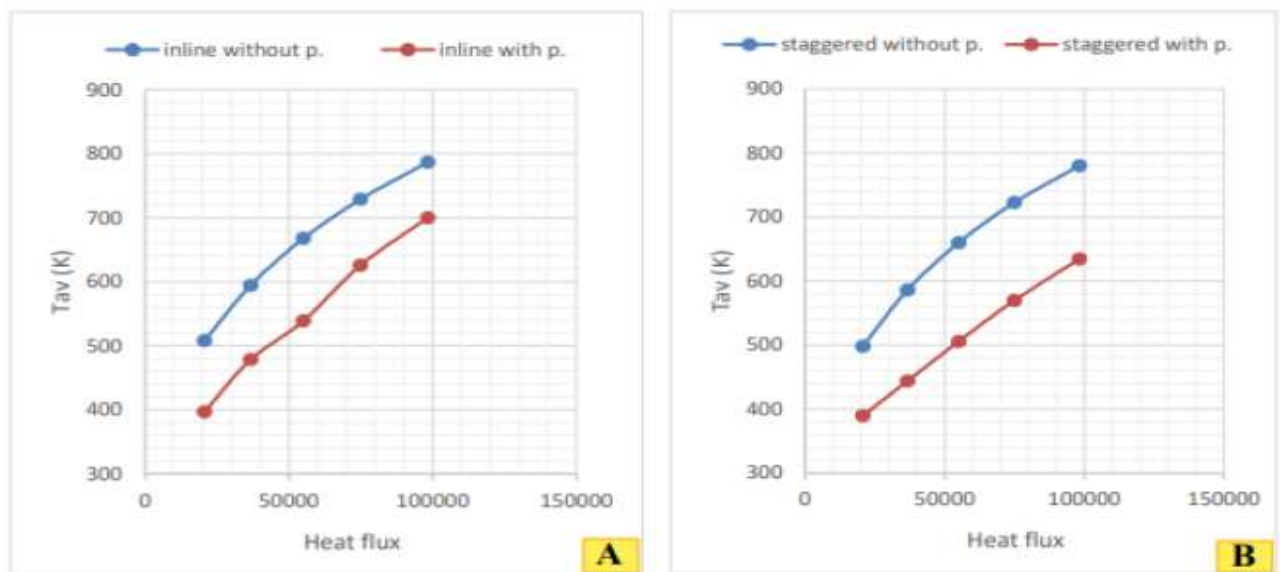


**Figure 10.** Relation heat flux with average surface temperature, A: inline arrangement, B: staggered arrangement

### Relation heat flux with average heat transfer coefficient:

Average heat transfer coefficient, the average heat transfer coefficient in the inline arrangement without porous media is ( $114.48 \text{ W/m}^2 \cdot ^\circ\text{K}$ ) less than the heat transfer coefficient in the presence of the porous media. Also, in the staggered arrangement without porous media it is ( $133.64 \text{ W/m}^2 \cdot ^\circ\text{K}$ ) less than the average heat transfer coefficient in the presence of the porous media. Also, the average heat transfer coefficient in the staggered arrangement is ( $21.06 \text{ W/m}^2 \cdot ^\circ\text{K}$ ) higher than the average heat transfer coefficient in the inline arrangement with porous media as shown in figure (10).

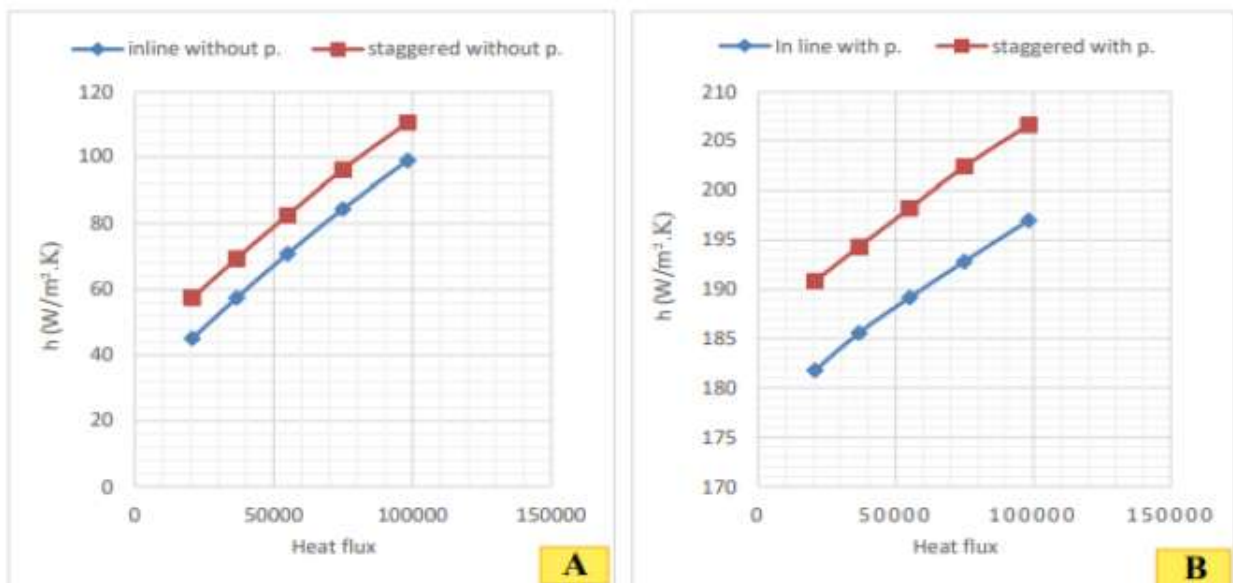


**Figure 11.** Relation heat flux with average heat transfer coefficient at two arrangement, A: without porous media & B: with porous media

### Relation heat flux with average Nusselt Number:

In both the inline and staggered arrangements that the values of the average Nusselt Number without a porous medium are higher than the average of the Nusselt Number in the presence of the porous medium as shown in figure (11).



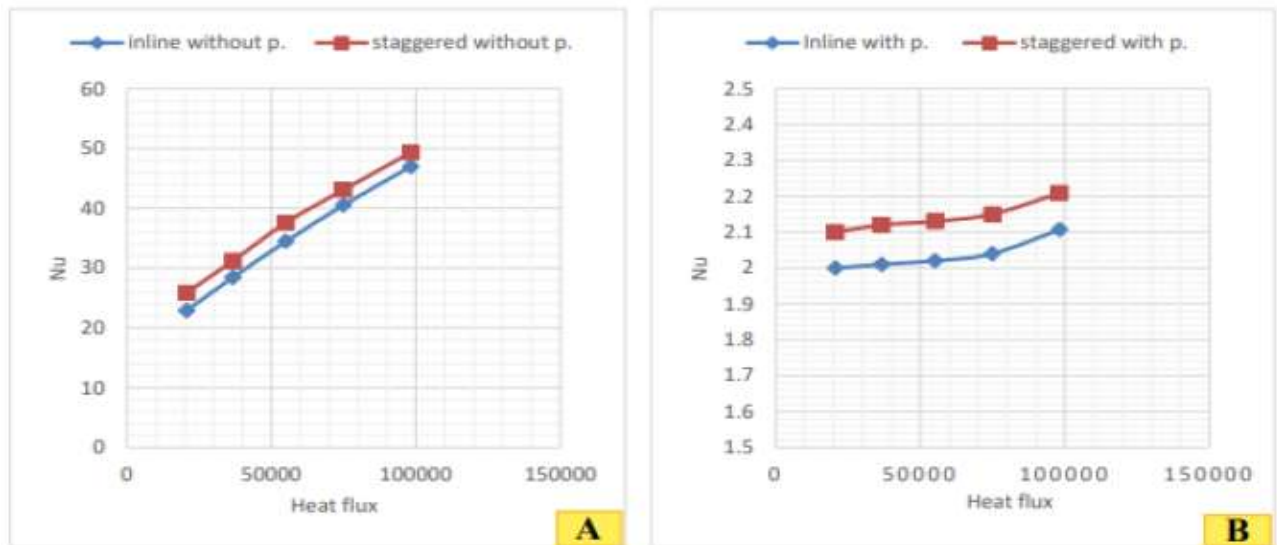


**Figure 12.** Relation heat flux with average Nusselt Number, A: inline arrangement, B: staggered arrangement

#### Relation Reynolds Number with average surface temperature:

It is normal for the average surface temperature to rise with the increase in the heat flux because of high heat supplied to a constant mass flow rate. The average surface temperature in inline arrangement without a porous media is (140.68 °k) higher than with a porous media. Also, in a staggered arrangement, the average surface temperature without a porous medium is (141.28 °k) higher than with a porous media. This indicates that the presence of the porous media increases heat transfer which Compatible to I. W. Maid, et al; [19] and instaggered average surface temperature is reduce to (1.76 %) than in line arrangement at without porous media and (2.36 %) with porous media which Compatible with H. Sayehvand, et al; [9] as shown in figure (12).

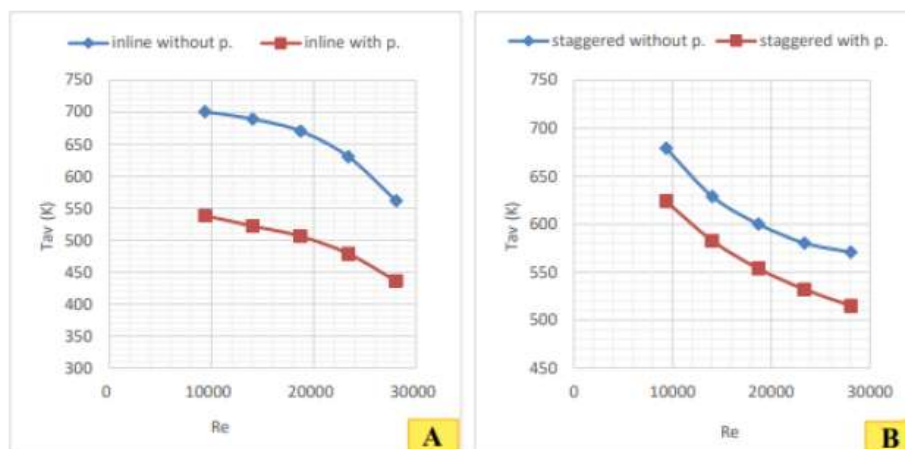


**Figure 13.** Relation Reynolds Number with average surface temperature, A: inline arrangement, B: staggered Figure (4.10) Effect of GC% on the compressive strength.



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## THE INTEGRATION OF 3D ANATOMY PLATFORMS AND AI-BASED IMAGE ANALYSIS SYSTEMS IN THE DIGITAL RENAISSANCE ERA

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### ABSTRACT

Anatomy education has been conducted for centuries through classical teaching methods based on cadaver dissection and has been recognized as one of the fundamental cornerstones of medical education. However, in recent years, difficulties in cadaver procurement worldwide, limited donation rates, ethical and legal regulations, and cost-related issues have necessitated the development of alternative methods in anatomy education. In this context, advancements in digital technologies have led to the emergence of new instructional tools in anatomy education. Particularly, three-dimensional (3D) anatomy platforms and artificial intelligence (AI)-based image analysis systems are creating significant transformations in both educational and clinical processes. The aim of this review is to evaluate the educational effectiveness of advanced 3D digital platforms used in anatomy education in light of current literature and to demonstrate the potential contributions of these technologies, especially in educational environments where cadaver shortages occur. This study is a review based on the examination of scientific articles published within the last ten years. The literature search was conducted across PubMed, Scopus, and Google Scholar databases. Investigations indicate that 3D platforms enhance students' spatial perception and facilitate the learning of complex structures. Furthermore, it has been determined that AI-based image analysis systems provide high accuracy in automatic segmentation and diagnostic processes in radiological imaging. In conclusion, the integration of digital anatomy platforms and artificial intelligence applications is considered a significant transformative tool in modern medical education and healthcare services.

**Keywords:** Digital anatomy, artificial intelligence, 3D visualization, medical education, image analysis

### DİJİTAL RÖNESANS SÜRECİNDE ÜÇ BOYUTLU ANATOMİ PLATFORMLARI VE YAPAY ZEKA TABANLI GÖRÜNTÜ ANALİZ SİSTEMLERİNİN ENTEGRASYONU

### ÖZET

Anatomi eğitimi, yüzyıllar boyunca kadavra diseksiyonuna dayanan klasik öğretim yöntemleri ile yürütülmüş ve tıp eğitiminin temel yapı taşlarından biri olarak kabul edilmiştir. Bununla birlikte son yıllarda dünya genelinde kadavra temininde yaşanan güçlükler, bağış oranlarının sınırlı olması, etik ve yasal düzenlemeler ile maliyet sorunları anatomi eğitiminde alternatif yöntemlerin geliştirilmesini zorunlu hale getirmiştir. Bu bağlamda dijital teknolojilerde yaşanan gelişmeler, anatomi eğitiminde yeni öğretim araçlarının ortaya çıkmasına yol açmıştır. Özellikle üç boyutlu (3B) anatomi platformları ve yapay zekâ (YZ) tabanlı görüntü analiz sistemleri, hem eğitim hem de klinik süreçlerde önemli dönüşümler yaratmaktadır. Bu derlemenin amacı, anatomi eğitiminde kullanılan ileri düzey üç boyutlu (3B) dijital platformların eğitim etkinliğini güncel literatür ışığında değerlendirmek ve özellikle kadavra eksikliğinin yaşandığı eğitim ortamlarında bu teknolojilerin potansiyel katkılarını ortaya

koymaktır. Çalışma, son on yıl içerisinde yayımlanmış bilimsel makalelerin incelenmesine dayalı bir derleme niteliğindedir. Literatür taraması PubMed, Scopus ve Google Scholar veri tabanlarında gerçekleştirilmiştir. Yapılan incelemeler, 3B platformların öğrencilerin mekânsal algısını artırdığı ve kompleks yapıların öğrenilmesini kolaylaştırdığını göstermektedir. Ayrıca yapay zekâ (YZ) tabanlı görüntü analiz sistemlerinin, radyolojik görüntülemelerde otomatik segmentasyon ve tanı süreçlerinde yüksek doğruluk sağladığı saptanmıştır. Sonuç olarak, dijital anatomi platformları ve yapay zekâ uygulamalarının entegrasyonu, modern tıp eğitimi ve sağlık hizmetlerinde önemli bir dönüşüm aracı olarak değerlendirilmektedir.

**Anahtar Kelimeler:** Dijital anatomi, yapay zekâ, 3B görselleştirme, tıp eğitimi, görüntü analiz

## INTRODUCTION

Anatomy education is one of the most fundamental components of medical training and represents one of the oldest disciplines, playing a central role in helping students understand the structural organization of the human body. For centuries, this discipline has been taught through cadaver dissection under the philosophy of “*mortui vivos docent*” (the dead teach the living). A solid foundation in anatomical knowledge is indispensable for a wide range of competencies, from the acquisition of clinical skills to the understanding of surgical approaches. Therefore, the quality of methods used in anatomy teaching directly influences the overall quality of medical education. For many years, cadaver dissection has served as the cornerstone of this education, enabling students to learn three-dimensional anatomical relationships through direct observation. The tactile feedback and hands-on experience provided by dissection offer significant advantages in terms of knowledge retention. However, in recent years, difficulties in cadaver procurement, limited donation rates, ethical concerns, and high costs have increasingly challenged the sustainability of this method (Aziz & McKenzie, 2016; Jones, 2019).

The rapid advancement of digitalization has led to the emergence of new approaches in anatomy education. In particular, three-dimensional (3D) digital anatomy platforms allow students to examine anatomical structures from multiple perspectives, navigate between layers, and better understand complex spatial relationships. These systems transform the learning process from passive information transfer into an interactive and exploratory experience. Several studies have demonstrated that 3D digital tools enhance students’ spatial understanding and increase learning motivation (Nicholson et al., 2006; Moro et al., 2017; Nicholson & Chalk, 2019).

In parallel, artificial intelligence (AI) applications are increasingly being integrated into both medical education and clinical practice. Deep learning algorithms developed for medical imaging have achieved significant progress in areas such as automated image segmentation, anomaly detection, and diagnostic decision support systems. AI-based systems can provide

personalized feedback to students during the learning process and support clinicians by improving diagnostic accuracy in clinical settings (Litjens et al., 2017; Topol, 2019). These developments indicate that anatomical knowledge is evolving from a purely theoretical foundation into a dynamic structure integrated with digital and analytical tools.

In this transformation process, often described as a “Digital Renaissance,” anatomy education is becoming more accessible, visualizable, and individualized. Rather than completely replacing traditional methods, digital platforms and AI applications often serve as complementary tools, contributing to the development of hybrid educational models. In this context, it becomes possible to create a multifaceted learning environment that addresses different learning styles (Erdal, 2021; Pather et al., 2020).

This study aims to evaluate digital anatomy platforms and artificial intelligence applications together, and to comprehensively examine their impact on both anatomy education and clinical practice.

## **MATERIALS AND METHODS**

This review is based on a comprehensive examination of scientific studies published within the last ten years. In line with the main objective of the study, the literature search was conducted using the PubMed, Scopus, and Google Scholar databases. During the search process, the broad coverage of different databases was taken into consideration in order to access a wide range of relevant literature.

The keywords “digital anatomy,” “3D anatomy education,” “artificial intelligence in medical imaging,” “deep learning segmentation,” and “medical education technology” were used individually and in various combinations. Following the initial search, the retrieved studies were screened at the title and abstract level, and publications not directly related to the aim of the study were excluded. The full texts of the eligible studies were then reviewed for final evaluation.

The selected studies were categorized under four main headings: (i) anatomy education, (ii) three-dimensional visualization technologies, (iii) artificial intelligence applications, and (iv) clinical application areas. This classification enabled a more systematic analysis of the findings in the literature and facilitated the identification of relationships between different fields. Each study was examined in detail in terms of methodology, sample characteristics, technologies used, and key findings.

The inclusion criteria comprised studies published within the last ten years, articles published in peer-reviewed journals, and studies with accessible full texts. Additionally, only studies published in English were included. Exclusion criteria consisted of editorial papers, conference abstracts, studies without full-text access, and publications not directly relevant to the subject.

The obtained data were evaluated using a qualitative analysis approach, and similarities and differences among the studies were comparatively analyzed.

## **RESULTS AND DISCUSSION**

The literature review clearly demonstrates that three-dimensional (3D) anatomy platforms provide multifaceted contributions to students' learning processes. These platforms have been found to be more effective than traditional atlases and two-dimensional images, particularly in understanding the spatial relationships of complex anatomical structures.

A study by Moro et al. showed that 3D visualization tools significantly improve students' spatial thinking skills and positively contribute to learning performance. Similarly, Pujol et al. reported that digital anatomy applications enhance academic achievement and make the learning process more motivating.

These findings are also supported by earlier studies. Nicholson et al. reported that computer-assisted 3D anatomy models enhance students' conceptual understanding, while a systematic review by Yammine and Violato emphasized that 3D learning tools provide more pronounced benefits, particularly for students with low to moderate spatial abilities. Additionally, Triepels et al. demonstrated that virtual and augmented reality-based anatomy applications increase student engagement and make learning more durable. Taken together, these studies indicate that digital anatomy platforms not only facilitate knowledge acquisition but also transform the quality of learning.

Another important advantage of digital tools is their ability to support individualized learning. Students can study at their own pace, revisit challenging structures, and personalize their learning experience through various visualization options. However, some studies have noted that digital tools alone may not be sufficient, particularly due to the lack of tactile feedback, which remains an important limitation (Pather et al., 2020). This highlights the importance of hybrid educational models.

When artificial intelligence (AI)-based image analysis systems are examined, significant advancements are evident, particularly in radiology and neuroimaging. Litjens et al. demonstrated that deep learning algorithms have a wide range of applications in medical image analysis and provide high accuracy rates. Esteva et al. further showed that AI-based systems can achieve performance levels comparable to experts in image classification and diagnostic processes.

Studies in brain imaging have shown that automated segmentation algorithms make important clinical contributions. The automated segmentation methods developed by Fischl have been reported to produce results in brain volumetric measurements that are highly comparable to manual methods. More recent studies, such as those by Isensee et al., have demonstrated that deep learning-based segmentation models achieve high performance across different datasets and are suitable for clinical use.

Furthermore, the integration of AI systems into clinical decision support mechanisms shortens diagnostic time and reduces physicians' workload. Topol emphasized the potential of artificial intelligence to reduce error rates in diagnostic processes and support early detection.

In studies focusing on neurodegenerative diseases, AI algorithms have been shown to have high sensitivity in detecting early-stage changes, thereby enabling earlier intervention in treatment processes (Vieira et al., 2017).

Evaluating digital anatomy platforms together with AI applications reveals that these two technologies form a complementary structure. While digital platforms help students better understand fundamental anatomical knowledge, AI systems facilitate the translation of this knowledge into clinical practice. For example, anatomical structures learned through 3D platforms can be identified on real patient data using AI-supported image analysis systems, thereby reducing the gap between theoretical knowledge and clinical application.

In conclusion, the current literature indicates that the combined use of digital anatomy and artificial intelligence technologies creates a synergistic effect in both education and clinical practice. However, for the effective implementation of these technologies, it is necessary to redesign pedagogical approaches, strengthen technical infrastructure, and enhance faculty training. Future studies should focus on evaluating long-term learning outcomes and their impact on clinical performance in a more comprehensive manner.

## **Challenges and Limitations**

Despite the advantages of digital anatomy platforms and artificial intelligence applications, several important limitations remain. First, the cost and technical infrastructure requirements of these technologies are not accessible for every institution. In addition, digital environments cannot fully provide the tactile experience obtained through cadaver dissection.

From an educational perspective, integrating these systems into the curriculum and providing adequate faculty training are essential. In AI applications, data quality, ethical concerns, and privacy issues stand out. Moreover, there is still insufficient evidence regarding their long-term effects.

Therefore, it is recommended that digital and AI-based methods be used in a complementary manner alongside traditional education.

## **CONCLUSION**

The "Digital Renaissance" in anatomy education represents a hybrid era where traditional methods are blended with technological opportunities. Three-dimensional anatomy platforms allow medical students to go beyond mere theoretical memorization of anatomical structures, enabling them to manipulate these structures in a three-dimensional plane and gain a sense of depth perception. Literature studies prove that these platforms are the closest and most effective alternative to cadaver dissection, particularly in developing spatial intelligence (Kartal et al., 2021).

Considering the global decline in cadaver donations and the complexity of ethical procedures, digital tools have become a necessity for the sustainability of medical education rather than just a preference (Erdal, 2021). However, the success of these technologies is measured not only by their visual capabilities but also by their ability to integrate with artificial intelligence systems. Artificial intelligence-based image analysis systems enable anatomical knowledge to materialize in the clinical application phase. In particular, automatic segmentations minimize the margin of error in physicians' diagnostic processes and pave the way for "personalized medicine" applications (Demircan and Aktaş, 2021).

In the future, it is predicted that augmented reality (AR) and virtual reality (VR) technologies will establish a deeper integration with artificial intelligence algorithms. This will open the door for medical students to perform surgical simulations on virtual patients and experience anatomical variations in real-time before moving on to the clinical stage (Wang et al., 2021).



Consequently, digital platforms and artificial intelligence systems, as an integral part of modern medical education and healthcare services, serve as a fundamental transformative tool that enhances both academic success and patient safety.

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## BIBLIOMETRIC ANALYSIS OF CIRCADIAN RHYTHM RESEARCH IN SPORTS SCIENCE: AN APPROACH BASED ON WEB OF SCIENCE DATA

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### ABSTRACT

The aim of this study is to identify the bibliometric characteristics of scientific publications on circadian rhythm research in sports science. Within the scope of the study, 517 articles published in the sports science category and included in the Web of Science (WoS) database were examined. Using bibliometric analysis methods via the VOSviewer software, the data were analyzed to assess the distribution of publications by year, the most productive authors, institutions, and countries, as well as co-authorship and keyword networks. The findings indicate that the number of publications in the field of circadian rhythms in sports has increased significantly, particularly after 2003, and that France and the United Kingdom are the top publishing countries. Additionally, it was determined that certain authors and institutions played a central role in the field's development, while keyword analyses highlighted terms such as "sleep," "exercise," and "menstrual cycle." Consequently, it is believed that this bibliometric study can contribute to the field by presenting research trends, collaboration structures, and scientific orientations in the field of circadian rhythms in sports within a comprehensive framework.

**Keywords:** Circadian rhythm, Sleep, Bibliometric analysis, biological clock

### SPOR BİLİMLERİNDE SİRKADİYEN RİTİM ARAŞTIRMALARININ BİBLİYOMETRİK İNCELEMESİ: WOS VERİLERİNE DAYALI BİR YAKLAŞIM

### ÖZET

Bu çalışmanın amacı, spor bilimlerinde Sirkadiyen ritim araştırmaları ile ilgili yapılan bilimsel çalışmaların bibliyometrik özelliklerini ortaya çıkarmaktır. Yapılan Araştırmada, Web of Science (WoS) verilerinde bulunan ve spor bilimleri kategorisinde yer alan 517 çalışma incelenmiştir. Çalışmalar, bibliyometrik analiz metodu kullanılarak VOSviewer programı aracılığı ile analiz edilmiştir. Çalışmaların yıllara göre dağılımı, en üretken yazarlar, kurumlar, ülkeler ile yazarlık ortaklıkları ve anahtar kelime ağları incelenmiştir. Bulgular, sporda Sirkadiyen ritim alanındaki yayınların 2003 tarihinden sonra artış gösterdiğini Amerika Birleşik Devletleri, Fransa ve İngiltere'nin yüksek çalışma yapan ülkeler olduğunu göstermektedir. Ayrıca belirli kurum ve araştırmacıların alanın gelişiminde ön plana çıktığı tespit edilmiştir, anahtar kelime analizlerinde ise sleep, exercise ve menstrual cycle kelimelerinin ön planda olduğu görülmektedir. Bu bibliyometrik çalışmanın sporda sirkadiyen ritim alanındaki araştırma eğilimlerini ve iş birliği yapılarını ortaya çıkararak alana katkı sağlayabileceği düşünülmektedir.

**Anahtar kelimeler:** Sirkadiyen ritim, Uyku, Bibliyometrik analiz, Biyolojik saat

## GİRİŞ

İnsan organizmasında fizyolojik süreçler, içsel biyolojik saat tarafından düzenlenmekte olup bu düzenin temelini sirkadiyen ritim oluşturmaktadır. Yaklaşık 24 saatlik döngüler halinde işleyen bu ritim; uyku-uyanıklık dengesi, hormonal salınım, vücut ısısı, metabolik süreçler ve bilişsel fonksiyonlar gibi birçok biyolojik mekanizmanın zamanlanmasında belirleyici rol oynamaktadır (Czeisler & Gooley, 2007; Potter ve ark., 2016). Sirkadiyen ritmin düzenli işleyişi, organizmanın fizyolojik dengeyi koruyabilmesi ve günlük performans kapasitesini sürdürebilmesi açısından kritik bir öneme sahiptir (Brainard ve ark., 2015). Son yıllarda sirkadiyen ritim üzerine yapılan çalışmaların artmasıyla birlikte, bu biyolojik mekanizmanın yalnızca uyku düzeni ile sınırlı olmadığı, aynı zamanda fiziksel ve bilişsel performans üzerinde de belirleyici etkiler oluşturduğu tespit edilmiştir. Spor bilimleri alanında gerçekleştirilen araştırmalar, günün farklı saatlerinde sergilenen performans düzeylerinde anlamlı değişimler olduğunu ve bu değişimlerin büyük ölçüde sirkadiyen ritim ile ilişkili olduğunu göstermektedir (Reilly & Edwards, 2007). Kuvvet, sürat, dayanıklılık, reaksiyon zamanı ve koordinasyon gibi performans bileşenlerinin gün içindeki dalgalanmaları, sporcuların biyolojik ritimlerine bağlı olarak farklılık gösterebilmektedir (Watson, 2017). Sporcularda sirkadiyen ritmin performans üzerindeki etkisi, özellikle antrenman planlaması ve yarışma zamanlaması açısından önemli bir araştırma alanı haline gelmiştir. Bireysel kronotip farklılıklarının (sabahçı-akşamcı eğilimler) performans çıktıları üzerinde belirleyici olduğu ve antrenman saatlerinin bu biyolojik özelliklere göre düzenlenmesinin performansı optimize edebileceği ifade edilmektedir (Randler & Schaal, 2010; Selvi ve ark., 2017). Ayrıca, antrenman programları, seyahat, yarışma stresi ve düzensiz uyku gibi faktörlerin sirkadiyen ritmi etkileyerek sporcularda yorgunluk, performans kaybı ve toparlanma süresinde gecikmeye yol açabileceği belirtilmektedir (Sargent ve ark., 2014; Fullagar ve ark., 2015).

Bibliometrik analizler, belirli bir araştırma alanındaki bilimsel üretimin gelişimini, araştırma eğilimlerini ve bilgi yapısını ortaya koymada etkili yöntemler arasında yer almaktadır. Web of Science (WoS) veri tabanından elde edilen verilerin VOSviewer yazılımı ile görselleştirilmesi, anahtar kelime ağları, yazar iş birlikleri ve konu kümeleri gibi önemli bilimsel yapıların analiz edilmesine olanak sağlamaktadır.

Bu doğrultuda, mevcut çalışmanın amacı spor bilimleri alanında sirkadiyen ritim üzerine yapılan araştırmaların bibliyometrik özelliklerini incelemek ve bu alandaki bilimsel eğilimleri ortaya koymaktır. Elde edilen bulguların, gelecekte yapılacak çalışmalar için yol gösterici olması ve sporcularda performans optimizasyonuna yönelik bilimsel bir çerçeve sunması öngörülmektedir.

## **MATERYAL VE METOT**

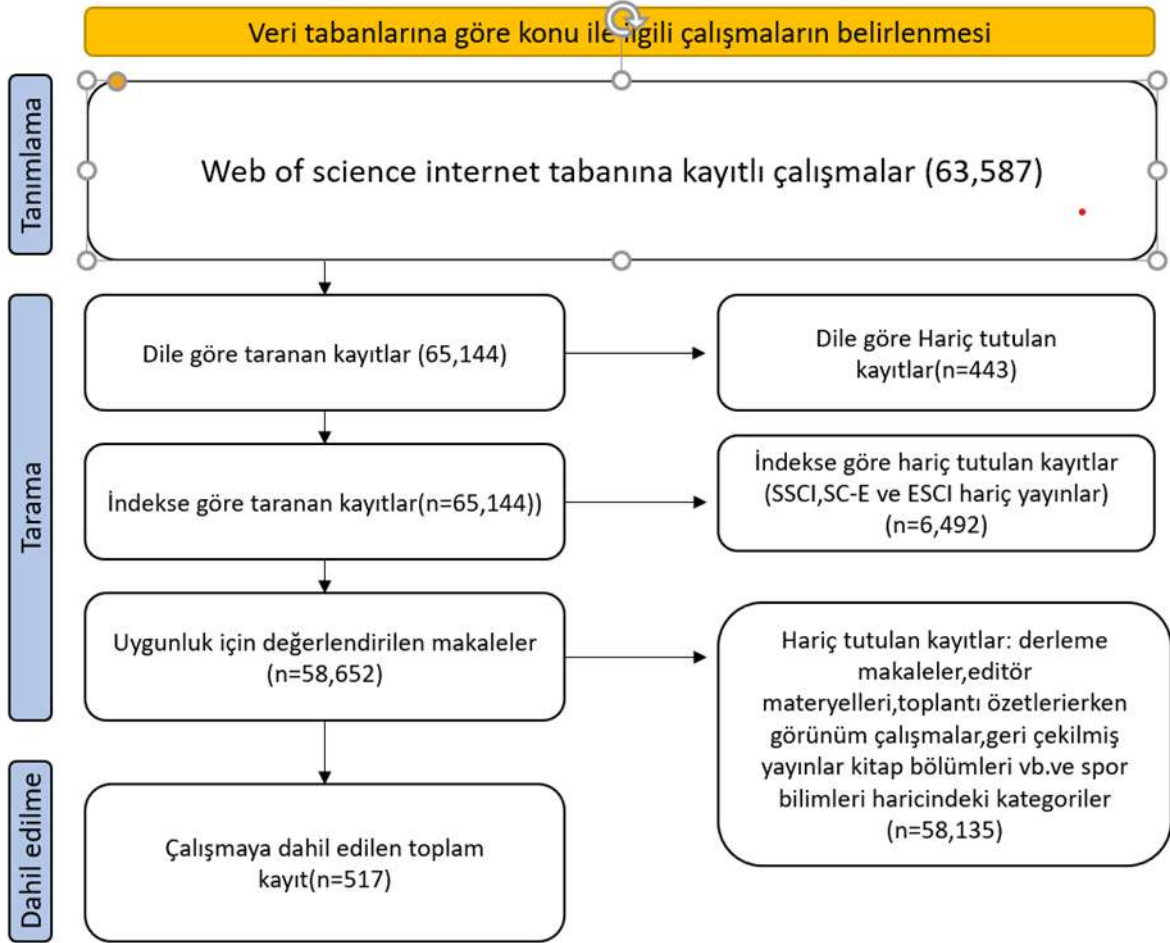
Sporda sirkadiyen ritim üzerine yapılan araştırmaların literatürüne yönelik Web of Science (WoS) aracılığı ile bulunan 517 çalışmanın VOSviewer programı aracılığıyla haritalandırıldığı çalışmada "amaçlı örnekleme" yöntemi kullanılmıştır.

**Verilerin Elde Edilmesi:** Yapılan çalışmaya WoS veri tabanında bulunan makaleler dâhil edilmiştir. WoS veri tabanına, “circadian rhythm or biological clock and sport” anahtar kelimeleri yazılarak elde edilen veriler incelenmiştir. Doküman türü olarak “makale” , Kategori: “spor bilimleri” Dil: “İngilizce” filtrelemeleri uygulanmıştır. Toplamda 63,587 çalışma ile başlayan araştırma , yapılan değerlendirmeler sonucunda 517 çalışmaya düşürülmüştür. Verilerin seçilmesinde, PRISMA kontrol protokolünden faydalanılmıştır (Page vd., 2021).

## **Verilerin Toplanması ve Analizi:**

Bu çalışmadan edinilen veriler WoS analiz sonuçları ve VOSviewer programı ile değerlendirilmiştir. Elde edilen verilerin analizinde, bibliyometrik analiz yöntemi kullanılmıştır. Bibliyometrik analiz yöntemi alana yön veren temel çalışmaları sayısal verilerle inceleyen nicel bir araştırma yöntemidir (Mezquita vd., 2024). Bibliyometrik analiz işleminde, VOSviewer programı kullanılmıştır. VOSviewer, programı verileri görselleştirmek için bilimsel haritalara dönüştüren bir analiz programıdır (Van Eck ve Waltman, 2010). WoS analiz sonuçları sekmesinde, “circadian rhythm or biological clock and sport” ilişkisine yönelik; çalışmaların yazarlara göre dağılımı, yayınların kurumlara göre dağılımı, yayınların ülkelere göre dağılımı, yayınların finansman kurumlarına göre dağılımı belirlenerek edinilen sonuçlar çalışmaya dahil edilmek üzere analiz edilmiştir. Sirkadiyen ritim ile ilgili yapılan çalışmaların özelliklerini belirlemek amacıyla analizler üç temel boyutta çalışılmıştır. Öncelikle, sosyal yapıyı belirlemek adına yazarlar, kurumlar ile ülkeler arasındaki ortak yazarlık (co-authorship)

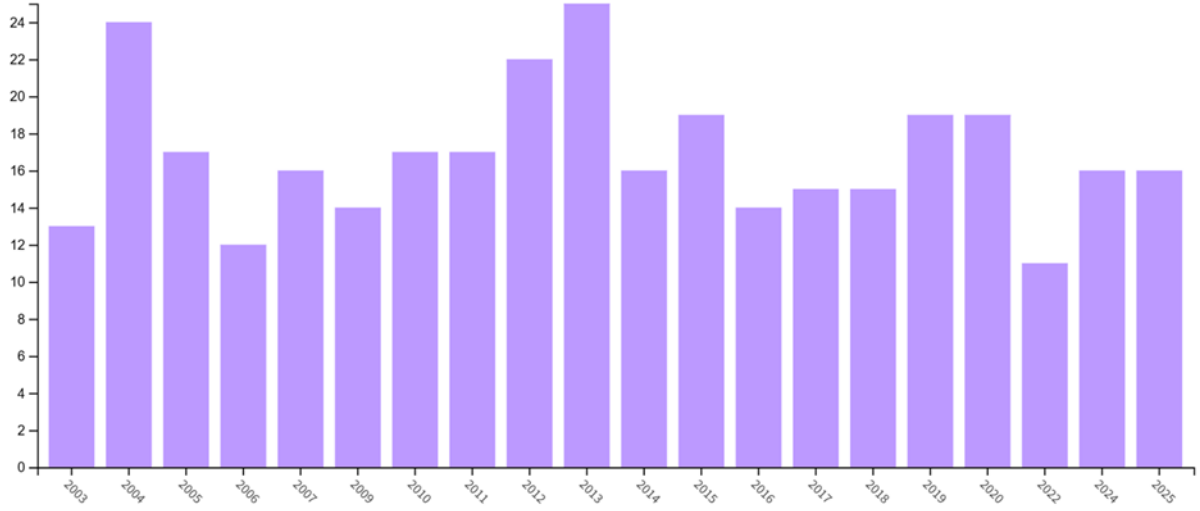
ağları belirlenmiştir. Sonraki aşamada, literatürün güncelliğini belirlemek için anahtar kelime (co-occurrence) analizleri uygulanmıştır. Son olarak, yazar ve ülke bazındaki atıflar (citation) haritalandırılmıştır. Alizlerden elde edilen görsel ve sayısal veriler bulgular kısmında açıklanmıştır (Şekil 1,2,3,4,5,6,7,8 ve 9)



Şekil 1. PRISMA akış diyagramına göre çalışmanın dizaynı (Page ve ark., 2021).

## BULGULAR

Verilerin incelenmesinde, (WOS) tabanının sunduğu grafiksel ara yüzler ile VOSviewer görselleştirme araçları kullanılmıştır. Analiz sonuçları; TreeMap Chart ve Bar Charts ile VOSviewer tabanlı ağ haritaları (network maps) olmak üzere iki şekilde detaylandırılmıştır.



Şekil 2. Sporda sirkadiyen ritim alanı ile ilgili yapılan çalışmaların yıllara göre dağılımı



Şekil 3. Sirkadiyen ritim ve spor çalışmaları ile ilgili yayınların kurumlara göre dağılımı

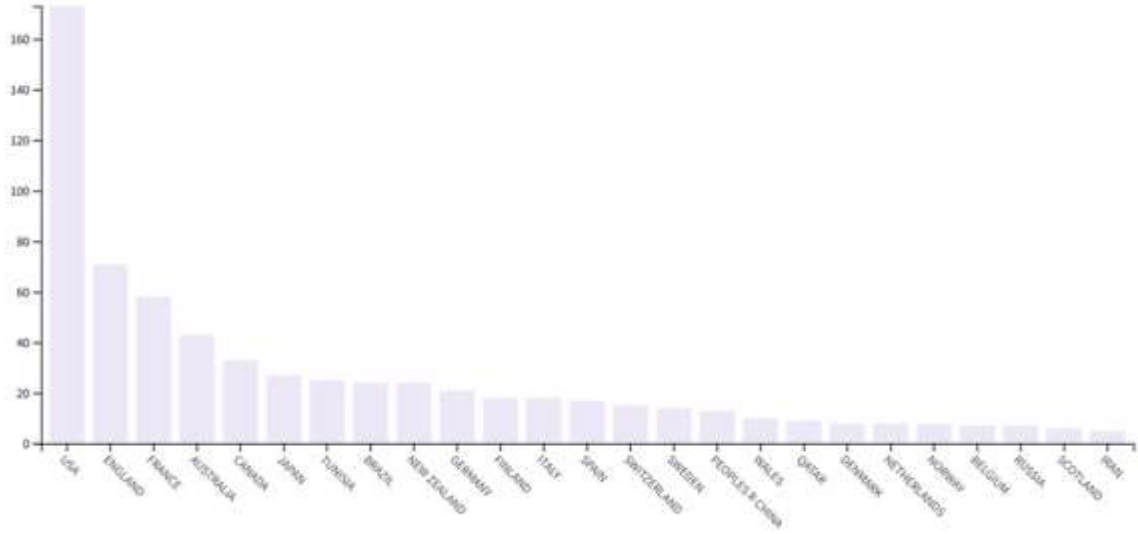


**Şekil 4.** Sirkadiyen ritim ve spor arařtırmalarına yönelik en çok yayın yapan yazarların dağılımı

**Şekil 2.** Web of Science tabanındaki 517 çalışmanın 2003-2025 yılları arasındaki dağılımı incelendiğinde, yayınların dalgali bir seyir izlediđi gözlemlenmektedir. Çalışmaların en düşük seviyede olduđu yıl 12 yayınla 2022, en yüksek olduđu yıl ise 26 yayınla 2013 olarak belirlenmiştir.

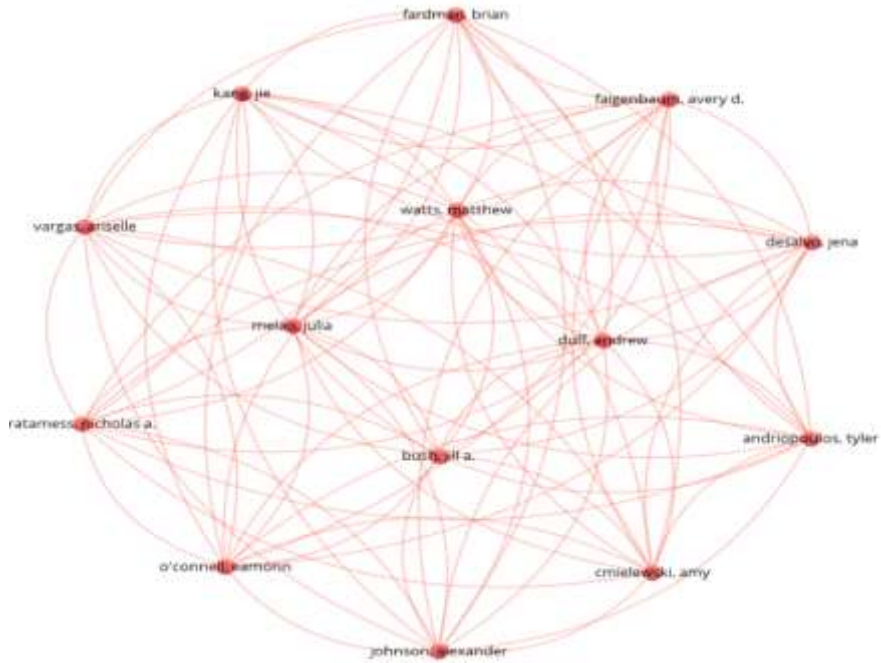
**Şekil 3.** İncelendiğinde, sirkadiyen ritim ve spor alanı ile ilgili yayın yapan kurumların dağılımı gösterilmektedir. En yüksek katkının 21 yayın ile liverpool john moores university birimine ait olduđu görölmektedir. Bu kurumu, University de sfax 18 yayın, Universite de caen 13 yayın ile takip etmektedir.

**Şekil 4.** İncelendiğinde, sirkadiyen ritim ve spor ile ilgili yapılan yayınların yazar dağılımı görölmektedir. En üretken 25 yazar arasında Chtourou H. 17 yayın ile ilk sırada yer alırken, Chamarika K. 13 yayın ile ikinci sırada, Chaouachi A. ise 12 yayın ile alana katkı sağlamıştır



Şekil 5. Sirkadiyen ritim ve spor konulu yapılan yayınların ülkelere göre dağılımı

Şekil 5. incelendiğinde, sirkadiyen ritim ve spor alanında yapılan yayınlara katkı sağlayan ülkelerin grafiği gösterilmektedir. En fazla yayının 173 çalışma ile ABD kaynaklı olduğu görülmektedir. ABD'yi 71 yayınlı İngiltere izlemiş 58 yayın ile Fransa 'da yapılan çalışmalara katkı sağlamıştır.



Şekil 6. Sirkadiyen ritim ve spor konulu yapılan yayınların ortak yazar bağlantısı

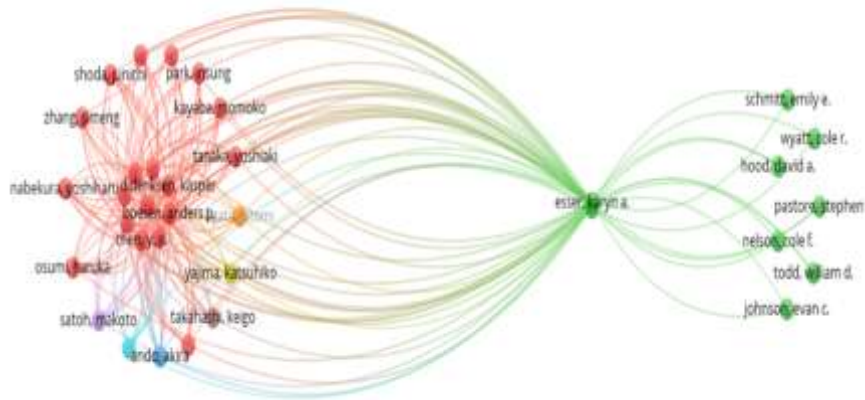


**Şekil 6.** İncelendiğinde, sirkadiyen ritim ve spor alanındaki yazar iş birliği ağının, araştırmacılar arasında yoğun ve çok yönlü bir etkileşim yapısına sahip olduğu görülmektedir. Ağın genel olarak yüksek derecede bağlantılı olması, çalışmaların büyük ölçüde ortak yazarlık temelinde yürütüldüğüne işaret etmektedir.



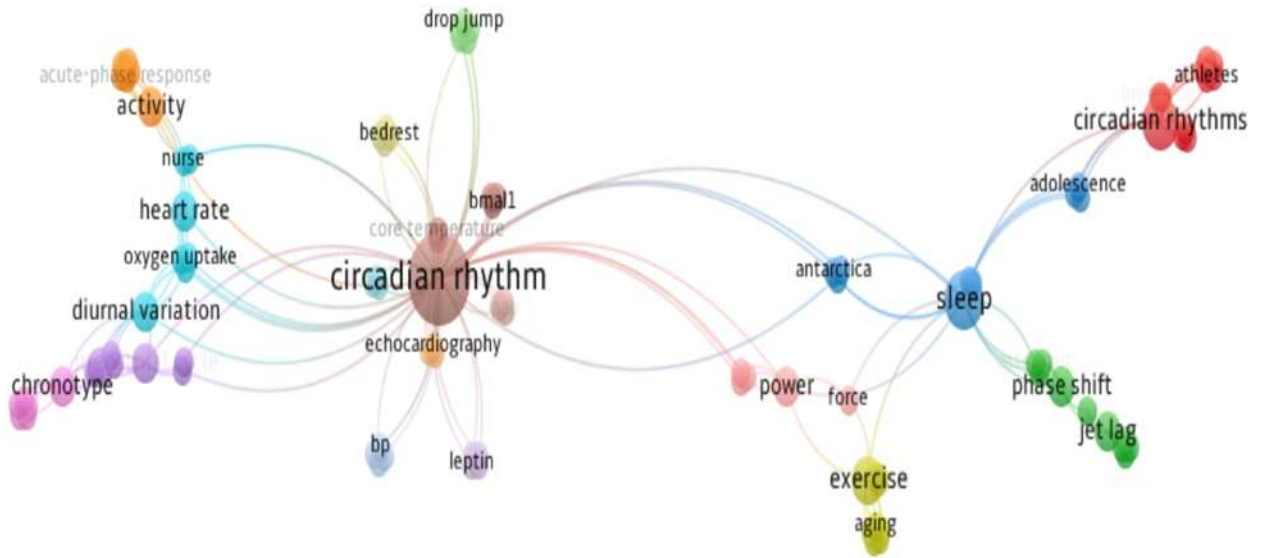
**Şekil 7.** Sirkadiyen ritim ve spor konulu yayınların ortak yazar ülkeler arası bağlantısı

**Şekil 7.** İncelendiğinde, sirkadiyen ritim ve spor alanındaki ülkeler arası iş birliği ağının merkezinde USA'nın yer aldığı görülmektedir. USA'nın başta İngiltere ve Fransa olmak üzere birçok ülke ile doğrudan bağlantı kurduğu, diğer ülkelerin ise daha sınırlı iş birliği ilişkilerine sahip olduğu görülmektedir. Bu durum, uluslararası iş birliklerinin belirli merkezler etrafında yoğunlaştığını göstermektedir.



**Şekil 8** Sirkadiyen ritim ve spor ilişkisine yönelik yapılan yayınların ortak alıntı yazar bağlantısı

**Şekil 8.** İncelendiğinde, Esser, Karyn A. ve Wolff, Gretchen’in yüksek atıf sayıları ve bağlantı gücü değerleri ile ağın merkezinde yer alan iş birlikçi yazarlar olduğu görülmektedir. Bu durum, söz konusu yazarların alan içerisindeki en etkili ve belirleyici araştırmacılar olduğunu göstermektedir.



| Anahtar kelime    | Oluşum | Toplam bağlantı kuvveti |
|-------------------|--------|-------------------------|
| Circadian rhythm  | 12     | 45                      |
| Sleep             | 5      | 17                      |
| Circadian rhythms | 4      | 13                      |
| Muscle strength   | 3      | 14                      |
| Exercise          | 3      | 10                      |

**Şekil 9.** İncelendiğinde sirkadiyen ritim ve spor ilişkisini konu alan çalışmalarda kullanılan anahtar kelime bağlantıları gösterilmektedir. Anahtar kelimeler farklı renk gruplarına ayrılmaktadır. Anahtar kelime kullanımında “circadian rhythm” 12 sayı ile birinci, “sleep” 5 sayı ile ikinci, “circadian rhythms” 4 sayı ile üçüncü, “muscle strength” 3 sayı ile dördüncü, “exercise” 3 sayı ile beşinci sırada yer almaktadır. Toplam bağlantı gücü açısından sirkadiyen

ritmin; kalp hızı, kas kuvveti ve egzersiz kapasitesi gibi performans parametreleriyle merkezi bir ilişki içinde olduğu görülmektedir.

## TARTIŞMA

Bu çalışmada elde edilen bulgular, spor bilimlerinde sirkadiyen ritim araştırmalarının gelişiminin doğrusal değil, dalgalı bir seyir izlediğini göstermektedir. Sirkadiyen ritim ve spor ile ilgili yapılan yayın sayısının 2013 yılında 26 yayın ile en yüksek seviyeye ulaştığı, 2022 yılında ise 12 yayın ile en düşük yayın sayısının gerçekleştiği tespit edilmiştir. Kurumlar düzeyinde Liverpool John Moores University 21 yayın ile alana en fazla katkı sağlayan kurum olmuştur. University of Sfax 18 yayın, Université de Caen Normandie ise 13 yayın ile alana katkı sağlayan diğer kurumlar arasında yer almaktadır. Sirkadiyen ritim ve spor ilişkisine ait yayınlarda, Hamdi Chtourou'nun 17 yayın, K. Chamarika'nın 13 yayın ve Anis Chaouachi'nin 12 yayın ile alanın gelişiminde ön plana çıktığı görülmektedir. Atıf ağlarında ise Karyn A. Esser ve Gretchen Wolff gibi yazarların merkezde yer alması hem üretkenliğin hem de bilimsel etkinin belirli isimler üzerinde yoğunlaştığını göstermektedir. Alana katkı sağlayan ülkeler incelendiğinde en fazla yayının 173 yayın ile Amerika Birleşik Devletleri'ne ait olduğu görülmektedir. Bunu 71 yayın ile İngiltere ve 58 yayın ile Fransa takip etmektedir. Anahtar kelime analizlerinde ise “Circadian rhythm”, “sleep”, “muscle strength” ve “exercise” gibi kavramların öne çıkması, araştırmaların doğrudan performans parametreleriyle ilişkili olduğunu göstermektedir. Sirkadiyen ritmin kalp atım hızı, kas kuvveti ve egzersiz kapasitesi gibi değişkenlerle güçlü bağlantı göstermesi, bu biyolojik mekanizmanın spor performansı üzerindeki belirleyici rolünü desteklemektedir. Bu bağlamda, antrenman zamanlaması, toparlanma süreçleri ve bireysel kronotip farklılıkların daha fazla dikkate alınması gerektiği düşünülmektedir. Sonuç olarak, bu çalışmada elde edilen bulgular spor bilimlerinde sirkadiyen ritim araştırmalarının dalgalı ancak genel olarak gelişim gösteren bir yapıya sahip olduğunu ortaya koymaktadır. Yayınların belirli yıllarda yoğunlaştığı, araştırma üretiminin ise sınırlı sayıda ülke, kurum ve araştırmacı etrafında toplandığı görülmektedir. Özellikle anahtar kelime analizleri, literatürün performans fizyolojisi ve egzersiz ilişkisi üzerinde yoğunlaştığını göstermektedir. Bu bağlamda, sirkadiyen ritmin spor performansı üzerindeki etkilerinin gelecekte daha bütüncül ve uygulamaya dönük çalışmalarla ele alınmasının önemli olacağı düşünülmektedir.

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## ULTRASONIC-ASSISTED ROOT CANAL RETREATMENT IN A C-SHAPED MANDIBULAR FIRST MOLAR

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### ABSTRACT

The C-canal structure is a complex anatomy that increases the difficulty of disinfection and the risk of iatrogenic complications due to the connections between root canals and thin dentin walls. The aim of this report is to present the one-year clinical and radiographic follow-up of root canal retreatment (RCR) performed in a left mandibular first molar tooth (#36) with a C-canal configuration. A systemically healthy 24-year-old female patient presented to the endodontics clinic with the complaint of severe pain in tooth #36. Clinical and radiographic examination revealed a C-canal configuration and a periapical lesion in the tooth with inadequate root canal treatment. After rubber dam isolation was achieved, the old restoration was removed. During the examination performed under a dental operating microscope (DOM), four separate canal orifices were identified. Subsequently, the previous root canal fillings were removed by the combined use of a TD6 ultrasonic tip (Woodpecker, Guangxi, China) and a retreatment file (Perfect, Guangxi, China). The root canals were shaped up to 50/.04 with rotary files (Endo Art, Istanbul, Türkiye), and calcium hydroxide medication was placed. Two weeks later, final irrigation was performed with ultrasonic activation (Eighteenth, Jiangsu, China) in the asymptomatic tooth. Root canal obturation was performed using the cold lateral compaction technique with a bioceramic-based root canal sealer. The permanent restoration was completed using composite resin. In the one-year follow-up radiograph, a significant reduction in periapical radiolucency was observed. The patient was asymptomatic and the tooth was functional. In teeth with complex C-canal morphology, the use of ultrasonic systems and DOM may provide important contributions to the performance of minimally invasive RCR and the improvement of treatment success.

**Keywords:** Bioceramic, C-canal, Dental operating microscope, Mandibular first molar, Ultrasonic

### C-KANALLI MANDİBULAR BİRİNCİ MOLARDA ULTRASONİK DESTEKLİ KÖK KANAL TEDAVİSİ TEKRARI

#### ÖZET

C-kanal yapısı, kök kanalları arasındaki bağlantılar ve ince dentin duvarları nedeniyle dezenfeksiyon güçlüğü ve iatrojenik komplikasyon riskini artıran kompleks bir anatomidir. Bu raporun amacı, C-kanal yapısına sahip sol mandibular birinci molar dişte (#36) gerçekleştirilen kök kanal tedavisi tekrarının (KKTT) bir yıllık klinik ve

radyografik takibini sunmaktır. Sistemik olarak sağlıklı 24 yaşındaki kadın hasta, #36 numaralı dişinde şiddetli ağrı şikâyeti ile endodonti kliniğine başvurdu. Yapılan klinik ve radyografik muayenede, yetersiz kök kanal tedavisine sahip dişte C-kanal konfigürasyonu ve periapikal lezyon tespit edildi. Rubber dam izolasyonu sağlandıktan sonra eski restorasyon uzaklaştırıldı. Dental operasyon mikroskobu (DOM) altında yapılan incelemede dört ayrı kanal orifisi tespit edildi. Ardından TD6 ultrasonik tip (Woodpecker, Guangxi, Çin) ve retreatment egesi (Perfect, Guangxi, Çin) kombine kullanılarak eski kök kanal dolguları uzaklaştırıldı. Kök kanalları, döner eğeler (EndoArt, İstanbul, Türkiye) ile 50/.04'e kadar şekillendirildi ve kalsiyum hidroksit medikasyonu yapıldı. İki hafta sonra asemptomatik olan dişte ultrasonik aktivasyon (Eighteeth, Jiangsu, Çin) ile final irrigasyon yapıldı. Biyoseramik esaslı kök kanal patı kullanılarak soğuk lateral kompaksiyon tekniği ile kök kanal dolumu gerçekleştirildi. Daimi restorasyon kompozit rezin kullanılarak tamamlandı. Bir yıllık takip radyografisinde periapikal radyolüenside belirgin azalma gözlemlendi. Hasta asemptomatik ve diş fonksiyonundaydı. Karmaşık C-kanal morfolojisine sahip dişlerde, minimal invaziv KKT'T'nin gerçekleştirilmesi ve tedavi başarısının artırılması açısından ultrasonik sistemler ve DOM kullanımı önemli katkılar sağlayabilir.

**Anahtar Kelimeler:** Biyoseramik, C-kanal, Dental operasyon mikroskobu, Mandibular birinci molar, Ultrasonik

## INTRODUCTION

Success in endodontic treatment depends on the effective cleaning, shaping, and hermetic obturation of the root canal system (Ahmed, Abu-bakr, Yahia, & Ibrahim, 2007; Torabinejad, 2023). Therefore, standard root and canal morphology must be thoroughly understood, and anatomical variations should be accurately identified and distinguished. Mandibular first molars exhibit highly complex root canal morphologies. These teeth typically present with a well-defined mesial root containing two canals and a well-defined distal root containing one or two canals (Vertucci, 1984). Variations in the root canal system may include configurations with five, six, or even seven canals; the presence of a middle mesial canal, a middle distal canal, four mesial root canals, or four distal root canals (Kırıcı & Koç, 2019; Tredoux, Warren, & Buchanan, 2021). These anatomical variations have been shown to be strongly associated with several factors, including ethnicity, age, sex, and environmental influences (Marceliano-Alves et al., 2019).

The C-shaped canal configuration was first described in the endodontic literature by Cooke and Cox in 1979. This morphology was termed a “C-shaped canal” based on the cross-sectional shape of the root and root canal system (Cooke & Cox, 1979). C-shaped canals are considered an anatomical variation resulting from root fusion. This condition arises due to the failure of Hertwig's epithelial root sheath to develop or fuse in the furcation area during tooth development. Failure on the buccal side results in a lingual groove, and vice versa. Failure on both sides leads to the formation of a conical or prism-shaped root (Kadam & Ataide, 2013). In teeth with C-shaped canals, either both or one of the mesiobuccal or mesiolingual canal orifices

merge with the distal canal orifice. This fusion is commonly observed on the lingual side and rarely on the buccal side (Fan et al., 2009; Zhang et al., 2011).

It has been reported that the C-shaped canal configuration is most commonly observed in molars, particularly with a higher prevalence in mandibular second molars (Min, Fan, Cheung, Gutmann, & Fan, 2006; Yilmaz, Tuncel, Serper, & Calt, 2006). However, this morphology may also be encountered in mandibular first premolars (Yin et al., 2010), mandibular first molars (Bolger & Schindler, 1988), maxillary lateral incisors (Gu, 2011) and maxillary molars (Karaxha et al., 2012; Keinan, Nuni, & Slutzky-Goldberg, 2009). Furthermore, this morphology has been reported most frequently in mandibular second molars of individuals of Asian origin (14–52%) (Yin et al., 2010; Zheng et al., 2011). whereas its prevalence in the Turkish population has been reported to be approximately 8% (Cimilli, Cimilli, Mumcu, Kartal, & Wesselink, 2005).

While some studies have reported no correlation between the presence of C-shaped canals and sex or age (Feghali, Jabre, & Haddad, 2022; Shemesh et al., 2017), others have found a significantly higher prevalence in females (Armenta et al., 2024; Martins et al., 2019). Yang et al. (2021) reported that C-shaped canals were significantly less common in patients over 61 years of age (24.08%), compared to those aged 21–30 years (40.02%).

The complex anatomy of C-shaped canals presents significant challenges in achieving successful endodontic treatment. Their irregular morphology complicates effective cleaning, shaping, and obturation procedures, often leading to missed canals, inadequate disinfection, and incomplete filling (Patil M; Mujawar A; Rachalwar D; Şeyh S, 2023). This case report presents the successful nonsurgical retreatment of a left mandibular first molar (#36) with a C-shaped canal configuration.

## **CASE PRESENTATION**

A 24-year-old female patient, systemically healthy, presented to the endodontics clinic with a complaint of persistent pain in the left mandibular first molar, which had previously undergone endodontic treatment at another clinic. According to the patient's history, she experienced numbness in the jaw following the initial root canal treatment, which resolved after the use of a vitamin B derivative medication. Clinical examination revealed tenderness to percussion. Panoramic and periapical radiographic evaluation demonstrated a C-shaped canal configuration in tooth #36, along with inadequate root canal filling, a periapical lesion, and extrusion of root

canal sealer into the mandibular canal (Şekil 1). Based on the clinical and radiographic findings, a diagnosis of acute exacerbation of chronic apical periodontitis was established.

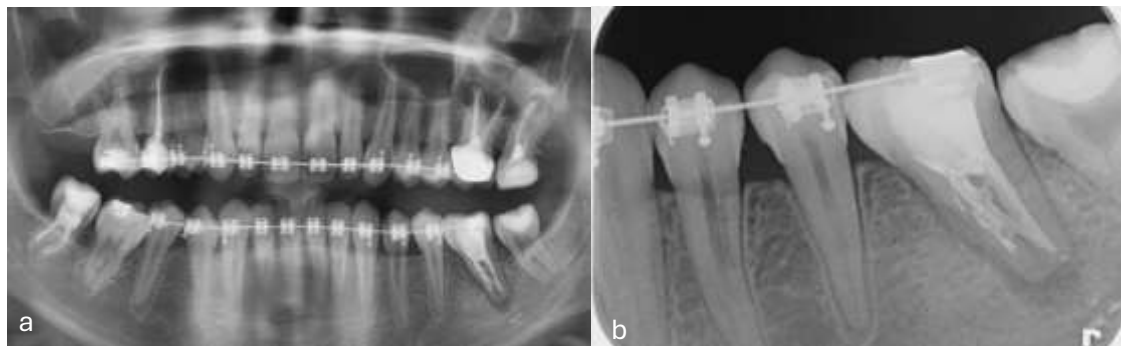


**Figure 1.** Preoperative radiographs: (a) panoramic radiograph, (b) periapical radiograph

After providing detailed information about the planned procedures, written informed consent was obtained from the patient. Inferior alveolar nerve block anesthesia was administered using Ultraver DS Forte (80 mg + 0.03638 mg + 2 mL; Haver Farma, Istanbul, Türkiye). Following rubber dam isolation, the existing restoration was removed under water cooling using a diamond round bur (Meisinger, Neuss, Germany), and the access cavity was refined. Under a dental operating microscope (DOM; Extaro 300, Zeiss, Oberkochen, Germany) at 1.6× magnification, four distinct canal orifices were identified. Subsequently, previous root canal fillings were removed using a combination of a TD6 ultrasonic tip (Woodpecker, Guangxi, China) and retreatment files (Perfect, Guangxi, China). Working length was determined using a #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) in conjunction with an apex locator (Root ZX Mini; J. Morita Co., Tokyo, Japan) and confirmed radiographically. Root canals were shaped up to size 50/.04 using rotary Ni-Ti files (EndoArt, Istanbul, Türkiye) (Figure 2). Irrigation was performed with 2 mL sodium hypochlorite (NaOCl) at each instrument change. Calcium hydroxide (Calsin, Imicryl, Konya, Türkiye) was placed as an intracanal medicament, and the cavity was temporarily sealed.





**Figure 2.** Intraoral view of root canal orifices

After two weeks, the tooth was asymptomatic. Circumferential filing was performed using a #50 H-file (Dentsply Maillefer) to facilitate effective removal of the medicament. Final irrigation was carried out using 5 mL of 17% EDTA, 20 mL of 2.5% NaOCl, and 5 mL of distilled water, all activated using ultrasonic activation (Eighteeth, Jiangsu, China). The canals were dried using sterile paper points (DiaDent, Heungdeok-gu, Korea). Root canal obturation was performed using a bioceramic-based sealer (Bio-C Sealer, Angelus, Londrina, Brazil) with the cold lateral compaction technique. The permanent restoration was completed using a composite resin (RubyFlow Flowable Composite, Rubydent, Istanbul, Türkiye) (Figure 3).



**Figure 3.** Postoperative periapical radiograph

At the 1-year follow-up, a significant reduction in lesion size was observed. The tooth remained asymptomatic and functional (Figure 4).



**Figure 4.** One-year follow-up radiographs: (a) panoramic radiograph, (b) periapical radiograph

## DISCUSSION

The primary requirement for successful endodontic treatment is the effective cleaning and shaping of the root canal system. However, in addition to normal canal anatomy, a comprehensive understanding and management of morphological variations can present challenges for clinicians (Fan, Cheung, Fan, Gutmann, & Bian, 2004). Mandibular first molars, in particular, exhibit more complex anatomical variations compared to other tooth groups. These teeth typically have two separate roots; the mesial root generally contains two canals, while the distal root often presents a single round or elliptical canal (Torabinejad, 2023).

Diagnosis and treatment planning are critical steps in the successful management of C-shaped canal systems. Accurate diagnosis requires careful clinical and radiographic evaluation, and advanced imaging techniques such as cone-beam computed tomography (CBCT) should be utilized in suspicious cases. Early recognition of complex root canal morphology allows for appropriate treatment strategy selection. Preoperative assessment of root canal anatomy plays a crucial role in endodontic success, particularly in retreatment cases (Fan et al., 2004). Radiographic findings such as fused roots, indistinct pulp chamber floor, radiolucent areas resembling perforation in the furcation region, and the convergence of endodontic instruments toward the apex may indicate the presence of a C-shaped canal, especially in mandibular second molars (Raisingani, Gupta, Mital, & Khullar, 2014).

In teeth with C-shaped canals, the pulp chamber typically has a greater apico-occlusal dimension and a more apically positioned furcation level (Gulabivala, Opananon, Ng, & Alavi, 2002). resulting in an unusually deep pulp chamber floor (Barnett, 1986). In the present case, the preoperative radiograph revealed a single wide root appearance and indistinct canal separations, supporting suspicion of a C-shaped canal morphology. Clinically, diagnosis becomes easier after access cavity preparation and pulp extirpation (Lambrianidis, Lyroudia, Pandelidou, & Nicolaou, 2001). However, due to the complex anatomy and extensive pulp tissue, excessive bleeding may impair visibility and hinder the identification of canal orifices. Inadequate hemostasis may increase the risk of perforation, particularly in areas with thin dentinal walls (Yang et al., 2021). For this purpose, effective irrigation activation along with appropriate irrigation protocols is recommended (Raducka et al., 2023). These approaches both facilitate the removal of debris and smear layer and contribute to a better understanding of the

complex root canal anatomy (Marx et al., 2025). Therefore, in the presented case, passive ultrasonic irrigation activation technique was preferred to increase irrigation effectiveness.

Studies on the cleaning efficiency of C-shaped canals demonstrate the presence of areas untouched by instruments (Yin et al., 2010). Research has shown that hand instrumentation may lead to debris accumulation in irregular regions and isthmuses (Melton, Krell, & Fuller, 1991). However, circumferential and anti-curvature filing techniques using hand instruments have been reported to leave fewer untouched areas and provide better canal wall contact compared to Ni-Ti rotary systems (Yin et al., 2010). Accordingly, in this case, circumferential filing was performed after rotary instrumentation to eliminate debris in untouched areas and remove calcium hydroxide.

The use of a DOM facilitates the detection of canal orifices and improves treatment outcomes (Vertucci & Haddix, 2011). Numerous studies recommend its use for exploring root canal anatomy and managing endodontic diseases (Adcock et al., 2011; De Groot et al., 2009; Kato et al., 2014). Therefore, in this case, 1.6× magnification using DOM was preferred to better visualize the C-shaped canal anatomy and to avoid missing additional canals.

In teeth with C-shaped root canal morphology, endodontic failure is most frequently due to microleakage (45.2%) and isthmus region (23.8%). Therefore, it is crucial for clinicians to be knowledgeable about the complex morphology of C-shaped root canal systems to ensure effective removal of pulp tissue and microorganisms, and hermetically seal the root canal system. (Kim, Lee, Kim, & Kim, 2018). In this context, obturation of C canals may require some technical modifications. When using cold lateral compaction technique for obturation, the compaction device needs to penetrate deeper into different regions of the canal. (Hasheminia, Farhad, Saatchi, Nejad, & Sanei, 2015). However, using only the lateral compaction technique can make it difficult to adequately fill the isthmus region. In order to overcome this problem, Barnett (1986), the study recommended using a large-diameter file in the most distal part of the canal before the main cone was placed in the mesial canal. After the removal of this file, the main cone is placed in the distal canal, and then the accessory cones are placed in the middle part of the C-shaped canal. In this case, the cold lateral compaction technique was applied using this method for obturation.

Bioceramic-based root canal sealants, especially in teeth with C-canal morphology, contribute to more effective filling of complex anatomical areas due to their good fluidity and ability to form chemical bonds with dentin in the isthmus, attachment pathways, and irregular canal

surfaces (Li et al., 2025). Furthermore, the fact that it hardens with minimal shrinkage by forming a hydroxyapatite-like structure during the hardening process helps bioceramic-based sealants maintain long-term watertightness in such cases.(Cheng et al., 2010). Therefore, due to its superior sealing properties, high biocompatibility, and hydrophilic structure, which allows it to maintain its effectiveness even in humid environments, a bioceramic-based root canal sealant was preferred in this case.(Jitaru, Hodisan, Timis, Lucian, & Bud, 2016).

## CONCLUSION

In the retreatment of mandibular molars with C-shaped canal morphology, the combined use of a DOM and ultrasonic systems may facilitate more effective identification, cleaning, and disinfection of the complex root canal system, thereby supporting periapical healing. Additionally, minimally invasive shaping, irrigation, and obturation protocols may significantly contribute to the long-term preservation of tooth function and the sustainability of clinical success.

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## **EOSINOPHILIC GRANULOMA OF THE THORACIC SPINE (T5) IN A PEDIATRIC PATIENT: A MINIMALLY INVASIVE APPROACH WITH LITERATURE REVIEW**

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### **ABSTRACT**

Langerhans cell histiocytosis (LCH) is a rare disorder characterized by the clonal proliferation of bone marrow–derived dendritic cells, most commonly presenting with osseous involvement in the pediatric population. Although the long bones and skull are most frequently affected, spinal involvement accounts for approximately 10% of cases and may present as vertebra plana. In this study, we present a case of eosinophilic granuloma involving the T5 vertebra in a 10-year-old boy who presented with back pain. Radiological evaluation demonstrated marked loss of vertebral body height consistent with vertebra plana, and malignancy as well as infection were considered the primary differential diagnoses. The diagnosis was confirmed fluoroscopy-guided percutaneous needle biopsy, and intralesional methylprednisolone injection was administered during the same session. Histopathological examination revealed morphological features consistent with Langerhans cells, while immunohistochemical analysis showed positivity for CD1a(+), S100, CD68, and Cyclin D1. Following the minimally invasive intervention, the patient exhibited rapid clinical improvement with significant pain relief. In accordance with the existing literature, percutaneous biopsy combined with intralesional steroid injection appears to be a safe and effective alternative to surgical treatment in appropriately selected cases.

**Keywords:** Langerhans cell histiocytosis, eosinophilic granuloma, vertebra plana, pediatric, minimally invasive treatment



## PEDİATRİK OLGUDA TORAKAL (T5) YERLEŞİMLİ EOZİNOFİLİK GRANÜLOM: MİNİMAL İNVAZİV YAKLAŞIM VE GÜNCEL LİTERATÜR IŞIĞINDA DEĞERLENDİRME

### ÖZET

Langerhans hücreli histiyositozis (LHH), kemik iliği kökenli dendritik hücrelerin klonal proliferasyonu ile karakterize nadir bir hastalık olup, özellikle pediatrik yaş grubunda kemik tutulumuyla ön planda görülmektedir. En sık uzun kemikler ve kafatası etkilenmekle birlikte, spinal tutulum olguların yaklaşık %10'unu oluşturmaktadır ve vertebra plana ile prezente. Bu çalışmada, sırt ağrısı şikâyeti ile başvuran 10 yaşındaki erkek hastada T5 vertebra yerleşimli eozinofilik granülom olgusu sunulmuştur. Radyolojik incelemelerde vertebra korpusunda belirgin yükseklik kaybı ile uyumlu vertebra plana görünümü izlenmiş, ayırıcı tanıda malignite ve enfeksiyon öncelikli olarak değerlendirilmiştir. Tanı, skopi eşliğinde gerçekleştirilen perkütan iğne biyopsisi ile doğrulanmış ve aynı seansta intratekal metilprednizolon enjeksiyonu. Histopatolojik değerlendirmede Langerhans hücreleri ile uyumlu morfolojik bulgular saptanmış; immünohistokimyasal incelemede CD1a (+), S100 (+), CD68 (+) ve Cyclin D1 (+) ekspresyonu gösterilmiştir. Minimal invaziv tedavi yaklaşımı sonrası hastada hızlı klinik iyileşme gözlenmiş, ağrı belirgin şekilde gerilemiştir. Literatür verileriyle uyumlu olarak, uygun seçilmiş olgularda perkütan biyopsi ve intratekal steroid enjeksiyonunun güvenli, etkili ve cerrahiye alternatif bir tedavi yöntemi olduğu düşünülmektedir.

**Anahtar Kelimeler:** Langerhans hücreli histiyositozis, eozinofilik granülom, vertebra plana, pediatrik, minimal invaziv tedavi

### GİRİŞ

Langerhans hücreli histiyositozis (LHH), CD1a ve langerin (CD207) pozitif dendritik hücrelerin klonal proliferasyonu ile karakterize nadir bir hastalıktır ve inflamatuvar-neoplastik özellikler gösteren özgün bir patolojik spektrum oluşturur (Emile ve ark., 2016). Kemik tutulumu langerhans hücreli histiyositozisin en sık prezentasyonu olup çocukluk çağında sıklıkla eozinofilik granülom şeklinde karşımıza çıkmaktadır (Haupt ve ark., 2013). Spinal tutulum olguların yaklaşık %10'unu oluşturmakta ve torakal vertebralar en sık etkilenen bölgeyi oluşturmaktadır (Grois ve ark., 2010). Bu olgularda en karakteristik radyolojik bulgu vertebra plana olmakla birlikte, bu görünüm spesifik değildir ve maligniteler ile enfeksiyonları taklit edebilmektedir (Azouz ve ark., 2005; Garg ve ark., 2004). Bu nedenle kesin tanı için histopatolojik doğrulama gereklidir. Bu çalışmada, minimal invaziv yöntemle tedavi edilen torakal yerleşimli pediatrik bir eozinofilik granülom olgusu sunulmuştur.

### MATERYAL VE YÖNTEM

Bu çalışma, yaklaşık üç haftadır devam eden mekanik karakterde sırt ağrısı şikâyeti ile başvuran 10 yaşındaki erkek hastanın retrospektif değerlendirilmesi üzerine kuruludur. Hastada travma öyküsü bulunmamaktadır. Nörolojik muayenede motor ve duyu defisiti saptanmamış, patolojik refleks izlenmemiştir. Laboratuvar incelemelerinde enfeksiyon lehine bulgu saptanmamıştır. Manyetik rezonans görüntülemesinde T5 vertebra korpusunda belirgin yükseklik kaybı ile uyumlu

vertebra plana görünümü izlenmiştir. Lezyonun tanısal değerlendirmesi amacıyla skopi eşliğinde perkütan iğne biyopsisi uygulanmış, aynı seansta intralezyonel metilprednizolon enjeksiyonu yapılmıştır. Elde edilen doku örnekleri histopatolojik ve immünohistokimyasal olarak incelenmiştir.

## BULGULAR VE TARTIŞMA

Histopatolojik incelemede Langerhans hücreleri ile uyumlu morfoloji izlenmiş; immünohistokimyasal boyamada CD1a (+), S100 (+), CD68 (+) ve Cyclin D1 (+) saptanmıştır. Bu bulgular ile LHH tanısı doğrulanmıştır. Tedavi sonrasında hastada hızlı klinik iyileşme gözlenmiş, ağrı yakınmasında belirgin gerileme olmuştur. Klinik takip sürecinde hastaya Jewett korse uygulanmıştır.

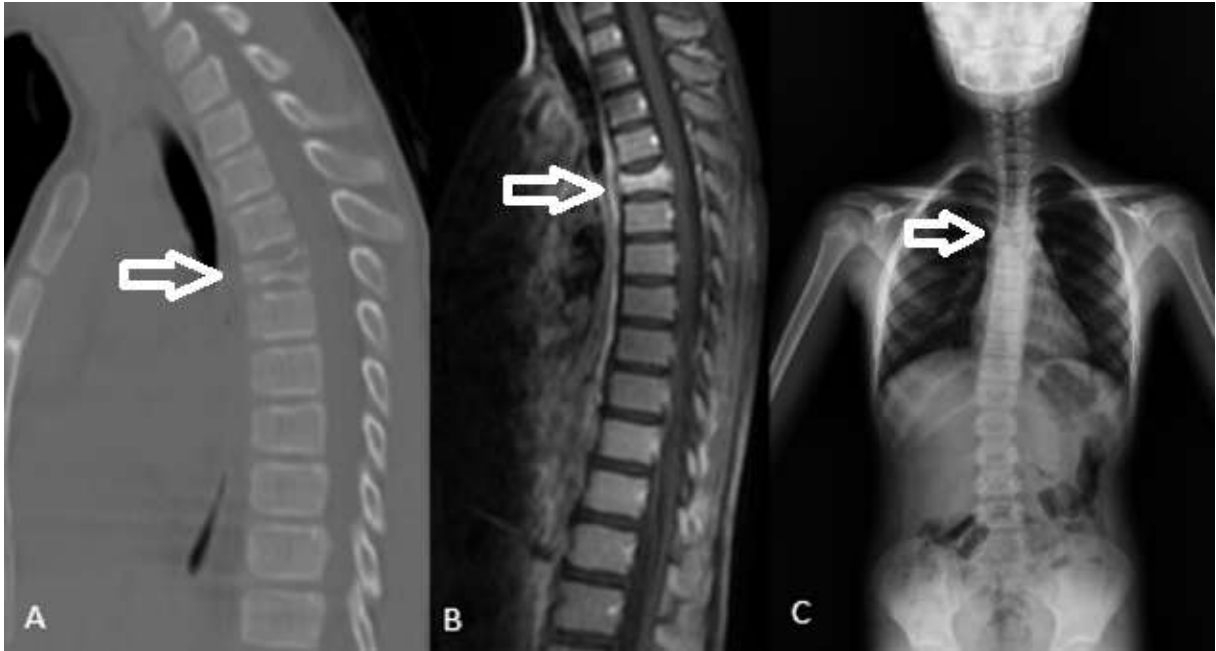
Pediyatrik spinal tümörlerin yaklaşık %6,5 ila %25'ini oluşturan eozinofilik granülom (EG), LHH'in genellikle benign ve kendini sınırlayan bir formudur (Haupt ve ark., 2013). Bu lezyonlar iyi huylu olmalarına rağmen spinal yerleşimli olgularda vertebral kollaps, progresif deformite ve nadir durumlarda nörolojik defisit gelişme potansiyeli taşımaktadırlar.

Pediyatrik spinal LHH için patognomonik bir bulgu olarak kabul edilen vertebra plana, vertebral gövdenin simetrik veya asimetrik çökmesiyle karakterizedir. Ancak bu radyolojik görünüm; Ewing sarkomu, lenfoma, enfeksiyöz spondilit gibi patolojilerle benzerlikler taşımaktadır (Azouz ve ark., 2005; Garg ve ark., 2004). Bu nedenle görüntüleme bulguları tek başına tanı koydurucu değildir. Kesin tanı için biyopsisi altın standarttır.

Spinal EG yönetimine dair standart bir tedavi algoritması bulunmamakla birlikte, tedavi stratejisi semptomların şiddeti, mekanik stabilite ve radyolojik değerlendirmeyeyle belirlenmelidir. Asemptomatik veya stabil lezyonlarda konservatif izlem ve immobilizasyonu ilk seçenek olarak önerilmesine rağmen, üç aylık gözlemlerde %50'den fazla vertebral yükseklik kaybı olan, instabilite bulguları bulunan ve nörolojik defisiti bulunan olgularda cerrahi müdahale önerilmektedir. Cerrahi tedavide ise perkütan kifoplasti ve geçici pedikül vidası fiksasyonu ile vertebral korpus yüksekliğinin ortalama %86 yeniden sağlandığı ve VAS skorunda çok hızlı bir düşüş yaşandığı bildirilmiştir. (Zheng ve ark., 2022). Buna karşın literatür verilerinde litik lezyonların biyopsiyle kesin tanısının konulmasının yeterli olduğu, pediyatrik popülasyonda kemik matürasyonunun devam etmesi sayesinde, litik sürecin kontrol altına

alınmasını takiben vertebral korpusun kendi yüksekliğini yeniden kazanabilme kapasitesine sahip olduğu ifade edilmiştir. (Jain ve ark., 2022),

Bu çalışmaların yansira intralezyonel steroid enjeksiyonu inflamatuvar süreci baskılayarak osteolitik aktiviteyi azalttığı ve hızlı semptomatik düzelme sağladığını bildiren çalışmalar da mevcuttur (Scaglietti ve ark., 1982). Literatürde perkütan biyopsi ile eş zamanlı uygulanan steroid tedavisinin yüksek başarı oranı ve düşük komplikasyon riski ile etkili olduğu bildirilmiştir (Bertram ve ark., 2002). Sunduğumuz olguda nörolojik defisit bulunmaması nedeniyle minimal invaziv yaklaşım tercih edilmiş, perkütan iğne biyopsisi uygulanmış, aynı seansta intralezyonel metilprednizolon enjeksiyonu yapılmıştır.



**Şekil 1.** (A) T5 vertebrada korpus çökmesini gösteren sagittal BT görüntüsü, (B) T5 düzeyinde lezyon sinyal değişikliklerinin izlendiği sagittal MR görüntüsü, (C) Torakal omurganın direkt grafi görüntüsü.

**Tablo 1.** Olgunun klinik ve tanısal parametreleri

| Kategori | Uygulama                                | Ana fonksiyon                       | Temel yarar                                                |
|----------|-----------------------------------------|-------------------------------------|------------------------------------------------------------|
| Tanı     | Perkütan iğne biyopsisi                 | Histopatolojik doğrulama            | LHH tanısını doğrular, maligniteyi dışlamaya yardımcı olur |
| Tedavi   | İntralezyonel steroid enjeksiyonu       | Osteolitik aktivitenin baskılanması | Hızlı ağrı kontrolü, düşük morbidite                       |
| Mekanik  | Jewett korse uygulaması                 | Omurga stabilizasyonu               | Destekleyici tedavi                                        |
| Patoloji | İmmünohistokimyasal boyama (CD1a, S100) | Klonal hücre tanımlaması            | Kesin tanı sağlar                                          |

## SONUÇ

Langerhans hücreli histiyositozisin spinal tutulumu, özellikle vertebra plana ile prezente olan pediatrik hastalarda malignite ve enfeksiyöz patolojilerle önemli ölçüde karışabileceğinden, ayırıcı tanıda mutlaka göz önünde bulundurulmalıdır. Nörolojik defisit ve belirgin spinal instabilite bulunmayan seçilmiş olgularda, perkütan biyopsi ile eş zamanlı intralezyonel steroid enjeksiyonunu içeren minimal invaziv yaklaşımın hem tanısal hem de terapötik açıdan etkili olduğu görülmektedir. Sonuç olarak, uygun hasta seçimi yapıldığında minimal invaziv tedavi yaklaşımlarının düşük morbidite ile başarılı klinik sonuçlar sağladığı ve spinal LHH olgularında güvenilir bir ilk basamak tedavi seçeneği olarak değerlendirilebileceği kanaatindeyiz.

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## USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN PHOTOVOLTAIC POTENTIAL ESTIMATION: A FIELD APPLICATION FOR ANTALYA PROVINCE

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### ABSTRACT

Rising energy costs have become one of the most critical factors threatening the sustainability of agricultural production. This study investigates the on-site energy generation potential in rural areas where agricultural activities are intense and the demand for electricity-based irrigation and acclimatization (cultivated mushroom growing) is high. Yazır Village, located in the Korkuteli district of Antalya province, was selected as the study site due to its high sunshine duration and favorable microclimate characteristics. Within the scope of the study, the roof areas of 1283 buildings throughout the village were digitized and analyzed using Geographic Information Systems (CBS/QGIS). The suitability for photovoltaic (PV) system installation was evaluated for pitched tile roofs, which constitute 95% of the building stock, and agricultural outbuildings (barns, warehouses, mushroom facilities), which make up 30%. Considering the region's low snow load risk and high irradiance values, the potential of existing roof areas to meet the energy needs of the village's agricultural irrigation and mushroom production facilities was calculated. This study aims to demonstrate both the economic and environmental benefits of a solar energy-supported transformation model in rural areas where fossil fuel (coal/wood) usage is prevalent.

**Keywords:** Renewable Energy; Rural Development; GIS; Photovoltaic Potential; Agricultural Energy Efficiency; Korkuteli Yazır.

### INTRODUCTION

Parallel to increasing population and technological advancements worldwide, energy demand is rising rapidly, bringing with it global problems such as the depletion of fossil fuel reserves and environmental issues (Kum et al., 2019; Endiz and Coşgun, 2023). These difficulties in meeting energy demand and policies combating climate change necessitate a shift in energy generation from centralized systems to distributed systems based on production at the point of consumption (Kılıç and Kekezoğlu, 2022). Particularly in countries like Turkey, where energy demand is constantly increasing and solar energy potential is high, on-site energy

production reduces transmission losses and increases energy supply security (Atak et al., 2019; Akkas et al., 2017). Although there are numerous studies on rooftop solar power plants (SPP) in urban areas and buildings (Fakhraian et al., 2021), the energy transformation of rural areas—the heart of agricultural production—is of vital importance for food security and farmer income.

Due to its geographical location, Turkey is quite fortunate regarding solar energy potential and possesses high potential in terms of average annual sunshine duration and radiation values (Kılıç, 2011; Colak et al., 2020). Although Antalya province is one of the regions with the highest sunshine duration in Turkey, as stated in the literature, very high ambient temperatures cause thermal losses in photovoltaic panels, reducing energy conversion efficiency (Kum et al., 2019). In this context, unlike the extreme heat of Antalya's coastline, the Korkuteli district, situated in the interior and possessing a cooler plateau climate, is in a more advantageous position regarding PV system efficiency. Yazır Village, the focus of this study; as seen in Figure 1, qualifies as an ideal solar energy site with its flat topography (Colak et al., 2020), high sunshine duration, and favorable microclimate features.



**Figure 1.** Satellite View of Yazır Village

When the socio-economic structure of the village is examined, it is observed that the main sources of livelihood are agriculture, fruit growing, and cattle breeding. However, the

primary factor rendering the region critical in terms of energy consumption is the cultivated mushroom growing extensively carried out on the ground floors or outbuildings of homes. Mushroom production is an agricultural activity requiring 24/7 acclimatization and ventilation, thus consuming high electricity per unit area. Additionally, underground borehole pumps used for agricultural irrigation significantly increase the village's electricity demand. Currently, the absence of natural gas infrastructure in the village and the provision of heating largely through biomass (wood) and fossil fuels (coal) increase the carbon footprint and threaten environmental sustainability (Endiz and Coşgun, 2023; Atak et al., 2019).

Geographic Information Systems (GIS) and remote sensing techniques are used as effective methods for analyzing large areas in the determination of solar energy potential (Kum et al., 2019; Colak et al., 2020; Fakhraian et al., 2021). In this study, a roof inventory of 1283 buildings in Yazır Village was extracted using QGIS software. It was determined that only 5% (63 buildings) of the analyzed building stock consisted of flat roofs, while the remaining vast majority were of the pitched tile roof type suitable for PV mounting. Observing the "Physical, Geographic, and Technical Potential" distinction stated in the literature (Fakhraian et al., 2021), the fact that 30% of the buildings are single-story structures used as barns or mushroom facilities offers extra potential in terms of ease of installation and maintenance. With this study, the electrical energy potential obtainable using the existing roof areas of Yazır Village will be determined, and the capacity of this production to meet the village's agricultural electrical load will be discussed.

## **MATERIAL AND METHODS**

In this study, a Geographic Information Systems (GIS)-based method was followed to determine the rooftop solar energy potential of Yazır Village, Korkuteli district, Antalya province. The methodology consists of three stages: data collection and digitization, determination of technical potential according to roof types, and PVGIS-based energy production simulation (Fakhraian et al., 2021; Colak et al., 2020).

### **Data Collection and Digitization with GIS**

QGIS open-source software was used for the analysis of the building stock in the study area. All structures within the village boundaries were digitized as polygons over high-resolution satellite images, and attribute data were created. As a result of the inventory work



conducted, as indicated by the purple shapes in Figure 2, a total of 1283 buildings were identified throughout the village, and the total gross roof area of these buildings was calculated as 216,357 m<sup>2</sup>.



**Figure 2.** Yazır Village Satellite View, polygon shapes of roofs in QGIS program

As can be seen via Figure 2, when the characteristics of the building stock are examined, it is observed that the majority of the buildings consist of detached houses and, unlike apartment structures in city centers, there are no administrative barriers (common ownership issues, etc.) regarding roof usage rights. This situation provides a significant advantage in terms of making investment decisions and managing maintenance-repair processes (Kılıç and Kekezoğlu, 2022). Furthermore, the existence of PV systems currently installed in 6 buildings, working with a heat pump-supported heating model in winter and a grid-sale (net-metering) model in summer, indicates that the region's technological adaptation has begun.

### Roof Typology and Usable Area Determination

The digitized data were classified according to roof geometry and intended use. To determine the net area free of shading and structural obstacles, defined as "Geographic Potential" in the literature (Fakhraian et al., 2021), the following assumptions were made. As can be seen in Figure 3, yellow shapes on the regional map were used to identify flat-roofed houses, and their areas were calculated.



**Figure 3.** Yazır Village satellite view, polygon drawings of flat roofs in QGIS program

- **Flat Roofs:** A total of 63 buildings have flat roofs, with a total area of 10,862 m<sup>2</sup>. The smallest of this group was measured as 74 m<sup>2</sup> and the largest as 437 m<sup>2</sup>. Due to the necessity of placing panels facing south at the optimum angle (33° for Yazır Village) and leaving inter-row shading distance on flat roofs, 45% of the gross area was accepted as the effective panel area (Fakhraian et al., 2021).
- **Pitched Roofs:** In the remaining tile-covered pitched roofs, considering that only south, southeast, and southwest facades are efficient and due to obstacles such as chimneys/antennas, 50% of the gross area was included in the calculation as usable area.
- **Agricultural and Commercial Structures:** 30% of the analyzed buildings consist of single-story outbuildings (barns, garages, and cultivated mushroom production facilities) located next to the main residence. Especially since mushroom production requires 24/7 acclimatization, systems installed on these structures will increase the self-

consumption rate and shorten the amortization period. Additionally, the 5 largest roofs detected (maximum 3915 m<sup>2</sup>) belong to cold storage facilities serving fruit growing activities in the region. These structures possess the highest priority investment potential with their high energy consumption and large roof areas.

### **Energy Production Simulation with PVGIS**

The PVGIS (Photovoltaic Geographical Information System) tool developed by the European Commission Joint Research Centre (JRC) was used to calculate the annual energy production potential over the determined effective areas (Kılıç, 2011). In the simulation based on Yazır Village coordinates (37.020° N, 30.290° E), Crystalline Silicon (c-Si) panels and a 14% system loss assumption were used.

According to the simulation results, the optimum tilt angle for the region was determined as 33° and the azimuth angle as 7° (South). Under these parameters, it was calculated that a system with 1 kWp installed power in Yazır Village could produce 1569 kWh of electricity annually. This value is above the Turkey average (Kılıç, 2011) and many European countries at similar latitudes (Endiz and Coşgun, 2023). This obtained unit production value was multiplied by the calculated total net roof area to reveal the village's total annual electricity production potential (GWh/year).

### **Photovoltaic Area and Installed Power Calculation**

Calculations made using analyses performed in the GIS environment and literature-supported (Fakhraian et al., 2021) coefficients are summarized in Table 1. When the roof surfaces of a total of 1283 buildings were analyzed, it was determined that the net area suitable for photovoltaic system installation, after deducting shading, orientation, and structural obstacles, is 107,636 m<sup>2</sup>. The total gross area for flat roofs is 10,862 m<sup>2</sup>, and with a 45% usability rate, 4,888 m<sup>2</sup> of area suitable for panel installation is obtained. The total gross area of pitched roofs is 205,495 m<sup>2</sup> (216,357 – 10,862), and with a 50% usability rate, 102,748 m<sup>2</sup> of area suitable for panel installation is provided. Thus, the total net panel area reaches 107,636 m<sup>2</sup>.

In flat roofs (total 63 buildings), 45% of the gross area was accepted as the effective area due to the necessity of placing panels facing south with a 33° tilt angle optimized for the region and leaving inter-row shading distance. In pitched roofs, north facades and obstacles

such as chimneys/antennas were excluded, and 50% of the gross area was evaluated as technical potential.

$$\text{Installed Power (MWp)} = \frac{\text{Net Panel Area (m}^2\text{)}}{5 \left(\frac{\text{m}^2}{\text{kWp}}\right) \times 1000} = \frac{107,636 \text{ m}^2}{5 \times 1000} = 21,527 \text{ MWp} \approx 21,5 \text{ MWp} \quad (1)$$

Considering the average efficiency (20-21%) and area requirement (5m<sup>2</sup>/kWp) of current monocrystalline silicon panel technology, the total rooftop installed power potential of Yazır Village (Table 1) was calculated as approximately 21.5 MWp (Megawatt-peak).

**Table 1.** Yazır village roof type PV potential distribution

| <b>Roof Type</b> | <b>Number of Buildings</b> | <b>Gross Area (m<sup>2</sup>)</b> | <b>Usage Coefficient</b> | <b>Net Panel Area (m<sup>2</sup>)</b> | <b>Estimated Installed Power (kWp)</b> |
|------------------|----------------------------|-----------------------------------|--------------------------|---------------------------------------|----------------------------------------|
| Flat Roofs       | 63                         | 10,862                            | 0.45                     | 4,888                                 | ~977                                   |
| Pitched Roofs    | 1,220                      | 205,495                           | 0.50                     | 102,748                               | ~20,550                                |
| <b>TOTAL</b>     | <b>1,283</b>               | <b>216,357</b>                    | <b>-</b>                 | <b>107,636</b>                        | <b>21,527</b>                          |

### Annual Energy Production Estimation

Using the determined installed power (21,527 kWp) and the region's PVGIS simulation data, the annual energy production was calculated as shown in Figure 4. In the simulation, "Crystalline Silicon" panel technology, 14% system loss (including cables, inverter, and soiling), and optimized 33° panel tilt parameters were used. Thanks to the region's high sunshine potential and the positive effect of the cool plateau climate on photovoltaic cell efficiency, it was foreseen that 1 kWp installed power could produce 1,569 kWh of electricity annually.



PVGIS-5 estimates of solar electricity generation:

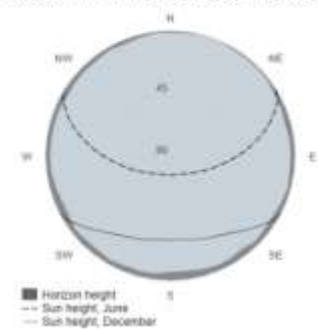
Provided inputs:

Latitude/Longitude: 37.020,30.290  
Horizon: Calculated  
Database used: PVGIS-SARAH3  
PV technology: Cryst Sil Original  
PV installed: 1 kWp  
System loss: 14 %

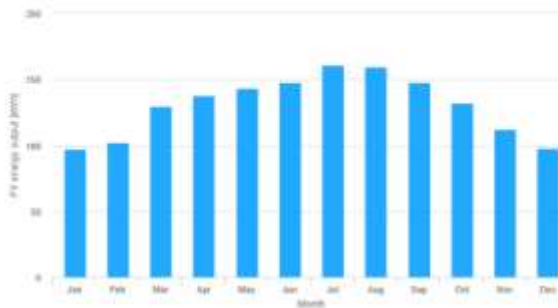
Simulation outputs

Slope angle: 33 (opt) °  
Azimuth angle: -7 (opt) °  
Yearly PV energy production: 1568.98 kWh  
Yearly in-plane irradiation: 2118.86 kWh/m<sup>2</sup>  
Year-to-year variability: 37.65 kWh  
Changes in output due to:  
Angle of incidence: -2.62 %  
Spectral effects: 0.57 %  
Temperature and low irradiance: -12.08 %  
Total loss: -25.95 %

Outline of horizon at chosen location:



Monthly energy output from fix-angle PV system:



Monthly in-plane irradiation for fixed-angle:



**Figure 4.** Energy production parameters of a 1 kWp panel for Yazır village from the PVGIS system (European Commission JRC, 2025)

Accordingly, the total annual electrical energy production to be obtained in the event that all suitable roof areas in Yazır Village are used is:

$$E_{\text{annual}} = 21,527 \text{ kWp} \times 1,569 \text{ kWh/kWp} \approx 33,775,863 \text{ kWh} \quad (2)$$

Consequently, the village's annual technical solar energy production potential has been determined as 33.78 GWh. This production amount is of a capacity capable of meeting the annual electricity consumption of the cold storage depots, mushroom production facilities, and agricultural irrigation pumps in the village.

## CONCLUSION

In this study, the rooftop solar energy potential of Yazır Village, Korkuteli district, Antalya province, was examined using GIS-based spatial analyses and PVGIS simulation tools. The findings present significant results in terms of rural development, agricultural energy efficiency, and on-site production strategies. As a result of the analyses, the technical and geographic suitabilities of the roof surfaces of 1283 buildings throughout the village were

evaluated; it was calculated that a total installed power of 21.5 MWp could be reached and approximately 33.78 GWh of electrical energy could be produced annually from this system.

The most critical output of the study is the compatibility of this production potential with the village's agricultural characteristics. As stated in the literature, increasing energy expenses in mushroom production (acclimatization and ventilation) are one of the largest cost items faced by producers and can cause the closure of many enterprises (Alkan and Akdemir, 2024). PV systems to be installed on the roofs of mushroom houses and outbuildings, which constitute 30% of the building stock in Yazır Village, will guarantee the sustainability of these enterprises by minimizing energy costs. Furthermore, research shows that photovoltaic systems used in mushroom production facilities not only provide energy but also contribute to production efficiency by reducing indoor temperature (6 – 11 °C) through the shading effect they provide (El Kolaly et al., 2020).

The large roof areas of the 5 major cold storage depots in the region offer an ideal application site for the "on-site production - on-site consumption" model. Generating energy using the roofs of existing structures without occupying agricultural lands overlaps with "land use efficiency," the fundamental principle of Agrivoltaic (Agri-PV) systems (Coşgun et al., 2024). Considering Turkey's solar energy potential and agricultural production capacity (Coşgun et al., 2024), the Yazır Village example constitutes a concrete model for how energy independence can be achieved without experiencing loss of agricultural land.

The fact that the vast majority of structures in Yazır Village are detached and do not have the difficulties of multiple ownership/management decision-making found in apartment-type structures is a significant social advantage that will accelerate installation processes. Current "Unlicensed Electricity Generation" regulations in Turkey and incentives provided for rooftop systems (Kılıç and Kekezoğlu, 2022) facilitate the village people's transition from a "consumer" position to a "prosumer" position. Especially thanks to the net-metering mechanism (Kılıç and Kekezoğlu, 2022), selling excess electricity produced in summer to the grid and covering heat pump-supported heating expenses in winter will provide direct cash input to the village economy.

In conclusion, the 33.78 GWh/year electricity production potential calculated for Yazır Village is at a level that can more than meet the village's agricultural irrigation, cold storage, and residential needs. This study proves with scientific data that the "Self-Sufficient Eco-

Village" model, which reduces fossil fuel dependency, lowers agricultural production costs, and minimizes the carbon footprint, is applicable in Turkey's rural regions.

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## PSYCHOSOCIAL AND CLINICAL EFFECTS OF SOCIAL MEDIA IN THE PERINATAL PERIOD

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### ABSTRACT

With the increasing digitalization, social media has become a significant determinant influencing women's access to information, decision-making processes, and emotional experiences during the perinatal period. Particularly in sensitive biopsychosocial phases such as pregnancy and postpartum, social media functions not only as a communication tool but also as a digital ecosystem shaping health behaviors. This study aims to evaluate the psychosocial effects and clinical implications of social media use during the perinatal period, drawing on current literature. A literature review was conducted using PubMed, Web of Science, Scopus, and Google Scholar databases. The search strategy included MeSH terms and their combinations such as "social media," "pregnancy," "postpartum period," "perinatal care," "maternal mental health," "breastfeeding," and "digital health." Studies published between 2015 and 2025 were included. Cross-sectional and qualitative studies, as well as randomized controlled trials, systematic reviews, and meta-analyses, were evaluated. Social media use during pregnancy is widespread and is primarily used for information seeking and symptom interpretation. However, intensive use of medical information has been associated with increased anxiety and prenatal stress. In the postpartum period, social media predominantly influences social comparison processes, body image, and maternal self-efficacy. These processes are associated with body dissatisfaction, decreased self-efficacy, and increased psychological distress. Conversely, structured digital health interventions have demonstrated positive effects, particularly on perinatal mental health and breastfeeding outcomes. Social media has a dual role in the perinatal period, presenting both risks and opportunities. Therefore, incorporating digital history-taking into perinatal care, promoting digital literacy, and implementing hybrid care models are essential. Social media should not be excluded but rather integrated into clinical care as a manageable component.

**Keywords:** Social Media; Pregnancy; Postpartum Period; Perinatal Care; Maternal Mental Health; Breastfeeding



## PERİNATAL DÖNEMDE SOSYAL MEDYANIN PSİKOSOSYAL VE KLİNİK ETKİLERİ

### ÖZET

Dijitalleşmenin artmasıyla birlikte sosyal medya, perinatal dönemde kadınların bilgiye erişim, karar verme ve duygusal süreçlerini etkileyen önemli bir belirleyici haline gelmiştir. Özellikle gebelik ve lohusalık gibi biyopsikososyal açıdan hassas dönemlerde sosyal medya, yalnızca bir iletişim aracı değil, aynı zamanda sağlık davranışlarını şekillendiren bir dijital ekosistem olarak öne çıkmaktadır. Bu çalışmanın amacı, sosyal medya kullanımının perinatal dönemdeki psikososyal etkilerini ve klinik yansımalarını güncel literatür doğrultusunda değerlendirmektir. Bu derlemede PubMed, Web of Science, Scopus ve Google Scholar veritabanları kullanılarak literatür taraması yapılmıştır. Taramada “social media”, “pregnancy”, “postpartum period”, “perinatal care”, “maternal mental health”, “breastfeeding” ve “digital health” MeSH terimleri ve bunların kombinasyonları kullanılmıştır. 2015-2025 yılları arasında yayımlanan çalışmalar incelenmiştir. Kesitsel ve nitel araştırmaların yanı sıra randomize kontrollü çalışmalar, sistematik derlemeler ve meta-analizler değerlendirmeye dahil edilmiştir. Gebelik döneminde sosyal medya kullanımı yaygın olup, özellikle bilgi arama ve semptom yorumlama amacıyla kullanılmaktadır. Ancak tıbbi bilgi için yoğun sosyal medya kullanımı, artmış anksiyete ve prenatal stres ile ilişkili bulunmuştur. Lohusalık döneminde ise sosyal medya daha çok sosyal karşılaştırma, beden algısı ve annelik yeterliliği üzerinden etkili olmakta ve bu süreçler beden memnuniyetsizliği, öz-yeterlilikte azalma ve psikolojik distres ile ilişkilendirilmiştir. Bununla birlikte, yapılandırılmış dijital sağlık müdahaleleri, özellikle perinatal ruh sağlığı ve emzirme sonuçları üzerinde olumlu etkiler göstermektedir. Sosyal medya, perinatal dönemde hem risk hem de fırsat içeren çift yönlü bir etkiye sahiptir. Bu nedenle perinatal bakımda dijital öykü alınması, dijital okuryazarlığın güçlendirilmesi ve hibrit bakım modellerinin uygulanması önemlidir. Sosyal medya, dışlanması gereken bir unsur değil, klinik bakım sürecine entegre edilmesi gereken bir bileşen olarak ele alınmalıdır.

**Anahtar Kelimeler:** Sosyal Medya; Gebelik; Postpartum Dönem; Perinatal Bakım; Maternal Ruh Sağlığı; Emzirme

## BEING A WOMAN IN AVIATION: WINGS HITTING THE GLASS CEILING

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### ABSTRACT

With the emergence of the aviation sector, women have made significant contributions to the field. While the Wright brothers are acknowledged for the first flight in 1903, Belkıs Şevket Hanım conducted the first flight in Turkish aviation history in 1913. Following the, women's interest in and activities within the aviation sector have increased. Today, as in the rest of the World, women's participation in the workforce in Turkish aviation has evolved and the contribution of women to the aviation workforce is showing a significant upward trend. Despite this increase, it is observed that men still hold more positions of power and occupy higher ranks compared to women in the aviation sector. This situation not only hinders women's Professional advancement but also brings to light the concept known as the "glass ceiling" which represents invisible barriers in their careers. The glass ceiling concept arises when employees encounter specific obstacles despite their efforts in Professional life. Those exposed to the glass ceiling in working life are predominantly women. The factors contributing to the perception of the glass ceiling are classified into three categories: individual, organizational and societal. In the aviation sector, obstacles such as the lack of women in top management, the low ratio of female pilots, wage inequality and the prioritization of men in promotions and recruitment can lead to loss of motivation, stress and anxiety among female employees. These barriers encountered in professional life impede women from advancing and sustaining their careers. The aim of this study is to examine the glass ceiling experiences of women working in the aviation sector; therefore, semi-structured interviews were conducted with women active in the sector and the data were analyzed accordingly. The findings reveal that despite the increasing presence of women in the aviation sector, societal perceptions and corporate culture remain the primary limiting factors for sustainable careers. The study concludes by offering solution proposals derived from the experiences of women in the aviation field.

**Keywords:** Women in Aviation, Glass Ceiling Concept, Career Barriers, Aviation Sector, Gender Inequality

### HAVACILIKTA KADIN OLMAK: CAM TAVANA ÇARPAN KANATLAR

### ÖZET

Havacılık sektörünün ortaya çıkmasıyla birlikte kadınlar, havacılık alanında önemli katkılarda bulunmuştur. Havacılık alanında dünyada ilk uçuşunu 1903 yılında gerçekleştiren Wright kardeşler havacılık tarihinin başlangıcı kabul edilmektedir. 1913 yılında Türk havacılığında ilk uçuşunu Belkıs Şevket Hanım gerçekleştirmiştir. Bu uçuşla beraber kadınların havacılık alanındaki faaliyetleri ve ilgileri artış göstermiştir. Günümüzde de tüm dünyada olduğu gibi Türk havacılığında da kadınların iş gücüne katılımı zaman içinde değişim göstermiştir, özellikle son yıllarda kadınların iş gücüne katkısı belirgin bir artış göstermektedir. Bu artışa rağmen havacılık alanında halen daha erkeklerin kadınlara oranla daha yüksek iş gücüne ve yüksek pozisyonlarda fazla paya sahip oldukları görülmektedir. Bu durum kadınların sektörde yükselmelerini engellemekle kalmayıp kariyerlerinde görünmez bir bariyer olarak adlandırılan "Cam tavanı" kavramını ortaya çıkarmaktadır. Cam tavanı kavramı, çalışanların iş

hayatındaki emekleriyle ulaştıkları başarılarında belirli engellerle karşılaşmaları sonucu oluşmaktadır. Çalışma hayatında cam tavan kavramına maruz kalan kişiler genellikle kadınlardan oluşmaktadır. Cam tavan algısına neden olan unsurlar bireysel, örgütsel ve toplumsal olarak üç şekildedir. Havacılık alanında kadınların karşılaştıkları üst düzey kadın yönetici azlığı, kadın pilot oranının düşüklüğü, ücret eşitsizliği, terfi ve işe alımlarda erkeklere öncelik verilmesi gibi engeller çalışan kadınlarda motivasyon kaybına, stres ve anksiyete kaygısına neden olabilmektedir. Çalışma hayatında karşılarına çıkan engeller kariyerlerinde ilerlemelerine ve sürdürmelerinin önüne geçmektedir. Bu çalışmada havacılık alanında cam tavan deneyimlerini incelemek amacıyla, sektörde faaliyet gösteren kadın çalışanlarla yarı yapılandırılmış mülakatlar yapılmıştır ve veriler sonucunda analiz yapılmıştır. Elde edilen bulgulara havacılık alanında kadınların etkinliğinin artmasına rağmen, toplumsal algı ve kurumsal kültür algısının sürdürülebilir kariyerlerinde kısıtlayıcı temel faktörler olduğu ortaya koymaktadır. Çalışma sonucunda, havacılık alanındaki kadınların deneyimlerinden yararlanılarak üretilen çözüm önerileri sunulmaktadır.

**Anahtar Sözcükler:** Havacılıkta Kadın, Cam tavan Kavramı, Kariyer Engelleri, Havacılık Sektörü, Toplumsal Cinsiyet Eşitsizliği

## INTRODUCTION

Throughout aviation history, the concept of flying has been a symbol of freedom and of transcending human limits. Today, along with advanced technologies, aviation has become a symbol of strategic decision-making courage, imagination and liberty. However, women in the field of aviation struggle not only with competence and technical knowledge but also with numerous invisible obstacles. These barriers experienced by women have been termed the “glass ceiling” (Cotter et al., 2001). The glass ceiling is expressed as an invisible and impassable barrier situated between top management and female employees that disregards the competencies and achievements of women in their professional lives, while restricting or preventing their advancement (Mizrahi and Aracı, 2010). This concept is not merely a result of individual failure but is a consequence of institutional policies, societal roles, and gender discrimination.

These invisible barriers prevent women in the field of aviation and many other sectors from advancing beyond certain career levels. In the aviation industry, which possesses a predominantly male-dominated mindset, the glass ceiling concept is intensely felt. Both globally and in Türkiye, the number of female maintenance technicians, pilots, managers and controllers remains a minority, and their gender is often prioritized over their professional talents within the sector.

This study aims to evaluate the obstacles and discrimination encountered by women in aviation within the framework of the glass ceiling concept. The factors producing the glass ceiling are addressed first; the inequalities faced by women in the sector are then examined through historical and current examples in aviation. Interviews conducted with women active in the field are evaluated, and recommendations are presented in the final section. For women in aviation

not only to reach the sky but also to find their way freely within it, a cultural and structural transformation is required.

### **Conceptual framework**

**Table 1. Factors causing the glass ceiling**

| <b>Individual</b>                    | <b>Organizational</b>                              | <b>Societal</b>          |
|--------------------------------------|----------------------------------------------------|--------------------------|
| Multiple role-taking                 | Organizational culture                             | Occupational segregation |
| Personal preferences and perceptions | Organizational policies                            | Societal prejudices      |
|                                      | Organizational climate                             |                          |
|                                      | Lack of mentoring                                  |                          |
|                                      | Lack of equal opportunity                          |                          |
|                                      | Inability to participate in communication networks |                          |
|                                      | Barriers set by male managers                      |                          |
|                                      | Barriers set by female managers                    |                          |

Source: Özel Bilim and Bülöz (2018), adapted from KSSGM (1998).

#### **Individual factors**

Under individual factors, multiple role-taking, and personal preferences and perceptions are considered. Multiple role-taking involves women in professional life undertaking responsibilities as housewives, spouses, children and mothers alongside their job duties, which causes them to assume intense roles in both domestic and professional life (Türkkahraman and Şahin, 2010). Personal preferences and perceptions refer to the professional choices of female employees, such as a lack of self-confidence, a lack of orientation toward career advancement, and an inability to take on the responsibilities required for promotion within their roles.

#### **Organizational factors**

While women may have the possibility to intervene in individual factors, influencing organizational factors is considerably more difficult. Organizational factors include organizational culture, organizational policies, organizational climate, lack of mentorship, lack of equal opportunity, exclusion from communication networks, and barriers set by male and female managers. One of the greatest obstacles to women holding managerial positions in professional life is organizational culture (Güldal, 2006). Organizational policies are another factor affecting women's advancement; however, these policies can serve either as an advantage or as a barrier. Due to beliefs that female employees in senior management may be hindered by

being mothers, by being married, or by biological limitations, organizations have unintentionally shaped their policies in ways that prevent women from rising in their professional lives (Durmuş, 2001). Transformational leadership has been proposed as one route for overcoming these organizational barriers (Ünal, 2015).

### **Societal factors**

Societal factors, along with organizational and individual factors, are among the elements that prevent female employees from advancing to senior levels. Occupational segregation and social prejudices, which are among the societal factors, are causes that lead to the glass ceiling for women (Yavuz and Uzun, 2019). In professional life, individuals in managerial positions are expected to be influential and assertive, and a perception consequently arises that men are more suitable for managerial roles. For subordinate positions, adaptability to the environment is sought, and female employees are thought to be suitable for these roles. Such perceptions cause female employees to feel under pressure and to perceive themselves as weaker than men (Utma, 2019). Changing these attitudes requires time and effort. To break free from stereotypical thinking, organizations must first recognize these misconceptions and then shape the organizational culture accordingly.

### **Women in the aviation sector**

Women have flown since almost the beginning of powered flight, but access to the cockpit and advancement within the industry are separate questions. In Türkiye the usual reference point is Sabiha Gökçen, whose career is recorded in her own memoirs (Gökçen, 2008) and in Kıvanç (1987). Almost a century later, the numbers have not followed the symbolism.

Vural (2025) argues that the standard vocabulary of this literature is too blunt for aviation. Alongside the glass ceiling and the glass cliff, a third metaphor is proposed, the “glass sky”, to describe how few women reach captain rank and how slowly that share has moved since the 1980s compared with other male-dominated professions such as law and medicine. The explanation offered rests on cultural expectation and prejudice rather than on qualification.

Damgacı (2023) approaches the same gap from the regulatory side and examines the Aviator Women Registry as an instrument for improving gender balance in Turkish civil aviation. Ekinçi (2019) documents a different mechanism through a case study of mobbing in the sector, which

moves the discussion away from recruitment figures and towards what happens to women who are already inside the organization.

Aviation adds its own conditions to the general picture summarized in Table 1. Progression is seniority-based and slow, duty periods are irregular by regulatory design, and the occupational culture remains strongly male. Each of these interacts with the individual, organizational and societal factors described above, which is why a sector-specific study is worth conducting.

## **MATERIALS AND METHODS**

This study adopts a qualitative research design in order to gain an in-depth understanding of women's subjective experiences and of the barriers to which they are exposed. Data were collected through semi-structured interviews with thirteen women actively working in the aviation sector.

Participants were recruited through purposive sampling supplemented by snowball referral. The sample size is consistent with thematic saturation guidance for qualitative research on relatively homogeneous groups, where twelve interviews are typically sufficient to reach saturation and additional interviews yield diminishing new content (Guest et al., 2006). To preserve confidentiality, participants were anonymized and are referred to throughout the paper as K1 through K13.

The interviews followed a semi-structured guide covering career trajectory, perceived barriers, promotion experiences and work–family arrangements. Each interview was audio-recorded with informed consent, transcribed verbatim, and then examined through content analysis. Ethics committee approval was obtained prior to data collection, and informed consent was recorded from all participants.

## **RESULTS AND DISCUSSION**

The findings indicate that the glass ceiling in aviation is not merely a perception but a concrete barrier. Ten of the thirteen participants (K1, K3, K4, K5, K7, K8, K9, K10, K11, K13) stated that promotion processes lack transparency and that their male colleagues are regarded as “natural candidates” for advancement. Four core themes emerged from the content analysis.

**Institutional barriers.** Male-dominated management networks were described as the most visible obstacle to advancement. Eleven of the thirteen participants (K1, K2, K3, K5, K6, K7,

K8, K9, K10, K12, K13) reported that decision-making circles at senior levels were dominated by men, and that women were rarely included in the informal networks through which promotions were prepared.

**Work-family conflict.** Irregular flight hours clashing with domestic responsibilities and a lack of institutional support emerged as a persistent tension. Nine of the thirteen participants (K1, K3, K4, K6, K8, K9, K10, K11, K13) linked this tension to career interruption or self-limitation, particularly in the years following childbirth.

**Gender roles.** The perception of women as inadequate for certain aviation roles was raised by eight of the thirteen participants (K2, K4, K5, K7, K9, K10, K11, K12). Several noted that assumptions about physical stamina, technical aptitude or emotional stability were applied to women in a way that they were not applied to men.

**Psychological barriers.** Twelve of the thirteen participants (all except K6) reported feeling the obligation to work twice as hard as men to prove themselves and described the resulting fatigue and stress as a career cost that their male colleagues did not carry.

## DISCUSSION

The four themes map onto the framework in Table 1, but not evenly. Institutional barriers and work-family conflict sit in the organizational column. Gender roles are societal. Psychological barriers fall between the individual and the organizational, because the compulsion to work twice as hard is a response to an external signal rather than a personal preference.

That distribution is worth comparing with İpçioğlu et al. (2018). Working with human resources managers rather than with women employees, they found that those managers attributed the glass ceiling mainly to individual factors, and that several of them denied it was specific to women at all. The participants in the present study describe something else: promotion criteria they cannot see, rosters that nobody adjusts, and a settled assumption about who the obvious candidate is. The distance between the two accounts is itself a result. Where the people who administer promotion believe the barrier is personal, organizational remedies do not get designed, because the problem is not recognized as organizational in the first place.

Promotion transparency was the issue raised most often in the interviews, and it is also the cheapest to address. Published criteria, minuted panel decisions and a stated route of appeal require no change in social attitudes and can be audited from records that already exist.

Work-family conflict is harder. Irregular flight duty periods follow from safety regulation and commercial scheduling rather than from administrative preference, so the roster itself is not going to become regular. What can change is how far in advance it is published and what institutional support surrounds it. This is where the case made by Damgacı (2023) for sector-level instruments becomes relevant, since an individual operator has limited room to move on rostering while a regulator does not.

The findings also support the argument of Vural (2025) for aviation-specific language. Participants did not describe a single ceiling located just below senior management. They described barriers spread across the whole career, several of which appear long before any managerial threshold is reached.

### **Recommendations**

**Promotion.** Publish the criteria for each rank, record panel decisions in writing, and provide a route of appeal that does not run through the candidate's own line manager.

**Measurement.** Report the distribution of women by rank and department annually. A barrier that is not measured is easy to dismiss as perception.

**Mentoring.** Pair junior women with senior staff outside their own reporting line. Mentoring inside the line of command tends to reproduce the networks that already exist.

**Rostering.** Publish rosters further in advance and provide a formal swap mechanism. Predictability, not reduced duty, is what participants described as missing.

**Training.** Include career barriers and gender bias in recurrent human factors and crew resource management training, where the sector already has an established mechanism for changing behaviour.

**Reporting.** Provide a channel for harassment and mobbing complaints that is independent of line management, given what Ekinci (2019) records about the sector.

### **Limitations**

The study covers one sector in one country and uses a small purposive sample of thirteen participants, so the findings describe these participants rather than women in aviation generally. Only women were interviewed; managers and male colleagues were not, which means the



account of how promotion decisions are made rests on how participants experienced those decisions. Participation was voluntary, so women with stronger experiences of the barrier may be over-represented.

## **CONCLUSION**

Women's presence in aviation has grown, but presence and progression appear to follow different rules. The barriers described in these interviews were not mainly about competence or training. They were about who is assumed to be the obvious candidate, about promotion processes that are not written down anywhere, and about rosters built on the assumption that domestic responsibilities are somebody else's problem.

Two of those three are organizational, and an operator can change them without waiting for social attitudes to shift. The third is slower and lies beyond any single firm. That asymmetry is the practical message of this study: the parts of the glass ceiling that are easiest to remove are also the parts that organizations most readily describe as beyond their control.

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## DETERMINATION OF THE MECHANICAL STRENGTH OF COFFEE BEANS WITH DIFFERENT ROASTING DEGREES

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### ABSTRACT

The degree of coffee roasting has a strong influence not only on the dynamics of volatile substance release and aroma perception, but also on mechanical properties. The aim of the study was to determine the effect of different roasting degrees of coffee beans on their mechanical strength. The “Typica” variety of Arabica coffee beans from Guatemala was used in this study. Three roast levels (light, medium and dark) were used in this study, which significantly differentiated the properties of the coffee beans. Light coffee beans were obtained at 198°C, while medium roasting was achieved at 212°C before the second crack. Roasting at a higher temperature, in the range of 228-230°C, until the second crack resulted in dark coffee beans. The beans were roasted at Rovigo Caffee (Lublin, Poland) in a Coffed SR 5 roaster, equipped with a double-walled drum with bean and exhaust temperature sensors. The tests were conducted using an MTS Insight 2 universal testing machine. A strain gauge head with a maximum force range of 250 N was used for the measurements, enabling precise force recording during compression tests. Individual coffee beans were placed centrally between the pressure plates, and the measurement was continued at a set head speed until the beans were crushed or cracked. The influence of the degree of roasting of coffee beans on their mechanical strength has been demonstrated. Coffee roasted to a light degree showed the greatest mechanical strength, while coffee roasted to the highest degree showed the lowest.

**Keywords:** coffee, roasting degrees, mechanical strength

## HOW AWARE ARE ADOLESCENTS OF OBESITY?

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### ABSTRACT

This descriptive study was conducted to determine the obesity awareness levels of adolescents aged 10–18 years who applied to the Pediatric Endocrinology Outpatient Clinic and to evaluate these levels according to sociodemographic characteristics, age group, and body mass index (BMI) categories. The sample consisted of 431 adolescents who attended the outpatient clinic between September 2022 and September 2023 and agreed to participate in the study. Data were collected through face-to-face interviews using the Adolescent Information Form developed by the researchers and the Obesity Awareness Scale. Descriptive statistics, Mann–Whitney U test, Kruskal–Wallis test, and Spearman correlation analysis were used for data analysis. The mean age of the participants was  $13.84 \pm 2.22$  years, and 65.7% were female. The mean total Obesity Awareness Scale score was  $57.70 \pm 9.05$ , indicating a good level of awareness in both the total scale and all subdimensions. It was found that 56.4% of the participants had a good level and 38.1% had a high level of obesity awareness, while no participant demonstrated a low level of awareness. The obesity awareness subdimension score was significantly higher in late adolescents than in early adolescents. According to BMI categories, the total scale score of the overweight group was significantly higher than that of the normal-weight group, while the obesity awareness subdimension score of the obese group was significantly higher than that of the normal-weight group. In addition, a very weak positive correlation was found between BMI and both the total obesity awareness score and the obesity awareness subdimension score. No significant differences were found in total scale or subdimension scores according to sex, socioeconomic status, presence of an additional health problem, or maternal history of obesity. In conclusion, obesity awareness among adolescents was generally at a good level; however, it varied according to certain variables such as age and BMI. These findings indicate that

developmental characteristics and risk groups should be considered in preventive interventions for adolescents.

**Keywords:** adolescents, obesity awareness, body mass index, nutrition, physical activity

#### ADOLESANLAR OBEZİTENİN NE KADAR FARKINDA?

##### ÖZET

Bu tanımlayıcı çalışma, Çocuk Endokrinoloji Polikliniğine başvuran 10–18 yaş arası adölesanların obezite farkındalık düzeylerini belirlemek ve bu düzeyleri sosyodemografik özellikler, yaş grubu ve beden kitle indeksi (BKİ) kategorilerine göre değerlendirmek amacıyla yapılmıştır. Araştırmanın örneklemini, Eylül 2022–Eylül 2023 tarihleri arasında polikliniğe başvuran ve çalışmaya katılmayı kabul eden 431 adölesan oluşturmuştur. Veriler, araştırmacılar tarafından geliştirilen Adölesan Bilgi Formu ve Obezite Farkındalık Ölçeği kullanılarak yüz yüze görüşme yöntemiyle toplanmıştır. Verilerin analizinde tanımlayıcı istatistikler, Mann–Whitney U testi, Kruskal–Wallis testi ve Spearman korelasyon analizi kullanılmıştır.

Katılımcıların yaş ortalaması  $13,84 \pm 2,22$  yıl olup, %65,7’si kızdır. Obezite Farkındalık Ölçeği toplam puan ortalaması  $57,70 \pm 9,05$  olarak bulunmuş ve bu durum hem toplam puan hem de tüm alt boyutlar açısından iyi düzeyde farkındalığa işaret etmiştir. Katılımcıların %56,4’ünün iyi düzeyde, %38,1’inin ise yüksek düzeyde obezite farkındalığına sahip olduğu, hiçbir katılımcının düşük düzeyde farkındalık göstermediği belirlenmiştir. Obezite farkındalığı alt boyut puanının geç adölesanlarda erken adölesanlara göre anlamlı derecede daha yüksek olduğu saptanmıştır. BKİ kategorilerine göre, fazla kilolu grubun toplam ölçek puanı normal kilolu gruba göre anlamlı derecede daha yüksek bulunurken, obez grubun obezite farkındalığı alt boyut puanı normal kilolu gruba göre anlamlı derecede daha yüksek bulunmuştur. Ayrıca, BKİ ile hem toplam obezite farkındalık puanı hem de obezite farkındalığı alt boyut puanı arasında çok zayıf düzeyde pozitif bir korelasyon olduğu belirlenmiştir. Cinsiyet, sosyoekonomik durum, ek sağlık sorunu varlığı ve anne obezite öyküsüne göre toplam ölçek ve alt boyut puanları arasında anlamlı bir fark bulunmamıştır. Sonuç olarak, adölesanlarda obezite farkındalığının genel olarak iyi düzeyde olduğu; ancak yaş ve BKİ gibi bazı değişkenlere göre farklılık gösterdiği belirlenmiştir. Bu bulgular, adölesanlara yönelik koruyucu girişimlerde gelişimsel özelliklerin ve risk gruplarının dikkate alınması gerektiğini göstermektedir.

**Anahtar Kelimeler:** adölesan, obezite farkındalığı, beden kitle indeksi, beslenme, fiziksel aktivite

## CURRENT APPROACHES TO OBESITY AWARENESS IN CHILDREN: A LITERATURE REVIEW

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### ABSTRACT

This review aims to examine the current literature on obesity awareness in children and to identify the main individual, familial, and environmental factors associated with this concept. It also seeks to evaluate the role of awareness-based approaches in the prevention and management of childhood obesity. This study was designed as a narrative review of the literature addressing obesity awareness in children. The review included studies published between 2020 and 2026 that focused on childhood obesity awareness. The selected studies were analyzed about the impact of obesity awareness on eating behaviors, levels of physical activity, parental influence, school-based interventions, and health education practices. The reviewed literature shows that obesity awareness in children is a multidimensional concept that extends beyond simple knowledge acquisition. It is associated with eating habits, physical activity level, family structure, parental education and awareness, school environment, and social surroundings. School-based educational interventions appear to be particularly effective in improving children's obesity awareness. Interactive methods such as creative drama, structured health education, and participatory teaching strategies have been reported to produce positive outcomes. However, increased awareness does not always directly lead to reductions in body mass index or obesity prevalence. This finding suggests that childhood obesity is a complex condition shaped by biological, behavioral, and environmental factors. Obesity awareness in children is a modifiable and supportable area, but it is not sufficient on its own in combating obesity. For more effective and sustainable outcomes, it is recommended to develop long-term, multicomponent interventions that target children together with their families and school environments.

**Keywords:** childhood obesity, obesity awareness, children, health education, school-based interventions

## ÇOCUKLARDA OBEZİTE FARKINDALIĞINA YÖNELİK GÜNCEL YAKLAŞIMLAR: BİR LİTERATÜR DERLEMESİ

### ÖZET

Bu derleme, çocuklarda obezite farkındalığına ilişkin güncel literatürü incelemeyi, bu kavramla ilişkili başlıca bireysel, ailesel ve çevresel faktörleri belirlemeyi amaçlamaktadır. Ayrıca farkındalık temelli yaklaşımların çocukluk çağı obezitesinin önlenmesi ve yönetimindeki rolünü değerlendirmeyi de hedeflemektedir. Bu çalışma, çocuklarda obezite farkındalığını ele alan literatürün anlatsal derlemesi olarak tasarlanmıştır. Derlemeye, 2020–2026 yılları arasında yayımlanmış ve çocuklarda obezite farkındalığına odaklanan çalışmalar dahil edilmiştir. Seçilen çalışmalar; obezite farkındalığının beslenme davranışları, fiziksel aktivite düzeyi, ebeveyn etkisi, okul temelli girişimler ve sağlık eğitimi uygulamaları üzerindeki etkileri açısından analiz edilmiştir.

İncelenen literatür, çocuklarda obezite farkındalığının yalnızca bilgi ediniminin ötesine geçen çok boyutlu bir kavram olduğunu göstermektedir. Bu farkındalık; beslenme alışkanlıkları, fiziksel aktivite düzeyi, aile yapısı, ebeveyn eğitimi ve farkındalığı, okul ortamı ve sosyal çevre ile ilişkilidir. Okul temelli eğitim girişimlerinin çocukların obezite farkındalığını artırmada özellikle etkili olduğu görülmektedir. Yaratıcı drama, yapılandırılmış sağlık eğitimi ve katılımcı öğretim stratejileri gibi etkileşimli yöntemlerin olumlu sonuçlar ortaya koyduğu bildirilmektedir. Bununla birlikte, artan farkındalık her zaman beden kitle indeksinde ya da obezite prevalansında doğrudan bir azalma ile sonuçlanmamaktadır. Bu bulgu, çocukluk çağı obezitesinin biyolojik, davranışsal ve çevresel etmenlerle şekillenen karmaşık bir durum olduğunu göstermektedir.

Çocuklarda obezite farkındalığı değiştirilebilir ve desteklenebilir bir alan olmakla birlikte, obezite ile mücadelede tek başına yeterli değildir. Daha etkili ve sürdürülebilir sonuçlar için, çocukları aileleri ve okul çevreleriyle birlikte hedef alan uzun süreli ve çok bileşenli müdahalelerin geliştirilmesi önerilmektedir.

**Anahtar Kelimeler:** çocukluk çağı obezitesi, obezite farkındalığı, çocuklar, sağlık eğitimi, okul temelli girişimler

## EMPLOYEE PERCEPTIONS OF GREEN LOGISTICS PRACTICES IN AIRPORTS: IMPLICATIONS FOR SUSTAINABLE AVIATION

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### ABSTRACT

Airports are complex operational ecosystems where logistics activities play a crucial role in ensuring the continuous flow of passengers, cargo, and ground services. Accordance with the rapid growth in global air transportation, concerns regarding environmental sustainability have become increasingly significant. In this context, green logistics practices have emerged as an important approach for reducing environmental impacts associated not only with aircraft operations but also with ground-based activities at airports. These practices include energy-efficient ground handling operations, waste management, sustainable transportation within airport facilities, reduced emissions from ground support equipment, and environmentally responsible resource management. Given that airport operations rely heavily on human interaction and operational coordination, the perceptions and awareness of airport employees toward green logistics practices are essential for the successful implementation of sustainability strategies. Employees who recognize and internalize such practices are more likely to support and contribute to organizational sustainability goals.

This study aims to examine the perception of green logistics practices among airport employees. Data will be collected through a structured questionnaire based on a five-point Likert scale administered to Antalya International Airport and Gazipaşa-Alanya Airport employees. The survey will measure the extent to which employees perceive and recognize green logistics practices implemented within their airport environment. The collected data will be analyzed using IBM SPSS, and descriptive statistical methods will be applied to evaluate the overall perception levels.

The findings are expected to provide insights into how airport employees perceive existing green logistics initiatives and whether these practices are sufficiently visible and understood within airport operations. A higher level of perception may indicate stronger organizational alignment with sustainability objectives. Therefore, the results of this study are expected to contribute to the literature on sustainable aviation management and highlight the role of employee awareness in advancing sustainability practices in airport environments.

**Keywords:** Green logistics practices, airports, sustainability, aviation



## THE IMPACT OF CLIMATE CHANGE ON THE AVIATION INDUSTRY: AN ANALYSIS OF THE CURRENT SITUATION IN TURKEY

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### ABSTRACT

Climate change has become one of the most pressing global challenges of the twenty-first century, affecting economic systems, transportation networks, and environmental sustainability. As a sector characterized by high mobility and energy consumption, the aviation industry both contributes to and is affected by climate change. Aviation activities generate greenhouse gas emissions, particularly carbon dioxide, which has led to increasing international pressure to reduce the environmental footprint of air transport. At the same time, climate change itself poses operational challenges for the aviation sector through extreme weather events, rising temperatures, and changing atmospheric conditions that may influence airport infrastructure, flight operations, and air traffic management.

In response to these challenges, international aviation organizations such as the International Civil Aviation Organization and the International Air Transport Association have introduced various initiatives and policy frameworks aimed at mitigating aviation-related emissions and supporting the transition toward more sustainable aviation systems.

This study examines the impact of climate change on the aviation industry and analyzes the current institutional approaches adopted in Türkiye. The research focuses on national aviation authorities and key stakeholders, including the Ministry of Transport and Infrastructure of Türkiye, the Directorate General of Civil Aviation, and the State Airports Authority. By reviewing policy documents, institutional reports, and sustainability initiatives, the study evaluates how climate change mitigation and adaptation strategies are integrated into aviation governance and airport operations in Türkiye.

The findings are expected to provide an overview of the current policy landscape and highlight the role of national aviation institutions in aligning with global sustainability goals and climate commitments within the aviation sector.

**Keywords:** Climate Change, Sustainability, Aviation, Türkiye

## ENVIRONMENTAL SUSTAINABILITY IN AIRPORT LAYOUT PLANNING: A CASE STUDY OF GAZİPAŞA-ALANYA AIRPORT

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### ABSTRACT

Airports are not only infrastructures that serve passenger transportation but also critical facilities that significantly contribute to economic development, tourism activities, and regional accessibility. However, the planning and development processes of airports may create various environmental pressures on surrounding natural areas and ecosystems. In recent years, environmental sustainability in airport planning has gained increasing importance in line with global efforts to combat climate change, reduce carbon emissions, and achieve sustainable development goals. In this context, evaluating the ecosystem impacts of airport layout planning has emerged as an important research area within the field of sustainable aviation management.

The aim of this study is to evaluate the potential ecosystem impacts of airport layout planning through the case of Gazipaşa-Alanya Airport, which operates in Türkiye and is categorized as a medium-sized airport. Within the scope of the research, the effects of airport land use, infrastructure planning, and operational activities on surrounding natural habitats, biodiversity, and environmental sustainability are examined. In addition, the relationship between airport infrastructure planning, environmental protection approaches, and sustainable development objectives is discussed.

The study adopts a qualitative research approach and utilizes literature review and document analysis methods. In this context, academic studies related to airport development, environmental management, and sustainable aviation were examined together with Environmental Impact Assessment (EIA) reports, reports published by civil aviation authorities, institutional documents related to airport operations, and relevant official statistics. The findings indicate that incorporating environmental sustainability principles into airport planning plays a significant role in mitigating potential negative impacts on surrounding ecosystems.

**Keywords:** Sustainable Aviation, Airport Planning, Environmental Sustainability, Ecosystem Impacts, Gazipaşa-Alanya Airport

## PREDICTING PSYCHOLOGICAL FLOW IN RECREATIONAL DART PARTICIPANTS: A MULTIDIMENSIONAL ANALYSIS OF LEISURE INVOLVEMENT

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### ABSTRACT

Recreational activities serve as autonomous spaces where individuals distance themselves from daily life stress to realize their potential and achieve optimal psychological experiences. The personal commitment an individual feels toward an activity and the meaningful connection established with it are considered primary determinants of the psychological focus that emerges during these activities. Particularly in sports like darts, which require technical skill and intense concentration, investigating the predictive effect of involvement levels on the flow experience is crucial for understanding the quality of leisure. This study aims to examine the predictive effect of leisure involvement levels on psychological flow among recreational dart participants. Within the scope of the research, the relationship between individuals' personal commitment to darts and the state of flow experienced during this activity is addressed at both theoretical and empirical levels. Accordingly, by determining the extent to which involvement dimensions explain the flow experience and how this process is shaped by demographic variables, the study intends to contribute to the leisure literature specifically focused on the sport of darts.

The research was conducted using a correlational survey design within a quantitative approach. The study group consisted of 229 participants (136 females, 59.4%; 93 males, 40.6%; Mage = 23.35±7.97) who actively engage in dart as a leisure activity, selected via purposive sampling. The five-dimensional Leisure Involvement Scale (LIS) and the nine-item Psychological Flow Scale (PFS) were used as data collection tools. Normality assumptions were tested via Skewness and Kurtosis values, which remained within the ±1.5 range, indicating a normal distribution. Data were analyzed using Pearson correlation, independent samples t-test (with Cohen's d for effect size), and one-way ANOVA (with  $\eta^2$  and Tukey HSD post-hoc). To determine the predictive power of involvement dimensions on flow, multiple linear regression analysis was performed after ensuring assumptions for multicollinearity (VIF < 3.0; Tolerance > 0.3) and autocorrelation (Durbin-Watson = 1.87).

Statistical analyses revealed significant positive moderate-to-high correlations between all dimensions of leisure involvement and psychological flow ( $r$  ranging from .540 to .676;  $p < .01$ ). Multiple regression results showed that leisure involvement dimensions explained 52.1% of the total variance in psychological flow ( $R^2 = .521$ ;  $F = 48.587$ ;  $p < .001$ ). Specifically, identification ( $\beta = .463$ ) and attraction ( $\beta = .261$ ) emerged as the strongest significant predictors

of the flow experience. While gender did not yield significant differences in involvement or flow ( $p > .05$ ), experience duration significantly increased both constructs ( $\eta^2 = .062$ ).

The study concludes that the identity bond an individual forms with the activity and the level of attraction are fundamental factors determining the flow experience in recreational dart.

The study is cross-sectional, and findings are limited to the sport of darts; additionally, the sample predominantly consists of young adults with 1-3 years of experience.

Recreational event planners should focus on organizations that support personal attraction and reinforce social identity to enhance the flow experience. Future research is recommended to include motivational processes as mediating variables and to conduct comparative analyses across different recreational branches.

**Keywords:** Recreation, dart, leisure involvement, psychological flow, identification.

## REKREASYONEL DART KATILIMCILARINDA PSİKOLOJİK AKIŞIN YORDANMASI: SERBEST ZAMAN İLGİLENİMİNİN ÇOK BOYUTLU ANALİZİ

### ÖZET

Rekreasyonel faaliyetler, bireylerin günlük yaşam stresinden uzaklaşarak kendilerini gerçekleştirdikleri ve optimal psikolojik deneyimler yaşadıkları özgür alanlardır. Bu süreçte bireyin bir aktiviteye yönelik hissettiği kişisel bağlılık ve aktiviteyle kurduğu anlam ilişkisi, o faaliyet sırasında ortaya çıkan psikolojik odaklanmanın temel belirleyicisi olarak görülmektedir. Özellikle dart gibi teknik beceri ve yoğun konsantrasyon gerektiren branşlarda, katılımcının ilgilenim düzeyinin akış deneyimi üzerindeki yordayıcı etkisinin incelenmesi, serbest zamanın niteliğini anlamak açısından kritik önem taşımaktadır. Bu araştırma, rekreasyonel dart katılımcılarının serbest zaman ilgilenim düzeylerinin psikolojik akış üzerindeki yordayıcı etkisini incelemeyi amaçlamaktadır. Çalışma kapsamında, bireylerin dart aktivitesine duydukları kişisel bağlılığın bu faaliyet sırasında deneyimlenen akış durumuyla olan ilişkisi kuramsal ve ampirik düzeyde ele alınmaktadır. Bu doğrultuda, ilgilenimin alt boyutlarının akış deneyimini ne derece açıkladığı ve bu sürecin demografik değişkenlere göre nasıl şekillendiği belirlenerek rekreasyon literatürüne dart branşı özelinde katkı sunulması hedeflenmektedir.

Araştırma, nicel araştırma yaklaşımı çerçevesinde ilişkisel tarama deseninde yürütülmüştür. Çalışma grubunu, amaçlı örnekleme yöntemiyle belirlenen ve serbest zamanlarında aktif olarak dart oynayan 229 katılımcı (136 kadın, %59,4; 93 erkek, %40,6; Yaş ort.=23,35±7,97) oluşturmaktadır. Veri toplama aracı olarak beş boyutlu Serbest Zaman İlgilenim Ölçeği (SZİÖ) ve dokuz maddelik Psikolojik Akış Ölçeği (PAÖ) kullanılmıştır. Analiz süreci öncesinde verilerin normallik varsayımları Skewness ve Kurtosis değerleri üzerinden test edilmiş; değerlerin  $\pm 1,5$  aralığında kalarak normal dağılım sergilediği saptanmıştır. Verilerin analizinde Pearson korelasyon analizi, bağımsız örneklem t-testi (etki büyüklüğü için Cohen's d ile) ve tek yönlü ANOVA (etki büyüklüğü için  $\eta^2$  ve Tukey HSD post-hoc ile) uygulanmıştır. İlgilenim boyutlarının akış üzerindeki yordayıcı gücünü belirlemek amacıyla; çoklu bağlantı (VIF < 3,0; Tolerans > 0,3) ve otokorelasyon (Durbin-Watson = 1,87) varsayımları karşılanmış çoklu doğrusal regresyon analizi kullanılmıştır.

İstatistiksel analizler, serbest zaman ilgileniminin tüm alt boyutlarının psikolojik akış ile pozitif yönlü, orta ve yüksek düzeyde anlamlı ilişkiler sergilediğini ortaya koymuştur ( $r=.540$  ile ,676

arası;  $p<,01$ ). Çoklu regresyon analizi sonuçlarına göre; serbest zaman ilgilenimi boyutları psikolojik akıştaki toplam varyansın %52,1'ini açıklamaktadır ( $R^2=,521$ ;  $F=48,587$ ;  $p<,001$ ). Alt boyutlar bazında özdeşleşme ( $\beta=,463$ ) ve çekicilik ( $\beta=,261$ ) akış deneyiminin en güçlü ve anlamlı yordayıcıları olarak belirlenmiştir. Cinsiyet değişkeninin ilgilenim ve akış puanları üzerinde istatistiksel olarak anlamlı bir farklılık oluşturmadığı ( $p>,05$ ), ancak deneyim süresi arttıkça hem ilgilenim hem de akış düzeylerinin anlamlı düzeyde yükseldiği tespit edilmiştir ( $\eta^2=,062$ ).

Araştırma sonucunda, rekreasyonel dart katılımında bireyin aktiviteyle kurduğu kimlik bağı ve aktiviteye duyduğu ilginin, akış deneyimini belirleyen temel unsurlar olduğu saptanmıştır.

Çalışma kesitsel bir yapıda olup bulgular dart sporuyla sınırlıdır; ayrıca örneklemin büyük çoğunluğu 1-3 yıl arası deneyime sahip genç yetişkinlerden oluşmaktadır.

Rekreasyonel etkinlik planlayıcıları, katılımcıların akış deneyimini artırmak için bireysel çekiciliği destekleyen ve sosyal kimliği pekiştiren organizasyonlara odaklanmalıdır. Gelecek araştırmaların, ilgilenim ve akış arasındaki ilişkide motivasyonel süreçleri aracı değişken olarak modele dahil etmesi ve farklı rekreasyonel branşlarda karşılaştırmalı analizler yapması önerilmektedir.

**Anahtar Kelimeler:** Rekreasyon, dart, serbest zaman ilgilenimi, psikolojik akış, özdeşleşme.

## A SYSTEMATIC REVIEW OF POSTGRADUATE THESES ON ADVENTURE RECREATION IN TÜRKİYE: TRENDS, METHODOLOGICAL APPROACHES, AND THEMATIC DISTRIBUTION

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### ABSTRACT

The aim of this study is to systematically examine postgraduate theses conducted in Turkey in the field of adventure recreation and to reveal trends regarding publication years, methodological approaches, sample characteristics, thematic focuses, and findings. A systematic review design was employed, and the review process was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. Data were collected from the National Thesis Center of the Council of Higher Education using the keywords “adventure recreation,” “adventure experience,” and “adventure behavior.” Initially, 24 studies were identified; after removing duplicates and excluding studies outside the scope, 21 theses were included in the final analysis.

Findings indicate that these were produced between 2016 and 2025, with a noticeable increase after 2020. In terms of methodology, most studies adopted quantitative research designs (n=17), while qualitative (n=3) and mixed-method (n=1) approaches were limited. Regarding sample distribution, branch-specific participants (n=9, 42.9%), general outdoor adventure participants (n=8, 38.1%), and general/specific demographic groups (n=4, 19.0%) were identified.

The most dominant research theme was adventure behavior seeking and sensation seeking (n=10). Other frequently studied variables included motivation, psychological well-being, subjective well-being, psychological resilience, and personality traits. The majority of findings demonstrated positive and significant relationships among variables. In recent years, mediation models and structural equation modeling have become more common. Additionally, emerging themes such as sustainability, virtual reality, and wearable technologies have started to appear in the literature.

In conclusion, adventure recreation research in Turkey appears to be predominantly psychology-oriented and quantitatively driven, with increasing theoretical sophistication and model testing in recent years. This systematic review provides a comprehensive overview of the field and offers guidance for future research directions.

**Keywords:** Adventure recreation, systematic review, PRISMA, postgraduate theses, adventure behavior.

TÜRKİYE’DE MACERA REKREASYONU ALANINDA HAZIRLANAN LİSANSÜSTÜ  
TEZLERİN SİSTEMATİK İNCELENMESİ: EĞİLİMLER, YAKLAŞIMLAR VE TEMATİK  
DAĞILIM

**ÖZET**

Bu araştırmanın amacı, Türkiye’de macera rekreasyonu alanında hazırlanmış lisansüstü tezleri sistematik biçimde incelemek ve mevcut literatürün yıllara göre dağılımını, yöntemsel eğilimlerini, örneklem yapılarını, konu temalarını ve bulgularını ortaya koymaktır. Çalışmada sistematik derleme yöntemi kullanılmış ve tarama süreci PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protokolü doğrultusunda yürütülmüştür. Veri kaynağı olarak YÖK Tez Merkezi kullanılmış; “macera rekreasyonu”, “macera deneyimi” ve “macera davranışı” anahtar kelimeleriyle yapılan tarama sonucunda 24 çalışmaya ulaşılmıştır. Yinelenen ve alan dışı çalışmalar çıkarıldıktan sonra analiz kapsamına 21 tez dahil edilmiştir.

Bulgular, tezlerin 2016–2025 yılları arasında üretildiğini ve özellikle 2020 sonrası dönemde belirgin bir artış gösterdiğini ortaya koymuştur. Yöntemsel açıdan çalışmaların büyük çoğunluğunun nicel araştırma deseninde olduğu (n=17), nitel (n=3) ve karma (n=1) yöntemlerin sınırlı düzeyde kullanıldığı belirlenmiştir. Örneklem dağılımı incelendiğinde branş temelli spesifik katılımcıların (n=9, %42,9), genel outdoor macera katılımcılarının (n=8, %38,1) ve genel/özel demografik grupların (n=4, %19,0) tercih edildiği görülmüştür.

Konu dağılımında en baskın temanın macera davranışı arayışı ve heyecan arayışı olduğu (n=10) tespit edilmiştir. Motivasyon, psikolojik iyi oluş, öznel iyi oluş, psikolojik sağlamlık ve kişilik değişkenleri sıklıkla çalışılan diğer temalar arasında yer almaktadır. Bulguların büyük çoğunluğunda değişkenler arasında pozitif ve anlamlı ilişkiler belirlenmiş; son yıllarda aracılık modellerinin ve yapısal eşitlik analizlerinin arttığı gözlenmiştir. Ayrıca sürdürülebilirlik, sanal gerçeklik ve giyilebilir teknoloji gibi yeni temaların literatüre dahil olmaya başladığı saptanmıştır.

Sonuç olarak Türkiye’de macera rekreasyonu alanının psikoloji temelli bir ekseninde geliştiği, yöntemsel olarak nicel araştırmaların baskın olduğu ve son yıllarda kuramsal ve model test eden çalışmaların arttığı görülmektedir. Bu sistematik derleme, literatürdeki eğilimleri ve boşlukları ortaya koyarak gelecekte yapılacak araştırmalara yön göstermeyi amaçlamaktadır.

**Anahtar Kelimeler:** Macera rekreasyonu, sistematik derleme, PRISMA, lisansüstü tezler, macera davranışı.

## THE IMPORTANCE OF SERVICE QUALITY AND ACCREDITATION IN INTERNATIONAL HEALTH TOURISM

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### ABSTRACT

Health tourism, rapidly gaining momentum with globalization and technological advancements, has become a fundamental component of today's inter-country economic and social competition. In this process, the quality of offered healthcare services and the international accreditation reports available are among the most critical variable destination choices for health tourists. This study examines the distribution of service quality and accreditation components in health tourism through a summarized literature review method. The study also details the roles, operations, and application of leading international accreditation bodies such as the “Joint Commission International (JCI)”, the “International Society for Healthcare Quality (ISQua)”, “TEMOS” and their impact on healthcare facilities in the context of global competition.

A review of the literature reveals that international health tourists are not only motivated by low cost expectations but they also prioritize medical reliability, patient safety, hygiene standards and communication quality. In this context, accreditation is seen to strengthen the corporation of healthcare facilities, systematize service standards and ensure sustainable quality management. In the case of Turkey, the “Healthcare Quality Standards (HQS)” and “Healthcare Accreditation Standards (HAS)” implemented by the “Ministry of Health of the Republic of Turkey”, as well as structures such as the “International Healthcare Services Inc. (USHAŞ)” and the “HealthTürkiye” portal, is getting stronger the country's position in the global health tourism market. Through tables prepared in light of 2023-2026 data, Türkiye's current status in “JCI and Temos” accreditations is presented in comparison with other countries.

In conclusion, for sustainability and international credibility in health tourism, accreditation processes should not be merely a certification process, but rather adopted as a dynamic institutional culture aimed at continuous improvement. This study highlights the necessity for healthcare facilities to integrate quality management processes into their corporate identity.

**Keywords:** International Health Tourism, Service Quality, Accreditation, Türkiye.



## ULUSLARARASI SAĞLIK TURİZMİNDE HİZMET KALİTESİ VE AKREDİTASYONUN ÖNEMİ

### ÖZET

Küreselleşme ve teknolojik gelişmelerle birlikte hızla ivme kazanan sağlık turizmi, günümüzde ülkeler arası ekonomik ve sosyal rekabetin temel belirleyici unsurlarından biri haline gelmiştir. Bu süreçte sağlık turistlerinin destinasyon seçimini etkileyen en kritik değişkenlerin başında, sunulan sağlık hizmetlerinin kalitesi ve bu kalitenin uluslararası geçerliliği olan akreditasyon belgeleriyle sunulması gelmektedir. Bu çalışma, sağlık turizminde hizmet kalitesi ve akreditasyon süreçlerinin stratejik önemini kapsamlı bir literatür taraması yöntemiyle derinlemesine incelemeyi amaçlamaktadır. Çalışma kapsamında “Joint Commission International (JCI)”, “International Society for Quality in Healthcare (ISQua)” ve “Temos” gibi önde gelen uluslararası akreditasyon kuruluşlarının rolleri, işleyişleri ve bu kuruluşların sağlık tesislerine sağladığı küresel rekabet avantajları ayrıntılı olarak ele alınmıştır.

Alanyazın incelenmesinde uluslararası sağlık turistlerinin sadece düşük maliyet beklentisiyle hareket etmediği; aynı zamanda tıbbi güvenilirlik, hasta güvenliği, hijyen standartları ve iletişim kalitesini de önceliklendirdiği tespit edilmiştir. Bu bağlamda akreditasyonun, sağlık tesislerinin kurumsal imajını güçlendirdiği, hizmet standartlarını sistematik hale getirdiği ve sürdürülebilir bir kalite yönetimi sağladığı görülmektedir. Türkiye özelinde ise Türkiye Cumhuriyeti Sağlık Bakanlığı tarafından yürütülen “Sağlıkta Kalite Standartları (SKS)” ve “Sağlıkta Akreditasyon Standartları (SAS)” ile “Uluslararası Sağlık Hizmetleri Anonim Şirketi (USHAŞ)” ve “HealthTürkiye” portalı gibi yapıların, ülkenin küresel sağlık turizmi pazarındaki konumunu güçlendirmektedir. 2023 ve 2026 verileri ışığında hazırlanan tablolar aracılığıyla Türkiye'nin “JCI ve Temos” akreditasyonlarındaki mevcut durumu, diğer ülkelerle karşılaştırmalı olarak sunulmuştur.

Sonuç olarak, sağlık turizminde sürdürülebilirlik ve uluslararası güvenilirlik için akreditasyon süreçlerinin sadece bir belge alma süreci değil, sürekli iyileştirmeyi hedefleyen dinamik bir kurum kültürü olarak benimsenmesi gerekmektedir. Bu çalışma, sağlık tesislerinin kalite yönetimi süreçlerini kurumsal kimliklerinin ayrılmaz bir parçası haline getirmelerinin gerekliliğini ortaya koymaktadır.

**Anahtar Kelimeler:** Uluslararası Sağlık Turizmi, Hizmet Kalitesi, Akreditasyon, Türkiye.

## PRESENTATION OF TECHNOLOGICAL METHODS USED IN TEACHING PATIENT CARE IN NURSING AND CURRENT RESEARCH

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### ABSTRACT

Disease is a condition that disrupts the physical, psychological, and social balance of individuals and complicates their adaptation process, occurring in both acute and chronic forms. Both the disease itself and its associated side effects negatively affect individuals' activities of daily living, leading to outcomes ranging from minor problems to life-threatening complications. This situation may result in delayed recovery and prolonged hospital stays. The effectiveness of nursing care plays a critical role in minimizing complications through appropriate care interventions. The aim of this study is to examine the technological methods used in teaching patient care in nursing and to present current research in this field.

This study is a descriptive review based on the analysis of recent literature on technological approaches used in nursing care.

According to the reviewed studies, simulation practices, virtual reality (VR) systems supported by head-mounted displays, augmented reality (AR) technologies, mobile learning tools, and artificial intelligence-based systems are widely used in nursing education. In particular, three-dimensional and interactive clinical environments created through virtual reality headsets have been found to improve students' psychomotor skills, support clinical decision-making processes, and enhance learning retention.

The use of technological methods in nursing education makes significant contributions to improving the quality of patient care. Therefore, it is recommended that educational programs be supported with innovative technologies such as virtual reality.

**Keywords:** Nursing education, patient care, technology, virtual reality, simulation, artificial intelligence

## HEMŞİRELİKTE HASTA BAKIMININ ÖĞRETİLMESİNDE KULLANILAN TEKNOLOJİK YÖNTEMLER VE GÜNCEL ARAŞTIRMALARIN SUNULMASI

### ÖZET

Hastalık, bireyin fiziksel, psikolojik ve sosyal dengesini bozarak uyum sürecini zorlaştıran bir durum olup akut ve kronik formlarda karşımıza çıkmaktadır. Hastalığın kendisi ve beraberinde getirdiği yan etkiler, bireylerin günlük yaşam aktivitelerini olumsuz yönde etkileyerek basit sorunlardan yaşamı tehdit eden komplikasyonlara kadar uzanan sonuçlara yol açabilmektedir. Bu durum, iyileşme sürecinin gecikmesine ve hastanede kalış süresinin uzamasına neden olmaktadır. Hemşirelik bakımının etkinliği, uygun bakım girişimlerinin planlanması ve uygulanması ile komplikasyonların en aza indirilmesinde önemli rol oynamaktadır. Bu bildirinin amacı, hemşirelikte hasta bakımının öğretilmesinde kullanılan teknolojik yöntemleri ve bu alandaki güncel araştırmaları incelemektir.

Bu çalışma, hemşirelik bakımında kullanılan teknolojik yaklaşımlara ilişkin güncel literatürün incelenmesine dayanan derleme niteliğindedir.

İncelenen çalışmalar doğrultusunda; simülasyon uygulamaları, sanal gerçeklik gözlüğü ile desteklenen sanal gerçeklik (VR) sistemleri, artırılmış gerçeklik (AR) teknolojileri, mobil öğrenme araçları ve yapay zekâ destekli sistemlerin hemşirelik eğitiminde etkin şekilde kullanıldığı belirlenmiştir. Özellikle sanal gerçeklik gözlükleri ile oluşturulan üç boyutlu ve etkileşimli klinik ortamların, öğrencilerin psikomotor becerilerini geliştirdiği, klinik karar verme süreçlerini desteklediği ve öğrenmenin kalıcılığını artırdığı saptanmıştır.

Hemşirelik eğitiminde teknolojik yöntemlerin kullanımı, hasta bakım kalitesinin artırılmasında önemli katkılar sağlamaktadır. Bu doğrultuda, eğitim programlarının sanal gerçeklik gibi yenilikçi teknolojilerle desteklenmesi önerilmektedir.

**Anahtar Kelimeler:** Hemşirelik eğitimi, hasta bakımı, teknoloji, sanal gerçeklik, simülasyon, yapay zekâ

## **EVALUATION OF MOBILE HEALTH APPLICATIONS FOR CHRONIC DISEASE MANAGEMENT: PUBLIC HEALTH NURSING STANDARDS AND AGE-FRIENDLY DESIGN PERSPECTIVE**

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### **ABSTRACT**

Chronic disease management in primary care relies on supporting individuals' self-care abilities and promoting sustainable lifestyle changes. Mobile health (mHealth) applications have become an integral tool in this process. However, “digital divide” remains a significant barrier, particularly for older adults who carry the highest chronic disease burden. Public health nurses play a critical role in education, monitoring, and counseling, yet there is a need for evidence-based evaluation tools that integrate these roles into digital platforms, while also being age-friendly and culturally appropriate.

This study aimed to evaluate commonly used mobile applications for diabetes and hypertension management in terms of nursing care standards and age-friendly design criteria and to develop an evidence-based Digital Health Application Selection Guide for primary care nurses. A descriptive qualitative content analysis was conducted. The sample included 15 highly downloaded Turkish-language applications from Google Play and App Store with a rating above 4.0. Data were collected using the Public Health Nursing Application Evaluation Matrix (PHN-AEM), developed based on nursing care standards (NIC/NOC), literature, and Age-Friendly Design Principles. The matrix evaluated health education, cultural sensitivity, geriatric accessibility, and integration with national health systems using a 0-1-2 scoring system.

Preliminary analysis indicated that while applications performed well in technical data tracking, they were insufficient in delivering evidence-based health education, age-friendly accessibility, and culturally adapted content. Simplified menus and modules reflecting local dietary habits were particularly limited for older users.

This study highlights the importance of public health nurses' role in guiding patients toward safe, accessible, and evidence-based digital health applications. The PHN-AEM and resulting guide are expected to improve care quality, reduce digital barriers, and enhance self-efficacy among older adults in chronic disease management.

**Keywords:** Primary care, Digital health, Public health nursing, Content analysis, Age-friendly design

## MOBILIZATION AFTER CARDIAC SURGERY: A BIBLIOMETRIC ANALYSIS

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### ABSTRACT

Early mobilization after cardiac surgery is a crucial component of nursing care, offering numerous benefits such as reduced hospital and intensive care unit stays, increased functional capacity, and reduced complications.

This bibliometric analysis was conducted to identify and visualize trends related to mobilization after cardiac surgery over a 10-year period from 2016 to 2026.

Data were collected from the Web of Science database between February and March 2026 and analyzed using the VOSviewer program. Changes in the number of published articles over the years, author, country, and institution analysis, citation analysis, country, institution, and author collaboration analysis, journal and author co-citation analysis, and keyword analysis were evaluated.

In the field of post-cardiac mobilization, 145 studies published between 2016 and 2026 included contributions from 243 authors from 5 countries and 12 institutions. “Critical Care Nurses” was identified as the journal with the most articles on the subject, while “Cochrane Database of Systematic Reviews” was the most cited journal. The top three countries supporting the published studies were Japan, the USA, and Türkiye. The top five most frequently used keywords in the published studies were “cardiac surgery,” “early ambulation,” “cardiac rehabilitation,” “pain,” and “early mobilization.”

This bibliometric analysis reveals an increased interest in studies on post-cardiac mobilization in recent years. Meta-analyses and systematic reviews are primary sources in this field. Enhanced recovery after surgery protocols, early mobilization, and cognitive and functional impairment in cardiac surgery patients are the most frequently researched topics in mobilization-related studies. The analysis shows that while there is a high number of publications in nursing journals, the number of citations to nursing journals is lower. Increasing citations to nursing journals is recommended.

**Keywords:** Bibliometrics, nursing, cardiac surgery, mobilization, data visualization.

## DIGITAL SUSTAINABILITY AND INCLUSIVITY: THE FUTURE ALGORITHM FOR EPISTEMIC JUSTICE

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### ABSTRACT

This study presents a critical analytical vision regarding the future of education in the Developing World under the umbrella of Artificial Intelligence (AI), examining the ongoing dialectic between digital transformation aspirations and the constraints of socio-economic reality. The research concludes that Digital Sustainability is not merely technical continuity; rather, it is the educational system's capacity to "localize" technology and transform it into a sovereign asset that serves inclusivity and epistemic justice (SDG4). The added value of this research lies in its revelation that barriers to inclusion in developing societies transcend the "material divide" to include "algorithmic dependency" and "financial fragility," both of which threaten educational sovereignty. To address this dilemma, the study proposes a strategic roadmap based on the adoption of open-source solutions, the activation of ethical governance frameworks for data protection, and the innovation of participatory financing models. These measures ensure that technology remains a tool for empowerment rather than a mechanism for exclusion. The study concludes that the essence of sustainability lies in the "humanization of digitalization"—positioning the human as the driver and overseer of the machine—to guarantee equitable education that transitions all learners toward a knowledge society without dependency or marginalization.

**Keywords:** Digital Sustainability, Educational Inclusion, Technological Sovereignty, Knowledge society.

## HEPCIDIN-25 AS A CENTRAL MEDIATOR OF IRON DYSREGULATION IN CHRONIC KIDNEY DISEASE

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### ABSTRACT

The common occurrence of anaemia complicates the treatment of patients with CKD (chronic kidney disease). There are two contributing factors to high hepcidin levels resulting in increased anaemia in patients with renal impairment; decreased clearance of the hormone from the kidney and increased production through chronic activation of the immune system by interleukin-6. High hepcidin levels lead to the internalisation of the iron transporter ferroportin and as such prevent both iron absorption from the intestines and iron recycling from the reticuloendothelial system, both of which are necessary for producing red blood cells. Iron Deficiency Anemia (IDA) affects the response to Erythropoiesis Stimulating Agents (ESA) and there is still limited understanding of the role of IDA on the laboratory parameters used in staging CKD in the Middle East. The aims of this study are to characterize the stage-stratified distribution of both hepcidin-25 and nine iron metabolism and inflammatory biomarkers across all five CKD stages in comparison with healthy controls; quantify bivariate associations between hepcidin-25, estimated glomerular filtration rate (eGFR), C-reactive protein (CRP), ferritin and co-regulatory iron indices; and to assess the diagnostic accuracy of hepcidin-25 for discrimination of CKD from healthy control subjects using receiver operating characteristic (ROC) analysis. A cross-sectional case-control study was conducted from September 2025 to January 2026 at the Imam Sadiq Teaching Hospital Hemodialysis Centre and hospital laboratory, Babylon Governorate, Iraq (Ethics Approval No. 336 dated 20 October 2025). One hundred chronic kidney disease (CKD) patients were staged according to KDIGO 2022 criteria (Stage 1, n = 15; Stage 2, n = 20; Stage 3, n = 30; Stage 4, n = 20; Stage 5, n = 15) and enrolled with age- and sex-matched healthy controls (n = 50). Fasting venous blood samples were withdrawn for serum hepcidin-25 (ELISA), haemoglobin (Hb), serum iron, total iron-binding capacity (TIBC), transferrin saturation (TSAT) and ferritin, CRP, sTfR and eGFR (CKD-EPI 2021 equation) measurements. Comparisons between groups were performed using the Mann-Whitney U test and Kruskal-Wallis H test with Dunn's post-hoc analysis. Inter-biomarker associations were assessed using Spearman rank correlation. ROC curve analysis was performed to evaluate the optimal thresholds derived from Youden-index for diagnostic performance. In CKD patients, serum levels of Hepcidin-25 were significantly higher than those in healthy subjects ( $46.36 \pm 24.79$  ng/mL vs.  $8.41 \pm 5.07$  ng/mL;  $p < 0.001$ ) and progressively increased with the progressing stages: Stage I ( $16.80 \pm 12.61$  ng/mL), Stage II ( $29.73 \pm 14.54$  ng/mL), Stage III ( $46.57 \pm 15.25$  ng/mL), stage IV ( $65.22 \pm 14.97$  ng/mL) and stage V ( $72.51 \pm 23.29$  ng/mL). Post-hoc Dunn's demonstrated that the elevation in inter-group p-values was statistically significant at Stage 2 relative to healthy controls ( $z = -3.890$ ;  $p < 0.001$ ). All 9 biomarkers differed significantly between groups (Kruskal-Wallis; all  $p < 0.001$ ). Spearman correlation analysis showed that hepcidin-25 was most significantly associated with CRP ( $\rho = 0.861$ ,  $p < 0.001$ ), ferritin ( $\rho = 0.780$ ,  $p < 0.001$ ) and eGFR ( $\rho = -0.756$ ,  $p < 0.001$ ), which in combination represent the inflammation-related transcriptional upregulation of hepcidin as well as impaired renal clearance being the dual underlying mechanisms of hepcidin accumulation [5]. The classic microcytic and hypochromic pattern of functional iron deficiency was confirmed by progressive increases in serum ferritin (50.33 to 390.15 ng/mL), differences in serum iron (88.08 to 41.05  $\mu$ g/dL) with TIBC (318.50 to 184.22  $\mu$ g/dL) and TSAT (27.70 to 10.52%) across stages. ROC analysis showed that hepcidin-25 had an excellent AUC 0.939 (95% CI: 0.903–0.975), the optimal threshold  $Y = 18.01$  ng/mL with sensitivity, specificity, PPV and NPV of: 86.0%, 98.0%,

97.7% and 89.1%, respectively. Among the three biomarkers, CRP has the highest AUC (0.976), followed by ferritin (0.933) and sTfR (0.930). Circulating hepcidin-25 is significantly and strongly elevated across all stages of CKD in a stage-dependent manner, driven by both decreased renal clearance as well as IL-6-driven inflammatory transcription. As hepcidin-25 was strongly correlated with eGFR and CRP, and co-segregated with a classical functional iron deficiency profile it represents a new mechanistically informative biomarker in the work-up of CKD-related anaemia. The high diagnostic performance of hepcidin-25 (AUC = 0.939; specificity = 98.0%) supports its potential use in guiding therapeutic decisions in patients with ESA hyporesponsiveness risk. Hepcidin-25 measurement, integrated with traditional iron indices — specifically ferritin and sTfR has the potential to enhance identification of functional iron deficiency in CKD and provide targeted management.

**Keywords:** Hepcidin-25; Chronic kidney disease; Iron metabolism; Functional iron deficiency; Ferritin; eGFR; C-reactive protein; Soluble transferrin receptor.

## INTRODUCTION

Chronic kidney disease (CKD) is a chronic and progressive deterioration of kidney function. The clinical definition of CKD includes: The presence of a reduction in the glomerular filtration rate (GFR) for three months or longer, and usually associated with structural abnormalities in the kidney parenchyma and GFR below 60 mL/min/1.73 m<sup>2</sup>. CKD is rapidly becoming one of the most significant public health problems worldwide. The estimated prevalence of CKD among adults is between 9–13%, which translates into a considerable burden for cardiovascular disease (CVD), metabolic related disorders, and premature mortality(1). A global overview illustrates the magnitude of the epidemiology of this disease, however in Iraq, particularly in Babylon Governorate which is at the intersection of multiple environmental factors (determinants), has extremely limited access to nephrologists or nephrology prevention methods and has an extremely high prevalence of diabetes mellitus and hypertension (as leading contributors to the development of CKD)(2).

Anaemia is one of the earliest and most clinically important complications of CKD, occurring even at moderate degrees of renal impairment and increasingly symptomatic as kidney function deteriorates towards end-stage renal disease (ESRD). The pathophysiology of anaemia related to chronic kidney disease (CKD) is multifactorial, including shortages in erythropoietin production and red blood cell longevity, a shortage of haematinics and aberrations in iron homeostasis caused by chronic inflammation. Therapeutic options have traditionally focused on erythropoiesis-stimulating agents (ESAs) and intravenous iron supplementation; however, a considerable proportion of CKD patients are hyporesponsive to ESA therapy, a condition that has progressively been ascribed to dysregulation of a master iron-regulatory hormone: hepcidin-25(3,4).



Hepcidin-25, a 25-amino acid peptide primarily secreted by hepatocyte cells, has emerged as the main regulator of systemic iron homeostasis(5). Hepcidin-25 induces the internalisation and lysosomal degradation of ferroportin and, through its interaction with FPN1 that is expressed on enterocytes, hepatocytes, and macrophages, inhibits duodenal iron absorption and mobilisation of reticuloendothelial iron stores(6,7). Under healthy conditions, hepcidin synthesis is exquisitely adjusted by erythropoietic demand, iron stores and hypoxic signals; this regulatory axis is severely impaired in CKD(8,9). Renal clearance of hepcidin is markedly reduced as GFR decreases and the chronic inflammatory environment that characterises CKD — illustrated by increased interleukin-6 (IL-6) and C-reactive protein (CRP) levels — stimulates upregulation of hepcidin gene transcription through the IL-6/STAT3 signalling pathway. The resulting pathological hyperhepcidemia traps iron within cellular stores, thus making it functionally unavailable for erythropoiesis, despite frequently normal or increased concentrations of ferritin — a condition referred to as functional iron deficiency(10,11).

The clinical consequence of hepcidin excess in CKD is an iron metabolic profile defined by paradoxically increased ferritin levels, an increasingly reduced serum pool of transferrin-bound iron, and decreased transferrin saturation (TSAT) and total iron-binding capacity (TIBC), along with increasing plasma concentrations of sTfR a sensitive biomarker unique to iron-restricted erythropoiesis(12). These biomarkers together characterize the progression of iron sequestration in CKD as it progresses from early (Stages 1–2) to late (Stages 3–5) stages(13). While mechanistic insights are now increasing, longitudinal and cross-sectional data characterising the stage-specific patterns of hepcidin-25 and concomitant iron parameters in Middle Eastern CKD populations remain scarce.

Although previous studies have shown that hepcidin-25 levels are elevated in CKD(14,15), many of these reports were limited to Stage 5 dialysis patients, lacked healthy control groups or did not systematically assess the whole spectrum of iron metabolism biomarkers at all stages of CKD simultaneously. In addition, the independent diagnostic utility of hepcidin-25 evaluated by receiver operating characteristic (ROC) analysis and relative to known markers such as CRP, ferritin and sTfR has not been thoroughly characterised in Iraqi patients with CKD(16).

For this research, we looked at how stage of CKD patients relates with nine iron metabolism biomarkers (including hepcidin-25) at the Imam Sadiq Hemodialysis Center in Babylon to gain insight into their diagnostic properties, determine their strength and direction of associations

with eGFR and other co-regulatory biomarkers through non parametric statistical methods, and compare hepcidin-25 against CRP, ferritin and sTfR using ROC curve analysis to help understand CKD patients and healthy controls in terms of diagnosing and developing a treatment strategy for both groups. Finally, we linked these data with other hepcidin biology/pathophysiology studies and provided evidence for future hypothesis generating studies which can support the rational use of hepcidin as a potential diagnostic and therapeutic target in nephrology.

## **MATERIALS AND METHODS**

### **Study Design and Setting**

Between September 2025 and January 2026, an observational case-control research project was performed in the Hemodialysis Units at both the Imam Sadiq Hospital and the Cancer Institute of Al Hillah (which is located within the Babylon Governorate in Iraq) using data that was collected in this center during that time period. The study protocol received ethical review board approval (Reference number - 336, 20 October 2025). Written consent in accordance with the Declaration of Helsinki for all participating subjects was received prior to doing the research trial.

### **Study Population**

One hundred patients have been diagnosed with CKD, and 50 healthy individuals as controls: A total of 150 participants. Diagnosis and staging of CKD were defined according to Kidney Disease: Improving Global Outcomes (KDIGO) 2022 guidelines, based on eGFR calculated by the CKD-EPI creatinine equation. The patients were classified as follows: Stage 1 (eGFR  $\geq$  90 and evidence of kidney damage, n = 15), Stage 2 (eGFR 60–89, n = 20), Stage 3 (eGFR 30–59, n = 30), Stage 4 (eGFR 15–29, n = 20) and Stage 5 (eGFR < 15 and maintenance haemodialysis patients; n = 15).

Inclusion criteria for CKD patients included: confirmed diagnosis of CKD with recorded duration of disease (at least three months), age within the range between 18 and 75 years, and haemodynamic stability at recruitment. Patients with acute kidney injury, active haematological malignancy, hereditary haemochromatosis, known liver cirrhosis or chronic hepatitis were excluded from the study along with those with an acute infectious illness in the previous four weeks and who had received iron supplementation or blood transfusion within eight weeks prior to study entry. Patients wherein pregnancy or lactation was observed were also excluded. We

recruited healthy controls from those attending the hospital for routine health screening and with no chronic systemic illness, had values of eGFR 60 mL/min/1.73 m<sup>2</sup> or greater and normal inflammatory markers.

## **Laboratory Procedures**

### **Sample Collection**

Venous blood samples (10 mL) were obtained via antecubital venepuncture using standard aseptic technique after a minimum overnight fast (minimum eight hours) from all participants. Samples were split into EDTA-anticoagulated tubes for full blood count, clot activator tubes for biochemical analyses and no anticoagulant tubes for serum separation. Serum was separated by centrifugation at 2000 × g for 10 minutes at room temperature and frozen at –80°C until batch analysis to minimise freeze-thaw variation.

### **Biochemical and Haematological Assays**

Cyanmethhaemoglobin method in an automated haematology analyser (Sysmex XN-1000, Sysmex Corporation, Japan) was used to determine the haemoglobin (Hb) concentration. Serum iron, TIBC and TSAT were determined using colorimetric methods on an automated Beckman Coulter AU480 biochemistry analyser (Beckman Coulter, USA). Ferritin was measured by two-site immunoenzymometric assay (IEMA) on a Roche Cobas e 411 analyser (Roche Diagnostics, Germany). High-sensitivity immunoturbidimetric assay was used to measure C-reactive protein.

Serum hepcidin-25 concentration was measured using the commercial human hepcidin-25 ELISA kit (DRG International Inc., USA, according to the manufacturer's instructions. The intra-assay and inter-assay coefficients of variation were less than 8% and 10%, respectively, at a range of assays from 0.05–20 ng/mL. In cases where the concentration was above the linear range of the assay, all samples were diluted with assay diluent and re-analyzed; final values were corrected for dilution factor. Soluble transferrin receptor (sTfR) was assessed by immunoturbidimetry in Roche Cobas platform. Estimated GFR was calculated using the CKD-EPI 2021 creatinine equation from serum creatinine values.

### **Statistical Analysis**

Statistical analyses were done by using SPSS (version 28), with  $\alpha = 0.05$  denoting significance. Shapiro-Wilk test was used for normality assessment of continuous variables. Due to the non-

normal distribution noted for most biomarkers, all analyses were performed using non-parametric methods. Continuous data are presented as either mean  $\pm$  standard deviation (SD) or median with interquartile range (IQR) when appropriate. Comparison between CKD patients and healthy controls was carried out with Mann-Whitney U test. Differences between CKD stages were determined by the Kruskal-Wallis H test and Dunn's post-hoc comparison with Bonferroni correction for pairwise comparison.

Bivariate associations between biomarkers were evaluated by Spearman's rank correlation coefficient ( $\rho$ ), resulting matrix was presented as a colour-coded heatmap for visual interpretation. Constructing receiver operating characteristic (ROC) curves and calculating area under the curve (AUC) with 95% confidence intervals were used to evaluate diagnostic accuracy of each key biomarker for CKD diagnosis. The best diagnostic threshold was determined by maximising the Youden index (sensitivity + specificity - 1). The positive predictive value (PPV) and negative predictive value (NPV) were also calculated at the optimal threshold.

## RESULTS

### Demographic and Clinical Characteristics

In total, 150 individuals participated in this research; of these, 100 were diagnosed with chronic kidney disease (CKD) (average eGFR =  $46.83 \pm 29.11$  ml/min/1.73m<sup>2</sup>) and 50 were healthy individuals (average eGFR =  $99.44 \pm 11.60$  ml/min/1.73m<sup>2</sup>). There were statistically significant differences in the mean haemoglobin level between CKD and healthy individuals ( $10.33 \pm 1.88$  gm/dl versus  $13.34 \pm 1.31$  gm/dl); therefore, this finding confirms that the prevalence of anaemia associated with CKD is very high in this group of individuals. The CKD patients were at varying stages of the disease, as follows: Stage 1 (n=15), Stage 2 (n=20), Stage 3 (n=30), Stage 4 (n=20), Stage 5 (n=15). Statistically significant differences ( $p < 0.001$  for all nine markers examined) were shown by Kruskal-Wallis analysis among all groups studied (CKD patients and healthy controls). This supports the validity of the analytical approach to CKD patients, that is a stage-specific analysis.

**Table 1.** Descriptive Statistics (Mean  $\pm$  SD) of Iron Metabolism and Inflammatory Biomarkers Across CKD Stages and Healthy Controls

| Biomarker (Units)                 | Control (n = 50)   | Stage 1 (n = 15)   | Stage 2 (n = 20)   | Stage 3 (n = 30)   | Stage 4 (n = 20)   | Stage 5 (n = 15)    | p-value |
|-----------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------|
| eGFR (mL/min/1.73m <sup>2</sup> ) | 99.44 $\pm$ 11.60  | 92.65 $\pm$ 12.03  | 69.29 $\pm$ 11.97  | 45.04 $\pm$ 8.46   | 21.41 $\pm$ 4.41   | 8.55 $\pm$ 3.34     | <0.001  |
| Haemoglobin (g/dL)                | 13.34 $\pm$ 1.31   | 11.66 $\pm$ 1.18   | 11.60 $\pm$ 1.13   | 10.78 $\pm$ 1.41   | 9.28 $\pm$ 1.42    | 7.81 $\pm$ 1.42     | <0.001  |
| Serum Iron ( $\mu$ g/dL)          | 88.08 $\pm$ 22.28  | 72.20 $\pm$ 21.89  | 73.37 $\pm$ 19.85  | 56.88 $\pm$ 16.96  | 46.97 $\pm$ 22.29  | 41.05 $\pm$ 19.46   | <0.001  |
| TIBC ( $\mu$ g/dL)                | 318.50 $\pm$ 46.44 | 310.16 $\pm$ 38.71 | 269.25 $\pm$ 31.54 | 247.84 $\pm$ 35.64 | 204.06 $\pm$ 39.58 | 184.22 $\pm$ 39.52  | <0.001  |
| Ferritin (ng/mL)                  | 50.33 $\pm$ 29.97  | 103.01 $\pm$ 61.50 | 173.87 $\pm$ 86.40 | 209.62 $\pm$ 72.96 | 333.74 $\pm$ 87.81 | 390.15 $\pm$ 133.31 | <0.001  |
| TSAT (%)                          | 27.70 $\pm$ 7.14   | 19.11 $\pm$ 9.64   | 17.39 $\pm$ 4.79   | 13.39 $\pm$ 5.85   | 12.00 $\pm$ 6.67   | 10.52 $\pm$ 5.32    | <0.001  |
| Hepcidin-25 (ng/mL)               | 8.41 $\pm$ 5.07    | 16.80 $\pm$ 12.61  | 29.73 $\pm$ 14.54  | 46.57 $\pm$ 15.25  | 65.22 $\pm$ 14.97  | 72.51 $\pm$ 23.29   | <0.001  |
| CRP (mg/L)                        | 0.59 $\pm$ 0.46    | 2.97 $\pm$ 1.89    | 4.72 $\pm$ 2.51    | 9.23 $\pm$ 3.94    | 13.98 $\pm$ 4.27   | 19.47 $\pm$ 6.88    | <0.001  |
| sTfR (mg/L)                       | 1.23 $\pm$ 0.51    | 1.70 $\pm$ 0.51    | 2.55 $\pm$ 0.74    | 2.95 $\pm$ 0.87    | 3.67 $\pm$ 0.72    | 4.71 $\pm$ 1.12     | <0.001  |

All values are expressed as mean  $\pm$  SD. Statistical significance was determined by Kruskal-Wallis H test. eGFR, estimated glomerular filtration rate; TIBC, total iron-binding capacity; TSAT, transferrin saturation; CRP, C-reactive protein; sTfR, soluble transferrin receptor. \*\*\* p < 0.001.

### Comparison of CKD Patients and Healthy Controls

Using the Mann-Whitney U test, we compared the CKD group (n=100) to the healthy control group (n=50) on the measured biomarkers, and there were significant differences in all of the biomarkers (see Table 2). The CKD patients had significantly higher concentrations of hepcidin-25 (46.36  $\pm$  24.79 ng/mL vs. 8.41  $\pm$  5.07 ng/mL; p < 0.001), ferritin (238.38  $\pm$  129.29 ng/mL vs. 50.33  $\pm$  29.97 ng/mL; p < 0.001), CRP (9.87  $\pm$  6.82 mg/L vs. 0.59  $\pm$  0.46 mg/L; p < 0.001), and sTfR (3.09  $\pm$  1.21 mg/L vs. 1.23  $\pm$  0.51 mg/L; p < 0.001), indicating the presence of systemic inflammation as well as iron loading. In contrast to the CKD patients, the serum iron (58.12  $\pm$  22.88 vs. 88.08  $\pm$  22.28  $\mu$ g/dL; p < 0.001), total iron binding capacity (TIBC; 243.17  $\pm$  54.37 vs. 318.50  $\pm$  46.44  $\mu$ g/dL; p < 0.001), transferrin saturation (TSAT; 14.34  $\pm$  7.00 vs. 27.70  $\pm$  7.14%; p < 0.001), hemoglobin (Hb; 10.33  $\pm$  1.88 vs. 13.34  $\pm$  1.31 g/dL; p < 0.001)

and estimated glomerular filtration rate (eGFR) were significantly lower than in the patients with chronic kidney disease (CKD) as would be expected for the pathophysiology of iron deficient erythropoiesis in patients with CKD.

**Table 2.** Mann-Whitney U Test Comparison of Biomarker Concentrations Between CKD Patients and Healthy Controls

| <b>Biomarker<br/>(Units)</b>               | <b>CKD Patients<br/>(n=100)</b> | <b>Healthy Controls<br/>(n=50)</b> | <b>U Statistic</b> | <b>p-value</b> |
|--------------------------------------------|---------------------------------|------------------------------------|--------------------|----------------|
| <b>eGFR<br/>(mL/min/1.73m<sup>2</sup>)</b> | 46.83 ± 29.11                   | 99.44 ± 11.60                      | 245.5              | <0.001         |
| <b>Haemoglobin<br/>(g/dL)</b>              | 10.33 ± 1.88                    | 13.34 ± 1.31                       | 673.0              | <0.001         |
| <b>Serum Iron<br/>(µg/dL)</b>              | 58.12 ± 22.88                   | 88.08 ± 22.28                      | 1624.5             | <0.001         |
| <b>TIBC (µg/dL)</b>                        | 243.17 ± 54.37                  | 318.50 ± 46.44                     | 905.0              | <0.001         |
| <b>Ferritin (ng/mL)</b>                    | 238.38 ± 129.29                 | 50.33 ± 29.97                      | 534.0              | <0.001         |
| <b>TSAT (%)</b>                            | 14.34 ± 7.00                    | 27.70 ± 7.14                       | 862.5              | <0.001         |
| <b>Hepcidin-25<br/>(ng/mL)</b>             | 46.36 ± 24.79                   | 8.41 ± 5.07                        | 238.0              | <0.001         |
| <b>CRP (mg/L)</b>                          | 9.87 ± 6.82                     | 0.59 ± 0.46                        | 149.5              | <0.001         |
| <b>sTfR (mg/L)</b>                         | 3.09 ± 1.21                     | 1.23 ± 0.51                        | 802.5              | <0.001         |

Data expressed as mean ± SD. Significance assessed by two-tailed Mann-Whitney U test. All comparisons p < 0.001. Abbreviations as in Table 1.

Box plots were generated to demonstrate the distribution of six main biomarkers in all CKD stages and controls (Figure 1). Distributions clearly illustrate how markers diverge in directional fashion with progressive disease stage: hepcidin-25, ferritin, CRP and sTfR increase stepwise toward higher values; eGFR, Hb at baseline, serum iron, TIBC and TSAT decrease stepwise to lower values. This graphical outline emphasizes the clinical and biological vagueness of this dataset.

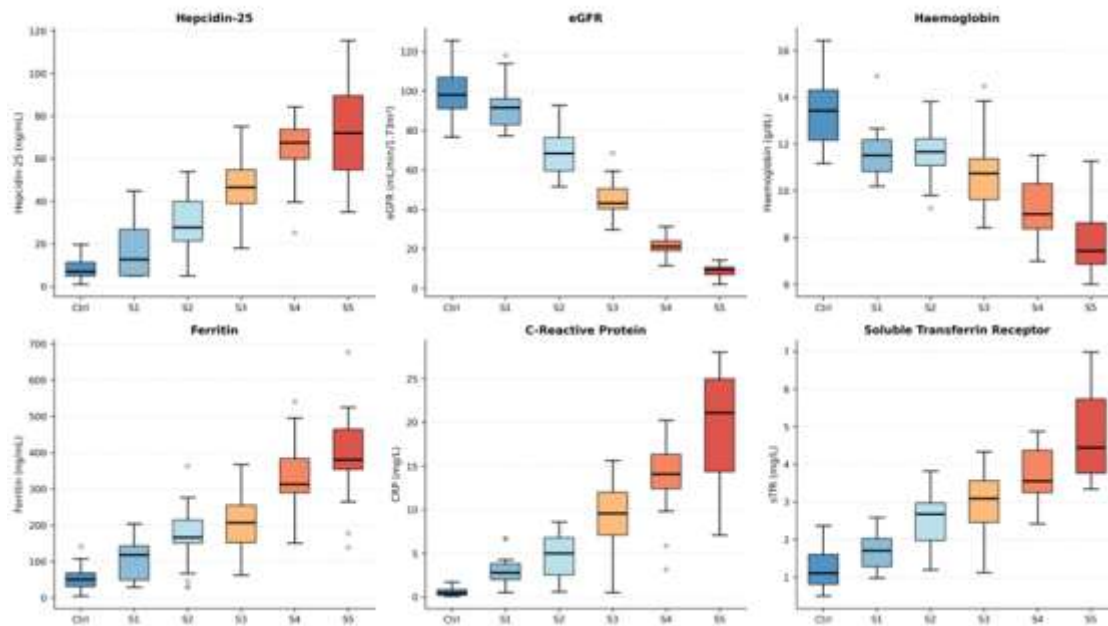


**Figure 1.** Box-and-whisker plots illustrating the distribution of hepcidin-25, eGFR, haemoglobin, ferritin, CRP, and sTfR across CKD stages (Stage 1–5) and healthy controls (Ctrl). Data presented as median with interquartile range; individual outliers are shown as open circles. Ctrl = Control; S1–S5 = CKD Stages 1–5.

### Stage-Stratified Elevation of Hepcidin-25

Hepcidin-25 stage-specific distribution is shown in Table 3 and Figure 2. There was a progressive and clinically relevant increase in hepcidin-25 with worsening CKD stage. Meanwhile, the mean hepcidin-25 concentration increased in healthy control group ( $8.41 \pm 5.07$  ng/mL), Stage 1 ( $16.80 \pm 12.61$  ng/mL), Stage 2 ( $29.73 \pm 14.54$  ng/mL), stage Stage 3 ( $46.57 \pm 15.25$  ng/mL), Stage 4 ( $65.22 \pm 14.97$  ng/mL) and stage Stage5 ( $72.51 \pm 23.29$  ng/mL) respectively.. Overall Kruskal-Wallis test showed highly significant differences between groups ( $p < 0.001$ ).

**Table 3.** Stage-Stratified Hepcidin-25 Levels with Concomitant Iron Parameters and Inflammatory Markers

| CKD Stage | n  | Mean $\pm$ SD (ng/mL) | Median (ng/mL) | IQR (ng/mL)   | Ferritin (ng/mL)   | CRP (mg/L)      |
|-----------|----|-----------------------|----------------|---------------|--------------------|-----------------|
| Control   | 50 | $8.41 \pm 5.07$       | 6.88           | 4.92 – 11.24  | $50.33 \pm 29.97$  | $0.59 \pm 0.46$ |
| Stage 1   | 15 | $16.80 \pm 12.61$     | 12.71          | 5.00 – 26.77  | $103.01 \pm 61.50$ | $2.97 \pm 1.89$ |
| Stage 2   | 20 | $29.73 \pm 14.54$     | 27.68          | 21.38 – 39.88 | $173.87 \pm 86.40$ | $4.72 \pm 2.51$ |

|                |    |               |       |               |                 |              |
|----------------|----|---------------|-------|---------------|-----------------|--------------|
| <b>Stage 3</b> | 30 | 46.57 ± 15.25 | 46.45 | 38.97 – 54.80 | 209.62 ± 72.96  | 9.23 ± 3.94  |
| <b>Stage 4</b> | 20 | 65.22 ± 14.97 | 67.52 | 59.83 – 73.70 | 333.74 ± 87.81  | 13.98 ± 4.27 |
| <b>Stage 5</b> | 15 | 72.51 ± 23.29 | 72.02 | 54.70 – 89.64 | 390.15 ± 133.31 | 19.47 ± 6.88 |

Hepcidin-25 values are presented as mean ± SD, median, and interquartile range (IQR). Ferritin and CRP values are mean ± SD. The Kruskal-Wallis test confirmed global statistical significance ( $p < 0.001$ ) for all parameters.

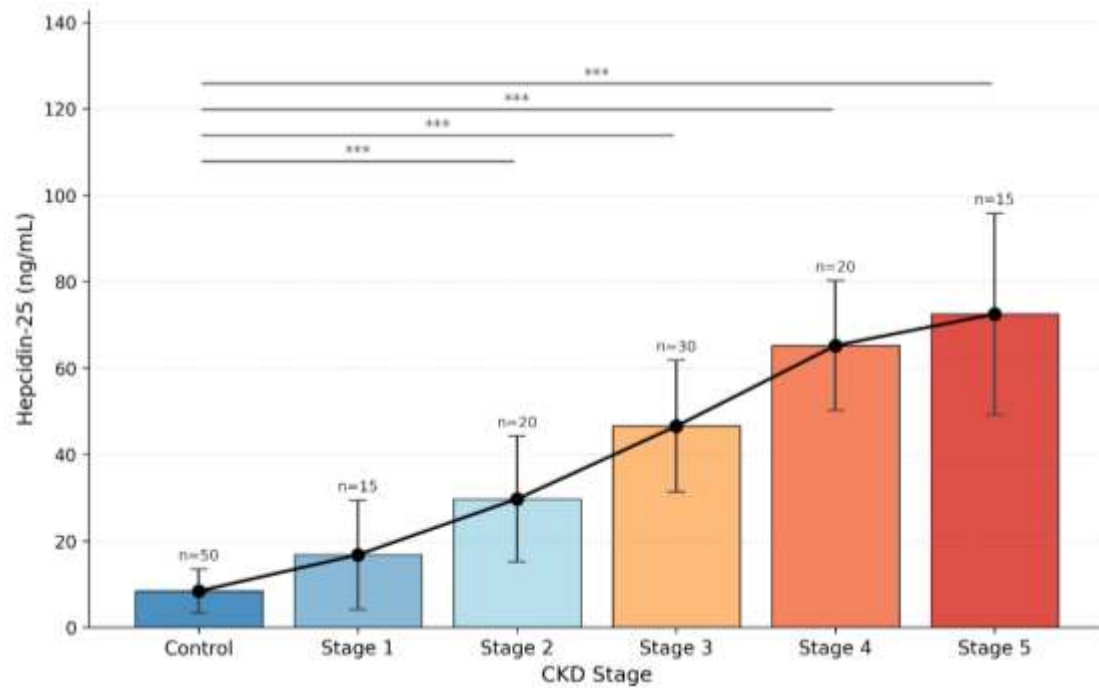


**Figure 2.** Mean ± SD concentrations of hepcidin-25 across CKD stages and healthy controls. Data labels indicate group sample sizes. Significance brackets are shown for pairwise comparisons relative to healthy controls; \*\*\*  $p < 0.001$ . The overlaid line graph illustrates the progressive linear trend of hepcidin elevation with advancing CKD stage.

A Dunn's post-hoc analysis using Bonferroni correction was conducted for inter-stage comparison (Table 6). Hepcidin-25 was first significantly elevated compared to healthy controls at Stage 2 ( $z = -3.890$ ,  $p < 0.001$ ). The differences between Stage 1 and Stage 2 were not statistically significant ( $p = 0.080$ ), indicating that the switch to hepcidin excess with haemodynamic significance takes place mainly from Stage 3 onwards. A borderline difference was noted in pairwise comparisons between Stages 3 and 4 ( $p = 0.058$ ) and Stages 3 and 5 ( $p = 0.053$ ), suggesting that, while numerical elevations remain, hepcidin increase is plateaued at advanced-stage CKD consistent with a ceiling effect represented by maximal renal hepcidin retention.



### Spearman Correlation Analysis

Within the CKD patient cohort (n = 100), Spearman rank correlation analysis between the nine biomarkers was conducted. The resulting correlation matrix is shown in Table 4 and illustrated as a heatmap in Figure 3. Hepcidin-25 had the strongest positive correlations with CRP ( $\rho = 0.861$ ,  $p < 0.001$ ) and ferritin ( $\rho = 0.780$ ,  $p < 0.001$ ), and the strongest negative correlations with eGFR ( $\rho = -0.756$ ,  $p < 0.001$ ) and TIBC ( $\rho = -0.635$ ,  $p < 0.001$ ). The strong inverse association between hepcidin-25 and eGFR mechanistically connects functional derangements in renal clearance of hepcidin with the progressive accumulation of this hormone as kidney function declines.

**Table 4.** Spearman Rank Correlation Matrix for Iron Metabolism and Inflammatory Biomarkers in CKD Patients (n = 100)

|          | eGFR      | Hb        | Ser.Fe    | TIBC      | Ferritin  | TSAT      | Hepc-25   | CRP       | sTfR      |
|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| eGFR     | —         | 0.664***  | 0.528***  | 0.737***  | -0.734*** | 0.385***  | -0.756*** | -0.789*** | -0.710*** |
| Hb       | 0.664***  | —         | 0.284**   | 0.639***  | -0.612*** | 0.278**   | -0.572*** | -0.604*** | -0.458*** |
| Ser. Fe  | 0.528***  | 0.284**   | —         | 0.324***  | -0.348*** | 0.237*    | -0.370*** | -0.376*** | -0.444*** |
| TIBC     | 0.737***  | 0.639***  | 0.324***  | —         | -0.643*** | 0.210*    | -0.635*** | -0.611*** | -0.554*** |
| Ferritin | -0.734*** | -0.612*** | -0.348*** | -0.643*** | —         | -0.271**  | 0.780***  | 0.727***  | 0.559***  |
| TSAT     | 0.385***  | 0.278**   | 0.237*    | 0.210*    | -0.271**  | —         | -0.206*   | -0.248*   | -0.315*** |
| Hepc-25  | -0.756*** | -0.572*** | -0.370*** | -0.635*** | 0.780***  | -0.206*   | —         | 0.861***  | 0.540***  |
| CRP      | -0.789*** | -0.604*** | -0.376*** | -0.611*** | 0.727***  | -0.248*   | 0.861***  | —         | 0.580***  |
| sTfR     | -0.710*** | -0.458*** | -0.444*** | -0.554*** | 0.559***  | -0.315*** | 0.540***  | 0.580***  | —         |

Values represent Spearman's rho ( $\rho$ ). Significance levels: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ . Negative values (red) indicate inverse correlations; positive values (blue) indicate direct correlations. Hepc-25 = Hepcidin-25; Ser. Fe = Serum Iron; ns = not shown (diagonal).

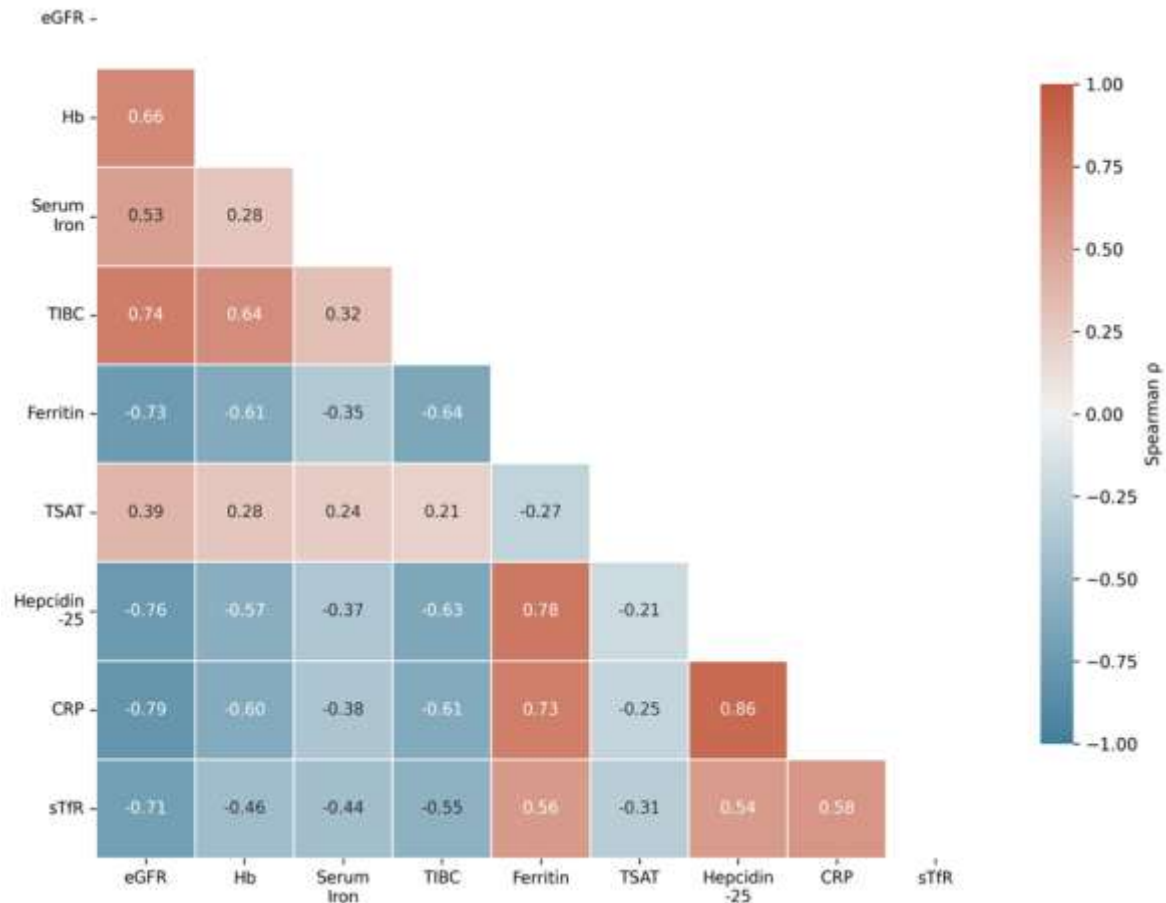


**Figure 3.** Spearman rank correlation heatmap for all nine biomarkers in the CKD patient group ( $n = 100$ ). Colour intensity reflects the magnitude of rho; red denotes negative and blue denotes positive correlations. Correlation coefficients are annotated within each cell. Only the lower triangle is displayed to avoid redundancy.

The high positive correlation of hepcidin-25 and CRP ( $\rho = 0.861$ ) points out inflammation as the main determinant of excess hepcidin in CKD [23–26]. Hepcidin-25 also correlated positively with sTfR ( $\rho = 0.540$ ,  $p < 0.001$ ), supporting a hepcidin-induced blockade of ferroportin-mediated iron access to erythropoiesis in the state of iron-restricted erythropoiesis. CRP was found to have the highest inverse correlation with eGFR ( $\rho = -0.789$ ), indicating that inflammatory markers increase as renal function worsens. These interconnections are also reflected in Figure 5, which shows scatter plots of hepcidin-25 v eGFR and CRP with colour-coded CKD stage stratifications.

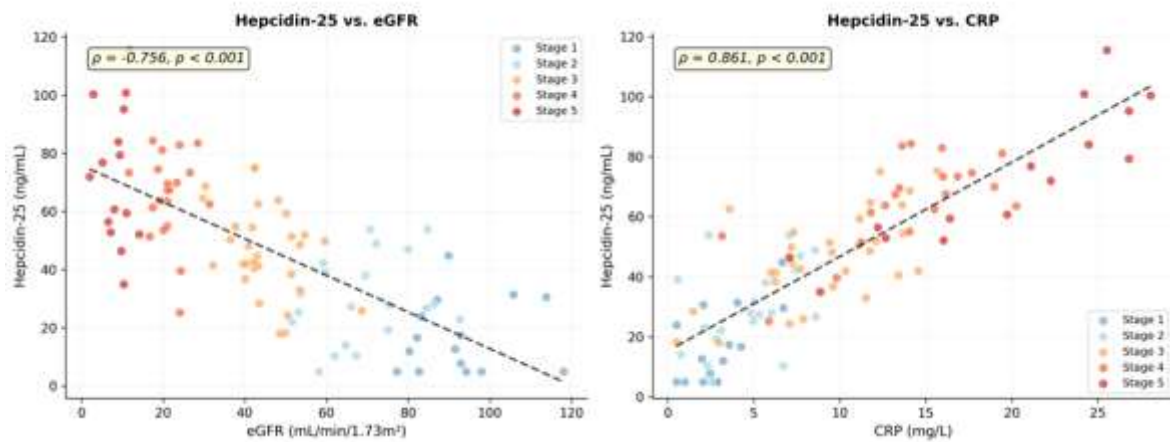


**Figure 5.** Scatter plots illustrating the relationship between hepcidin-25 and (A) eGFR and (B) CRP in the CKD patient cohort (n = 100). Data points are colour-coded by CKD stage. Regression lines (dashed) reflect the linear trend across the full patient cohort. Spearman correlation coefficients ( $\rho$ ) and p-values are displayed within each panel.

#### Dunn Post-Hoc Analysis for Hepcidin-25

**Table 6.** Dunn's Post-Hoc Pairwise Comparison of Hepcidin-25 Concentrations Across CKD Stages (Bonferroni-Corrected)

| Group 1 | Group 2 | z-score | p-value (adjusted) | Significance | Interpretation            |
|---------|---------|---------|--------------------|--------------|---------------------------|
| Control | Stage 1 | -1.462  | 0.144              | ns           | No significant difference |
| Control | Stage 2 | -3.890  | <0.001             | ***          | Significantly elevated    |
| Control | Stage 3 | -6.946  | <0.001             | ***          | Highly elevated           |
| Control | Stage 4 | -8.131  | <0.001             | ***          | Markedly elevated         |
| Control | Stage 5 | -7.529  | <0.001             | ***          | Markedly elevated         |
| Stage 1 | Stage 2 | -1.753  | 0.080              | ns           | No significant difference |
| Stage 1 | Stage 3 | -3.712  | <0.001             | ***          | Significantly elevated    |
| Stage 1 | Stage 4 | -5.038  | <0.001             | ***          | Highly elevated           |
| Stage 1 | Stage 5 | -4.892  | <0.001             | ***          | Highly elevated           |
| Stage 2 | Stage 3 | -1.992  | 0.046              | *            | Moderately elevated       |
| Stage 2 | Stage 4 | -3.548  | <0.001             | ***          | Significantly elevated    |

|                |                |        |        |     |                              |
|----------------|----------------|--------|--------|-----|------------------------------|
| <b>Stage 2</b> | <b>Stage 5</b> | -3.476 | <0.001 | *** | Significantly elevated       |
| <b>Stage 3</b> | <b>Stage 4</b> | -1.895 | 0.058  | ns  | Borderline (not significant) |
| <b>Stage 3</b> | <b>Stage 5</b> | -1.936 | 0.053  | ns  | Borderline (not significant) |
| <b>Stage 4</b> | <b>Stage 5</b> | -0.191 | 0.849  | ns  | No significant difference    |

z-scores and p-values are from Dunn's test following significant Kruskal-Wallis result. Significance codes: \*\*\*  $p < 0.001$ ; \*  $p < 0.05$ ; ns = not significant. Negative z-scores indicate that the first group has lower hepcidin-25 than the second group.

### **Diagnostic Performance: ROC Curve Analysis**

ROC (Receiver Operating Characteristic) analysis was conducted to assess the diagnostic usefulness of hepcidin-25 in identifying patients with CKD from healthy subjects and compared to CRP, ferritin, and sTfR (See Table 5 and Figure 4). Of the above-mentioned biomarkers, CRP was shown to have the highest AUC (AUC = 0.976; 95% CI: 0.954 - 0.998) indicating that it is reflecting an overall increase in inflammation due to CKD. The AUC of hepcidin-25 was 0.939 (95% CI: 0.903 - 0.975), which indicates that it is performing very well as a diagnostic indicator with a best threshold value of hepcidin-25 of 18.01 ng/mL (sensitivity = 86.0%; specificity = 98.0%; PPV = 97.7%; NPV = 89.1%). Ferritin (AUC = 0.933) and sTfR (AUC = 0.930) had a very similar ability to discriminate as well.

**Table 5.** Receiver Operating Characteristic (ROC) Analysis for Key Biomarkers in the Discrimination of CKD Patients from Healthy Controls

| <b>Biomarker</b>           | <b>AUC (95% CI)</b> | <b>Optimal Threshold</b> | <b>Sensitivity (%)</b> | <b>Specificity (%)</b> | <b>PPV (%)</b> | <b>NPV (%)</b> |
|----------------------------|---------------------|--------------------------|------------------------|------------------------|----------------|----------------|
| <b>Hepcidin-25 (ng/mL)</b> | 0.939 (0.903-0.975) | ≥18.01 ng/mL             | 86.0                   | 98.0                   | 97.7           | 89.1           |
| <b>CRP (mg/L)</b>          | 0.976 (0.954-0.998) | ≥1.97 mg/L               | 93.0                   | 100.0                  | 100.0          | 94.3           |
| <b>Ferritin (ng/mL)</b>    | 0.933 (0.893-0.973) | ≥110.33 ng/mL            | 88.0                   | 98.0                   | 97.8           | 90.7           |
| <b>sTfR (mg/L)</b>         | 0.930 (0.890-0.970) | ≥2.27 mg/L               | 77.0                   | 98.0                   | 97.5           | 82.4           |

AUC, area under the ROC curve. 95% CIs estimated by bootstrapping (1,000 iterations). Optimal threshold determined by maximisation of the Youden index (sensitivity + specificity – 1). PPV, positive predictive value; NPV, negative predictive value.

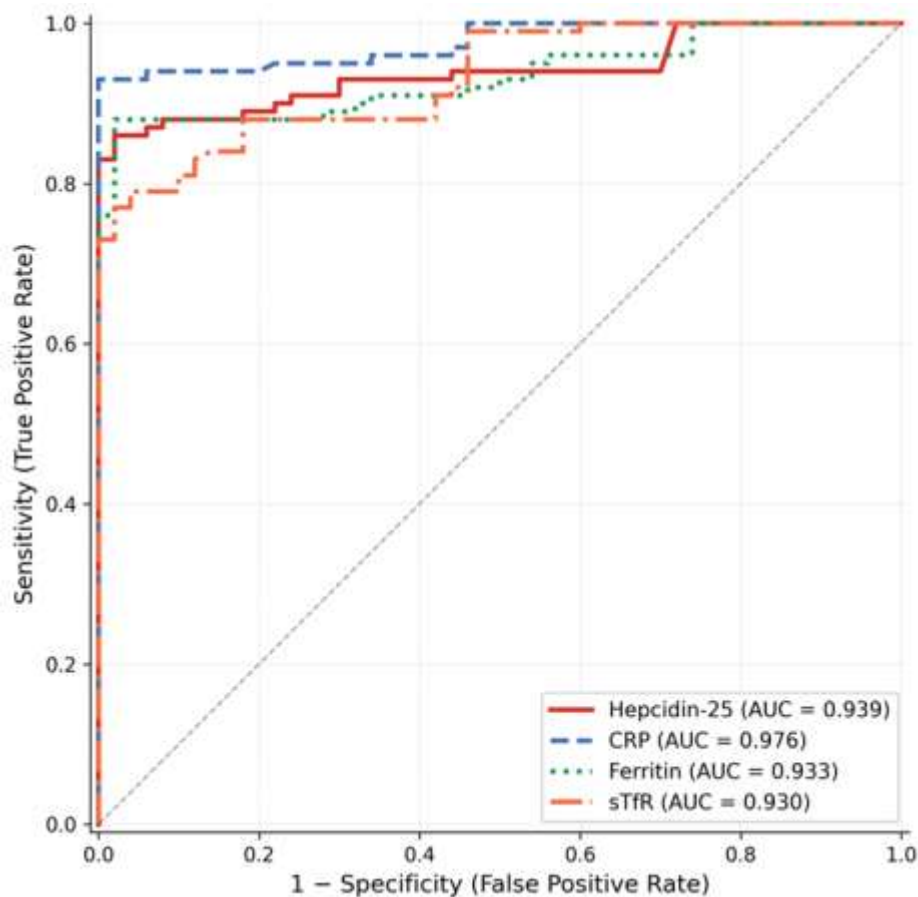


**Figure 4.** Receiver operating characteristic (ROC) curves for hepcidin-25, CRP, ferritin, and sTfR in discriminating CKD patients ( $n = 100$ ) from healthy controls ( $n = 50$ ). The diagonal dashed line represents chance performance ( $AUC = 0.50$ ). AUC values with 95% confidence intervals are provided in the legend. All biomarkers demonstrated excellent discriminatory performance ( $AUC > 0.90$ ).

## DISCUSSION

### Hepcidin-25 Elevation and the Renal Clearance Mechanism

#### The Inflammatory Axis: CRP as the Principal Driver of Hepcidin Transcription

A strong positive correlation exists between hepcidin-25 and CRP ( $\rho = 0.861$ ,  $p < 0.001$ ). This observation from this study demonstrates that the major transcriptional stimulus for the synthesis of hepcidin in CKD is inflammation. The IL-6/JAK2/STAT3 signaling pathway activates BMP responsive elements in the hepatic promoter of hepcidin, which is continually activated in CKD by a combination of multiple factors, including activation of immune cells by uremic toxins, dysbiosis of the gastrointestinal tract, metabolic acidosis, and dysregulation of adipokines(19,20). CRP is a reliable surrogate biomarker of the biological activity of IL-6(21). Therefore, CRP in the present study strongly correlated with hepcidin-25, demonstrating the

primary role of inflammation in maintaining hyperhepcidinemia in patients with CKD, regardless of their degree of renal failure.

This result could have an effect on how we use therapies in a clinical setting. Current approaches to treating chronic kidney disease - anaemia focus primarily on treating the issue of erythropoietin not being produced enough or giving people iron supplements; however, they do not look at the underlying problem of too much hepcidin in the body due to inflammation(22,23). Since we have demonstrated a strong relationship between hepcidin and CRP, this gives scientists a reason to continue research into developing anti-inflammatory treatments (such as pentoxifylline, tocilizumab or other hepcidin-based treatments) that can be used together with ESAs to help CKD patients with persistent anaemia(17,24).

### **Iron Metabolism Profile: Functional Iron Deficiency in CKD**

In this group of patients, the results of the iron metabolic profile are typical of the functional iron deficiency model(25,26). As chronic kidney disease advanced, the ferritin level increased steadily (ranging from  $50.33 \pm 29.97$  ng/ml in the normal population to  $390.15 \pm 133.31$  ng/ml in stage V), while serum iron ( $88.08 - 41.05$  µg/dL), total iron binding capacity (TIBC;  $318.50 - 184.22$  µg/dL), and transferrin saturation (TSAT;  $27.70 - 10.52\%$ ) decreased. This relationship — where high iron stores coexist with low amounts of circulating iron — is the physiologic hallmark of hepcidin-induced blockade of ferroportins which prevents the recycling of iron via macrophages and iron absorption via enterocytes despite large stores of iron within the reticuloendothelial system(27,28). The negative correlation between hepcidin-25 and TIBC ( $\rho = -0.635$ ,  $p < 0.001$ ) further illustrates this: when hepcidin inhibits iron release from storage, more iron will bind to transferrin and TIBC will rise.

The correlation between hepcidin-25 and soluble transferrin receptor (sTfR) was positive ( $\rho=0.540$ ,  $p<0.001$ ), which may help explain the mechanism of hepcidin action. Erythroid precursor cells produce sTfR as they develop(29). When iron is limited, these precursors release sTfR into circulation as evidence of the bone marrow requesting more iron than it can get(30). In the current study cohort, sTfR concentrations increased with increasing chronic kidney disease (CKD) stage, indicating that the erythroid precursors are becoming more iron-deprived with each stage of CKD progression, despite an increase in ferritin stores. This supports the hypothesis that the effects of hepcidin are mediated through the blockage of ferroportin. These

findings add to the utility of measuring both ferritin and sTfR together as part of an evaluation for anaemia related to CKD.

### **Diagnostic Utility of Hepcidin-25**

According to the ROC analysis, hepcidin-25 has an AUC of 0.939 for differentiating CKD patients from normal controls with excellent diagnostic accuracy via conventional criteria. A hepcidin-25 concentration of 18.01 ng/mL serves as the optimal threshold whereby any hepcidin-25 level above this value is highly unlikely to be found in healthy subjects and warrants clinical evaluation for renal iron dysregulation. Additionally, at this threshold, the PPV of 97.7% is highly significant for clinical practice; this indicates that up to 97.7% of CKD patients with a positive test at this threshold will be identified as having hepcidin dysregulation due to their CKD status.

The AUC for CRP was found to be 0.975 in one study, demonstrating robust diagnostic performance(31); however, due to its mechanism of action being that of an acute-phase, non-specific reactant, this biomarker can be raised from many different disease states, including infection and cancer, autoimmunity, among many others(32). On the other hand, hepcidin-25 has a true mechanistic relationship to iron metabolic disordering in CKD patients and thus provides information about levels of impairment with ferropotin-mediated release of stored iron which is not provided by CRP. This suggests that hepcidin-25's best use clinically would not be as an independent diagnostic marker for CKD but more so as a biomarker used to monitor and determine functional iron deficiency in patients who may be at risk of hyporesponsiveness to ESAs.

### **Implications for Clinical Practice and Future Research**

The outcomes of this research have multiple conclusions for the management of chronic kidney disease in the context of Iraqi health care and beyond. First, the measurement of serum hepcidin-25 routinely in combination with conventional iron markers could enhance the identification of patients experiencing functional iron deficiency, but who will not likely respond to conventional oral or intravenous iron supplementation. This would allow for more directed therapeutic interventions. Second, given the strong correlation between hepcidin-25 and C reactive protein (CRP), monitoring changes in CRP levels may provide a useful alternative to assist in assessing hepcidin activity in places that do not have direct assays for hepcidin activity.

It is important to consider the limitations of our study. First, this investigation was conducted as a cross-sectional study and therefore cannot determine the causal directionality of the increase in hepcidin-25 and the changes in the iron metabolism that were observed. Second, the study did not genotype for variants of hemojuvelin or TMPRSS6, which are known to modulate the transcription of hepcidin(33,34), thus creating methodological limitations to the study. Third, our cohort of patients was recruited from a single tertiary centre and additional studies will be needed to further assess whether our findings can be generalised to the primary care and rural CKD populations in Iraq. If longitudinal studies can be conducted using repeated hepcidin-25 measurements in conjunction with licexofied studies of ESA responsiveness, this will help to enhance the understanding of the clinical use of hepcidin-25 in this population.

## CONCLUSION

Data from this cross-sectional, case-control study provide compelling evidence that hepcidin-25 represents a biologic and clinically relevant biomarker of iron dysregulation at all stages of chronic kidney disease (CKD). In comparison to healthy subjects, hepcidin-25 concentrations are significantly increased in CKD patients relative to healthy subjects; furthermore, hepcidin-25 concentrations continue to have a monotonic, stage-dependent increase from Stage 1 through 5. In other words, hepcidin-25 concentration gradually increases in CKD patients as they progress through each stage of CKD and exhibits statistically significant inter-group differences at Stage 2; therefore, hepcidin-25 levels provide clinically important information that patients develop pathological accumulation of hepcidin-25 and its downstream effects on iron homeostasis well before reaching ESKD.

The accumulation of hepcidin-25 in chronic kidney disease (CKD) has two mechanistic bases: one being the impaired clearance of peptides by the renal system, which is illustrated by an inverse correlation with eGFR (-0.756) and an increase in transcriptional upregulation resulting from inflammation, evidenced by a linear correlation with CRP (0.861). We have demonstrated this dual mechanism with data obtained from this cohort. Additionally, the concurrent rise in ferritin with decreasing serum concentrations of iron, transferrin-bound iron, transferrin saturation, and the corresponding rise in soluble transferrin receptor (sTfR) all support that hepcidin mediates functional iron deficiency by rendering iron unavailable for erythropoietic function despite the presence of reticuloendothelial stores. This same pattern was consistently



observed throughout all stages of CKD within this cohort; therefore, ferritin alone is not a valid indicator of the need for iron replacement therapy within this population.

From a diagnostic point of view, hepcidin-25 was found to be very good for distinguishing between patients with CKD and healthy control subjects (AUC = 0.939), while maintaining high specificity (98.0%) at an optimal threshold of 18.01 ng/mL. Although CRP was the AUC winner in this study, its lack of specificity limits its ability to clarify the pathophysiology of iron dysregulation. Hepcidin-25 provides specific, functional information regarding the ferroportin-mediated pathway for iron export, which traditional acute-phase reactants cannot provide. The specificity (PPV 97.7%) of hepcidin-25 indicates that a level  $\geq 18$  ng/mL can be used to indicate CKD-related disruption of the iron axis, and may be useful for stratifying patients by risk for ESA hyporesponsiveness prior to initiating or increasing dosages of erythropoiesis-stimulating agents.

Overall, these study results suggest that hepcidin-25 can be used in addition to ferritin, TSAT, and sTfR as part of a routine assessment for the diagnosis of anaemia associated with CKD, rather than as a substitute for these other tests. Furthermore, the strong, independent association between hepcidin-25 and CRP serves to strengthen the rationale for targeting the inflammatory pathway as an adjunctive treatment strategy for patients with CKD-associated anaemia resistant to erythropoietin therapy. Larger longitudinal studies of these patients will be needed to determine both the predictive value and treatment implications of the associations identified in this study using sequentially collected hepcidin-25, with erythropoietic response data and possible genetic factors related to hepcidin regulation.

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## THE IMPORTANCE OF ORIGINAL PROBLEM-SOLVING SKILLS IN FAMILY MEDICINE: LEUKEMIA AT A YOUNG AGE

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### ABSTRACT

Family Medicine is an academic and scientific discipline, with its own educational content, research, evidence base and clinical activity, and a clinical specialty orientated to primary care. WONCA, the World Organization of National Colleges, Academies, and Academic Associations of General Practitioners/Family Physicians, short the World Organization of Family Doctors, through its various committees and working groups is trying to improve the quality of primary care throughout the world. The Family Medicine Tree published by WONCA defines the competencies of the discipline. Under the heading "Specific problem-solving skills," it addresses topics such as assessment of non-specific symptoms, differential diagnosis, early referral, and clinical prediction and experience. Chronic Lymphocytic Leukemia (CLL); is characterized by an increase of mature neoplastic B lymphocytes in peripheral blood, bone marrow and lymphoid tissues. Symptoms: Weight loss, fever, night sweats, anemia, bleeding, frequent infections. Typical features; Malignant proliferation of mature B lymphocytes, most common adult leukemia, mean diagnosis age: between 65–70, more common in males, rare in young patients. Case Report: The patient, identified as Z.Ö., aged 46, presented to the family medicine clinic on August 25, 2025, with complaints of fatigue, malaise, and weight loss. Other systems examinations were unremarkable. Laboratory test results were evaluated as "Hgb: 6.4 g/dL, WBC:  $89.3 \times 10^3/\mu\text{L}$ ". Referred to the hematology department due to suspected cancer. Following further investigations at the hematology clinic, the patient was diagnosed with CLL and treatment was initiated. Chronic lymphocytic leukemia is generally a disease of old age, but it can also occur at younger ages. The possibility of malignancy should be kept in mind in young patients presenting with non-specific symptoms such as fatigue and weight loss. This study aims to highlight the clinical significance of maintaining a high index of suspicion for malignancy in young patients presenting with non-specific symptoms, including fatigue and weight loss.

**Keywords:** Chronic lymphocytic leukemia (CLL), fatigue, cancer, family physician

## **BETWEEN CITY AND COUNTRYSIDE: LAND USE CHANGE IN THE SUBURBAN ZONE – A CASE STUDY FROM POLAND**

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### **ABSTRACT**

This study aimed to analyse changes in spatial development in Poznań County. Such an analysis makes it possible to assess development trends, land use transformations, and the effectiveness of the spatial planning policy implemented in the area.

The municipalities of Poznań County were selected as the study area. To identify differences between urban and rural areas, the municipalities were divided into towns and the rural parts of urban–rural municipalities. Ultimately, the study included 11 towns (including the city of Poznań) and 15 rural areas. The analysis covered the period from 2014 to 2023. This time frame was determined by the availability of data from the Topographic Objects Database (BDOT) while also providing an opportunity to identify changes over time. The research methodology was based on descriptive statistical measures, which enabled the identification and assessment of temporal changes. Particular attention was paid to changes in the spatial development structure, with a special focus on built-up areas.

The analysed areas exhibited considerable variation in terms of spatial development. The suburbanisation process significantly influenced changes in the built-up areas of the suburban areas, with a stronger impact observed in rural areas. Population migration to areas surrounding the city of Poznań contributed to changes in the structure of residential, commercial, educational, and cultural development. For example, in 2023, compared with 2014, the area of residential land in rural areas increased by an average of 36%, whereas the increase recorded in towns was more than twice as small. Clear differences were also observed in educational development. In rural areas, the land occupied by educational facilities increased by an average of 3% of the total built-up area, while changes in towns were negligible.

**Keywords:** land use, small town, spatial development, suburbanization.

## PSYCHOMETRIC PROPERTIES OF THE TURKISH VERSION OF THE SEXUAL COMMUNICATION SCALE

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### ABSTRACT

This study aimed to adapt the Sexual Communication Scale to Turkish and to evaluate its validity and reliability.

A methodological design was employed in this study, conducted between September and December 2024, involving 241 participants. Data collection instruments included a demographic information form and the Sexual Communication Scale. Construct validity was examined through confirmatory factor analysis (CFA), and reliability

Reability was assessed via internal consistency measures. Confirmatory factor analysis revealed that the Turkish version of the Sexual Communication Scale has a three-factor structure. Item loadings ranged from .57 to .92. The model showed acceptable to good fit:  $\chi^2/df = 2.53$ ; RMSEA = .073; SRMR = .041; CFI = .96. Internal consistency was strong, with Cronbach's alpha coefficients of .84 for the 'ease of personal contact' factor, .78 for the 'ease of mate contact' factor, and .91 for the 'frequency of bidirectional contact' factor.

This study was conducted without the support of any public, commercial, or charitable funding body. Accordingly, the Turkish version of the Sexual Communication Scale demonstrated validity and reliability.

**Keywords:** sexuality, communication, attitude, validity, reliability

## PSYCHOLOGICAL PRESSURES CAUSING SCHOOL DROPOUT AMONG FEMALE SECONDARY SCHOOL STUDENTS IN LIGHT OF SDG 4 (QUALITY EDUCATION)

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### ABSTRACT

The current research aims to identify the pressures causing school dropout among high school female students through testing the following hypothesis: Recognizing the level of pressures leading to psychological dropout among high school students. To achieve the research objectives and its hypothesis, the descriptive approach was chosen. The current research population consists of female students in the advanced school located in Hillah, which is affiliated with the General Directorate of Education in Babylon for the academic year (2025-2024), with a total of (697) students. A pressure scale was used to collect data and was applied to a sample of 400 students. The data was processed using several statistical methods, and the results showed that there were pressures among the sample members. After applying the scale and extracting the results, the study concluded with several recommendations and proposals.

**Keywords:** Pressures; School dropout; Female Students; SDG4; Education

### INTRODUCTION

Interest in the concept of Stress began as early as the seventeenth century. Murray and Kluckhohn clarified that stress represents the influential or fundamental determinants of behavior within an environment. They defined it as a characteristic of an environmental or personal object that either facilitates or hinders an individual's efforts to achieve a desired goal. Furthermore, stress is linked to individuals or objects directly related to an individual's attempts to satisfy their needs; thus, "object stress" is the force inherent in an object that affects a person's well-being in one way or another [1].

Similarly, McGrath views stress as an individual's perception of their inability to produce an appropriate response to a situation or task. This perception is accompanied by negative emotions such as anger, anxiety, depression, and withdrawal, in addition to physiological changes—serving as an "alarm reaction" to the pressures the individual faces. School dropout is considered one of the dangerous phenomena that has swept through Iraqi society recently. It



is not a new phenomenon; while it existed previously, it has increased significantly for several reasons. Whereas it was once prevalent in rural areas, it has now permeated urban centers. The dropout phenomenon has become a primary cause of "educational wastage," posing a heavy burden on the family, the school, and society in general. Stress is a significant factor driving students in general—and female students in particular—to drop out of school to escape the burden of these pressures. This is especially true when stressors are related to the curriculum and the difficulty of academic subjects, combined with parental pressure for academic excellence [2,3].

Psychological stress also threatens a student's personality, resulting in a reluctance to perform daily tasks normally, a perceived difficulty in achieving success or reaching previously set goals, and a fear of the future. It further leads to diminished self-confidence, depression, and various emotional problems that are difficult for the student to manage. The fundamental goal of education is to provide opportunities to develop a student's abilities in line with their potential. Educational institutions are among the most important organizations ensuring that students are equipped with knowledge, capabilities, and skills. They also work to modify and regulate behavior to prepare individuals capable of setting future goals, achieving them, and overcoming challenges. The current research problem is crystallized by answering the following question: "Does stress act as a cause for school dropout?" [4-7]

School dropout has become a widespread phenomenon driven by various educational, familial, economic, social, and psychological factors. The consequences of this phenomenon are negative and dangerous for the individual, the family, and society [8,9].

Many societies currently face the phenomenon of school dropouts, which exerts pressure on both the school and the family, extending its impact to all sectors of society. Dropping out is considered a contributing factor that pushes individuals toward acquiring incorrect behavioral habits. Adolescence is one of the most difficult stages an individual experiences. Adolescents exposed to psychological, social, and academic pressures often resort to "escape" (dropping out) as a form of protection from these stressors [10]. This is supported by the previous studies, which found that students resort to dropping out due to variables such as economic status and parental maltreatment during adolescence [11,12]. Similarly, a study by Ergun and Demer

(2017) titled "Adolescent School Dropout: Causes and Motives" indicated that school pressures and parental treatment play a major role in school dropout [13].

Hence, the significance of the current research sample—female secondary school students—is paramount. They represent one of the most vital segments of society requiring extensive attention and care. Providing this group with adequate educational, social, and psychological support is essential, as they are the future of the country and the cornerstone of its growth and development [14,15].

The importance of the current research stems from the role of the school as the ideal environment for individuals to receive education, upbringing, and vital scientific information. It helps individuals develop their skills and capabilities while contributing significantly to enhancing their mental health.

## **MATERIALS AND METHODS**

### **Psychological Stress**

In psychology, the concept of stress refers to situations in which an individual is under emotional or physical strain. If these pressures persist, the individual experiences aversion and a lack of acceptance of situations and events. This may lead to psychological and physical disturbances, commonly known as psychosomatic disorders.

Adolescence is one of the developmental stages most characterized by psychological, emotional, and mental changes; these shifts often predispose individuals to psychological stress. Stress can be defined as a state of maladjustment with the environment and the self. It involves an attempt to reduce this imbalance to avoid the accompanying emotional tension and maintain a sense of self. According to American statistics, approximately 80% of individuals suffering from psychological illnesses attribute them to stress, which negatively impacts their lives. While stress is a universal experience, it varies from person to person. Because the sources of stress are diverse, the methods individuals use to cope with them differ based on the source of the pressure and the individual's personality traits. Some individuals tend toward withdrawal and isolation, while others lean toward rebellion. Consequently, many adolescents' express rejection and anger regarding the demands placed upon them. These demands may cause such

pressure that the adolescent resorts to negative behaviors, leading to extreme exhaustion, deterioration of health, and psychological decline, often manifesting as aggression or rebellion against the self and others [16,17].

The following are the factors Influencing the Intensity of Psychological Stress:

1. Gender: Males and females are exposed to different stressors, affecting how they perceive environmental stimuli based on the nature of their distinct personal characteristics.
2. Age: Age influences sensitivity; adolescents are generally more affected by stressors than adults.
3. Individual Differences: Everyone has unique traits that influence their perspective and response to pressure. Differences in needs, values, and abilities affect how one perceives stressful situations.
4. Level of Aspiration: An individual's ambitions impact stress intensity. The higher the level of aspiration to effect social change or personal achievement, the more susceptible the individual may be to stress.

### **Types of Psychological Stress**

Psychological stress is a complex human phenomenon that impacts various biological, psychological, social, and economic spheres. These stressors include:

1. Natural Environmental Stressors: These include atmospheric pressure, extreme temperatures, overcrowded housing, and inadequate lighting, ventilation, or cooling.
2. Social Environmental Stressors: These encompass family disputes, cultural disparities, high numbers of children or dependents, generational conflict, and differing attitudes or inclinations.
3. Economic Stressors: A family's poor economic status exerts significant pressure on an individual, leading to feelings of helplessness and a sense of being different or less valued than their peers.
4. School Stressors: These represent difficulties faced by students at various educational stages, such as curriculum density, exams, disciplinary measures, school regulations, peer pressure, and overcrowded classrooms.

5. Other Stressors: These may stem from substance addiction, injuries, accidents, disabilities, chronic illnesses, or dissatisfaction with one's physical appearance.
6. Emotional Stressors: These are among the most prevalent and significant types affecting humans; some refer to them as Psychosocial Stressors. Studies confirm that failed emotional relationships, abandonment, and the inability to achieve personal hopes can lead to severe psychological pressure [18].

### **Causes of Psychological Stress**

These causes may relate to the genetic nature of certain individuals. Such factors lead to an imbalance and the depletion of energy and strength, making it difficult to function at a desired level. When we are ill, our bodies attempt to restore equilibrium; however, illness caused by damage or harm to the body leaves insufficient energy to perform required tasks.

### **External Stressors and Selye's General Adaptation Syndrome (GAS)**

The external stressors that taken into consideration in this study are: Family pressures, School-related pressures, Negative peer influence (bad companions), Economic pressures, and Pressures related to personal factors.

From another side, Selye emphasizes that stress is a critical factor affecting health because it weakens human functions. The unpleasant physical and emotional changes resulting from stress lead to a set of symptoms he termed General Adaptation Syndrome (GAS). Continuous exposure to psychological stress leads to systemic disturbances throughout the body across three distinct stages:

1. Alarm Reaction Stage: This is the initial stage where the body displays specific changes and responses upon the first exposure to a stressor. As a result, the body's resistance decreases; if the stress is sufficiently severe, it may lead to death.
2. Resistance Stage: Occurs due to continuous exposure to the stressor. Physical signs associated with the initial reaction may disappear as resistance increases, and the body appears to return to a normal state. During this stage, the organism gains the ability to adapt to the situation. However, this stage is critical for the development of "adaptation symptoms" or Psychosomatic Disorders (e.g., asthma, hypertension). These occur when

human capacity fails to resolve the situation through adaptive reactions. Continuous exposure eventually shifts the individual to the exhaustion stage.

3. **Exhaustion Stage:** Also known as the depletion stage. If exposure to various stressors continues for a long duration, the individual reaches a point where they can no longer maintain resistance. Hormonal defenses collapse, body resistance drops significantly, and various organ systems fail, leading the patient rapidly toward death.

### **Sources of Psychological Stress**

Hall and Lindzey indicated that stress sources include a lack of family influence or family loss, disasters, rejection, neglect, competition, aggression, dominance, coercion, and low self-esteem. Furthermore, Margaret Lloyd emphasizes that daily life events—such as exams, quarrels, and crises—serve as stressors. An individual's perception of these as threats leads to psychological, physical, or behavioral responses, which may be positive or negative.

Sources are categorized as follows:

1. **Positive Psychological Stress (Eustress):** These are stressors where the individual seeks out beneficial aspects that serve as motivation toward work and achievement. This type of stress is not negative if handled constructively; it helps enhance productivity, creativity, vitality, optimism, and mental alertness.
2. **Negative Stress (Distress):** These are events that lead to feelings of misery, frustration, and unhappiness, causing psychological imbalance.
3. **The Role of Perception:** Both positive and negative stress induce tension. The impact depends entirely on the individual's coping style and their evaluation of the stressor as either a beneficial challenge or a harmful disturbance [8].

### **Consequences of Psychological Stress**

Psychological research indicates that stress results in both physiological and psychological consequences, which can be clarified as follows:

## **Physiological Effects**

Physiological effects associated with stress manifest as chronic digestive disorders, respiratory issues, hypertension, headaches, and the spread of skin diseases. It is also linked to goiter (thyroid enlargement), diabetes, muscle spasms, rheumatoid arthritis, and eating disorders—such as anorexia, bulimia, or obesity—as well as a tendency toward nausea and vomiting, heart attacks, stomach ulcers, and elevated cholesterol levels.

Psychological research consistently indicates that stress results in a lack of clarity in individual perception and a distorted self-conception. Stressed individuals often suffer from poor memory, distractibility, and difficulty concentrating. They become more susceptible to psychological, mental, and physical illnesses. Furthermore, recurrent severe stress leads to anger, fear, sadness, feelings of depression, shame, and jealousy.

Psychological stress can also lead to developmental disturbances and a lack of self-confidence. Generally, stress is associated with impaired performance, auditory confusion, hyperactivity, self-loathing, a weak ego, identity crises, a tendency toward alienation, frequent somatic complaints, and excessive lethargy.

## **Cognitive Behavioral Theory (CBT)**

Cognitive Behavioral Theory is attributed to Aaron Beck, an American psychologist born in 1921. CBT is considered one of the most modern schools in psychology and psychotherapy. Significant interest in this field emerged in the latter half of the 20th century following the discovery of the role ideas play in directing human behavior and influencing well-being.

CBT integrates psychological and mental life, considering the thoughts individuals hold, their attitudes toward their surroundings, and their emotional responses. It has proven its merit over years of diagnosing and treating various psychological and behavioral disorders. The theory posits that psychological illnesses, stress, and negative emotions result from conscious processes caused by faulty learning and distorted reasoning based on incorrect or insufficient information. This leads to difficulty distinguishing between fantasy and reality.

Beck argues that psychological problems stem primarily from individuals distorting and falsifying reality based on faulty learning during developmental stages. CBT focuses on the

cognitive domain to modify behavior and psychological adjustment specifically, and social adjustment generally [19-22].

### **The Three-Dimensional View**

CBT is because every individual holds thought, expectations, and assumptions about themselves, others, and the world. This direct behavior and determines emotions. Problems arise when these assumptions are negative or erroneous. CBT adopts a comprehensive "three-dimensional" view that combines the cognitive, affective, and behavioral domains, which are in constant interaction.

From this perspective, emotions are linked to the way individuals think and interpret situations. The situation itself does not determine how one feels; rather, the emotional response is determined by the perception of the situation. Beck described this through Cognitive Schemas. Maladaptive schemas are those that individuals impose as "truths" about themselves and their world; they resist change and cause life difficulties, such as job loss [6,7].

### **Automatic Thoughts and Core Beliefs**

Beck believes some thoughts are absolute, extreme, and unrealistic. When individuals live by these rigid principles, they encounter distress. He highlighted Automatic Thoughts—reflexive responses that appear reasonable to the individual but emerge spontaneously without intent. While difficult to detect initially, a counselor can infer them through accompanying feelings and behaviors [22].

Beck identifies a hierarchy of cognition:

1. Core Beliefs: Fundamental, deep-rooted, and stable ideas about self and the world (e.g., "I am incompetent").
2. Intermediate Beliefs: Attitudes, rules, and assumptions that bridge core beliefs and automatic thoughts.
3. Automatic Thoughts: Situational thoughts that result in specific emotions and behaviors, often accompanied by unhealthy physiological responses [21].

In fact, the objectives of Cognitive Behavioral Theory are: Perceiving Connections: To understand the relationship between feelings, thoughts, and behavior, to train individuals to identify and evaluate maladaptive thoughts and fantasies that cause stress, to help individuals change latent, dysfunctional schemas, to replace negative, stressful thoughts with realistic, logical beliefs that facilitate emotional and behavioral control [14,15].

### **Foundations and Basic Assumptions**

Beck categorizes stress into three domains:

- Affective Domain: Feelings and emotions the individual finds difficult to understand or encode.
- Cognitive Domain: Weakness in concentration and thought organization.
- Social Domain: Traumatic or negative social situations encountered by the individual.

### **Key Assumptions of Cognitive Counseling:**

- There is a reciprocal relationship between thoughts, feelings, and behavior.
- Cognitive structures (images, expectations) are closely related to dysfunctional behaviors.
- Cognitive distortions reflect unrealistic, negative views of the self, the world, and the future.
- Changing negative beliefs leads to fundamental changes in emotions.
- Counseling focuses on the present and specific anxiety-provoking situations.
- CBT is an intensive, time-limited intervention [23,24].

### **Beck's Counseling Process**

Cognitive Behavioral Theory (CBT) is founded on the principle of collaborative empiricism between the counselor (or therapist) and the individual. This collaboration is a fundamental component of successful treatment; ambiguity or confusion in defining counseling goals frustrates the counselor and exerts additional pressure on the individual. Therefore, establishing a shared understanding of the relationship is essential [23].



## **School Dropout**

School dropout refers to a student's reluctance to complete their education at any point during the academic year. This phenomenon stems from various factors that lead students to reject the idea of continuing their schooling. The motives driving students toward dropout are diverse, especially amidst rapid technological advancement and open communication, which have become primary interests for students and occupy most of their time. These influences often lead to the acquisition of new, socially unacceptable behaviors within the educational environment.

Furthermore, educational staff at various levels face significant challenges in managing these behaviors, as they are dealing with a difficult, hesitant, and sensitive age group that requires containment and support rather than mere direction and criticism.

## **Types of School Dropout**

1. Total Dropout: Refers to the student's complete severance from school and a total refusal to return to their studies.
2. Partial Dropout: Characterized by frequent absenteeism or "skipping" school followed by a return during the same academic year or the following one. In this case, the student's commitment to attendance is intermittent throughout the year.

## **Manifestations of School Dropout**

- Difficulty waking up in the morning.
  - Mental distraction and daydreaming.
  - Poor relationship between the student and the school administration or teaching staff.
  - Lack of positive or close social bonds with peers.
  - Family maladjustment.
  - Association with negative peers combined with other external stimuli. The following are the factors Driving School Dropout
1. Family Factors: The family is often the primary factor. While a stable home fosters a desire for learning, frequent conflicts, large family size, and parental discrimination

between siblings create a gap. This may drive the student to drop out as a form of "retaliatory punishment" against the parents [25].

2. Social Factors: Social background plays a prominent role. If one or both parents have previously dropped out, it serves as a discouraging precedent for the children.
3. Economic Factors: Poor economic conditions are a major cause, as the family may be unable to meet educational requirements. This often leads female students to remain at home and male students to enter the labor market prematurely.
4. School and Environmental Factors:
  - The Teacher: A teacher's harsh or friendly treatment, the method of instruction, excessive homework, frequent exams, and strict grading can either limit or exacerbate dropout rates.
  - Curriculum: The intensity and difficulty of the subject matter.
  - Administration: The management style used by the school leadership.
  - Teaching Methods: Lack of modern educational tools and reliance on outdated, repetitive methods.

### **Characteristics of At-Risk Students**

Students prone to dropping out often exhibit specific mental, psychological, or social traits. Identifying these early is crucial for intervention:

- Forced Dropouts: Individuals who face crises, disasters, chronic illnesses, or severe social/family problems.
- Low Cognitive Ability: Students with learning difficulties or attention deficits who feel incapable of keeping up with their peers.
- High Cognitive Ability: Interestingly, highly gifted students may drop out due to extreme boredom and lack of challenge in a repetitive curriculum.
- Behavioral Disorders: Students characterized by socially unacceptable habits, such as bullying, aggression, or emotional disturbances, which negatively affect themselves and their classroom environment.

## **RESULTS AND DISCUSSION**

### **Results**

To achieve the research objectives, the researcher employed the Descriptive Research Method, which aims to identify, describe, and accurately document the phenomenon as it exists in reality [26,27].

### **Research Procedures**

The current research population is defined as middle and high school students at the Al-Hilla Secondary School for Gifted Girls in Hilla, the center of the Babylon Governorate, for the academic year (2023–2024). The total population consists of (796) students.

A sample is defined as a set of individuals drawn from the original population according to specific rules to ensure it represents the population accurately and truthfully. Nunnally (1987) emphasizes that the ratio of sample members to the number of scale items should not be less than (1:5) to reduce the margin of chance error during statistical analysis [28]. Application Sample (Main Research Sample): The research sample was selected using the random sampling method, consisting of (400) students.

### **Research Instrument**

Developing a research instrument requires ensuring Validity, Reliability, and Discrimination. The instrument serves as an objective and standardized method to measure a variable within the research sample. Choosing the right tool is vital for accurately identifying the trait or characteristic to be measured [2]. The steps for developing the instrument are as follows:

### **Psychological Stress Scale**

After reviewing numerous Arabic and foreign studies related to the research topic and objectives, and finding no suitable measurement tool that aligns with the current sample or the nature of the local environment, the researcher constructed a scale to measure psychological stress based on Aaron Beck's Theory [19-22].

Beck defines psychological stress as a response resulting from exposure to a situation that pressures an individual's self-esteem. He posits that an individual views the problems they face as unsolvable, leading to frustration, loss of equilibrium, and thoughts of helplessness, despair, and depression.

The scale consists of (20) items divided into three domains:

1. The Affective (Emotional) Domain: Refers to a set of emotional responses and mixed feelings, including guilt, anger, fear, low self-confidence, and a lack of self-actualization.
2. The Cognitive Domain: Refers to a diminished ability to concentrate, organize thoughts, and plan for the future.
3. The Social Domain: Refers to certain behaviors adopted by the individual, such as a lack of interest in social activities and isolation from others.

Response Mechanism: A three-point Likert scale was used: (Applies to me greatly, Applies to me often, never applies to me).

### **Validity of the Items (Face Validity)**

To verify the validity of the items and the suitability of the response alternatives, the 20-item scale was presented to a panel of (10) experts specialized in psychological counseling, educational guidance, measurement and evaluation, and psychology. Based on their feedback, all items were deemed valid; some were linguistically modified. An agreement rate of 80% or higher was adopted as the criterion for item validity.

### **Pilot Study**

The scale was administered to a pilot sample of (50) students selected randomly to:

- Ensure the instructions, items, and response alternatives are clear.
- Identify any difficulties students might face while responding.
- Determine the average time required to complete the scale.
- Verify the existence of psychological stress among middle and high school students.

## Statistical Analysis

For statistical analysis, the scale constructed according to Beck's theory was applied to a sample of (400) students from middle and high school levels, chosen randomly from the Al-Hilla Secondary School for Gifted Girls.

**Table 1:** Distribution of the Statistical Analysis Sample by Educational Level and Grade

| No. | Grade Level                  | Creativity | Excellence | Innovation | Superiority | Sample Size |
|-----|------------------------------|------------|------------|------------|-------------|-------------|
| 1   | 1st Intermediate (7th Grade) | 20         | 20         | 20         | 9           | 69          |
| 2   | 2nd Intermediate (8th Grade) | 20         | 25         | 20         | 20          | 85          |
| 3   | 3rd Intermediate (9th Grade) | 20         | 23         | 22         | 20          | 85          |
| 4   | 4th Preparatory (Scientific) | 15         | 15         | 15         | 15          | 60          |
| 5   | 5th Preparatory (Scientific) | 13         | 17         | 17         | 14          | 61          |
| 6   | 6th Preparatory (Scientific) | 11         | 11         | 10         | 8           | 40          |
|     | <b>Total</b>                 | 99         | 111        | 104        | 86          | 400         |

## Calculating Item Discrimination

Item discrimination refers to the ability of a specific item to distinguish between individuals who score high and those who score low on the trait being measured. The primary goal of calculating discrimination power is to provide information about individual differences in how participants respond to the scale. High discrimination indicates the item's effectiveness in distinguishing high-performing respondents from low-performing ones [29].

To calculate the discrimination power, the Extreme Groups Method was employed using the sample of (400) students.

The total scores were ranked in descending order. The top 27% (High Group) and bottom 27% (Low Group) were selected, with each group consisting of (108) students. The Independent Samples T-test was used to test the differences between the high and low groups for each item. All items were found to be discriminative, as their calculated t-values exceeded the critical t-value of (1.96) at a significance level of (0.05) with (214) degrees of freedom.

**Table 2:** Item Discrimination for the Stress Scale (Extreme Groups Method)

| Item No. | High Mean Group | High SD Group | Low Mean Group | Low SD Group | Calculated Value* | T- |
|----------|-----------------|---------------|----------------|--------------|-------------------|----|
| 1        | 2.6294          | 0.64984       | 2.1296         | 0.71162      | 5.392             |    |
| 2        | 2.6574          | 0.62893       | 2.1296         | 0.72463      | 5.716             |    |
| 3        | 2.7685          | 0.48542       | 2.0278         | 0.74204      | 8.682             |    |
| 4        | 2.8148          | 0.41351       | 2.1667         | 0.71695      | 8.138             |    |
| 5        | 2.8056          | 0.42047       | 1.9537         | 0.72839      | 10.526            |    |
| 6        | 2.6852          | 0.57434       | 2.0648         | 0.71399      | 7.036             |    |
| 7        | 2.6389          | 0.63332       | 2.0093         | 0.72981      | 6.772             |    |
| 8        | 2.6574          | 0.65798       | 2.1019         | 0.68276      | 6.089             |    |
| 9        | 2.7407          | 0.58598       | 2.0278         | 0.70324      | 8.094             |    |
| 10       | 2.6852          | 0.63611       | 2.0648         | 0.72696      | 6.674             |    |
| 11       | 2.6852          | 0.63611       | 1.8611         | 0.67614      | 9.225             |    |
| 12       | 2.5556          | 0.74046       | 1.8519         | 0.73389      | 7.015             |    |
| 13       | 2.7037          | 0.63037       | 1.8981         | 0.70961      | 8.820             |    |
| 14       | 2.7593          | 0.56155       | 2.0556         | 0.69489      | 8.186             |    |
| 15       | 2.8333          | 0.42139       | 1.9167         | 0.65745      | 12.199            |    |
| 16       | 2.8796          | 0.37981       | 1.8148         | 0.67184      | 14.338            |    |
| 17       | 2.7685          | 0.55714       | 1.8611         | 0.77891      | 9.847             |    |
| 18       | 2.8889          | 0.31573       | 1.8241         | 0.73407      | 13.848            |    |
| 19       | 2.8796          | 0.35435       | 1.7685         | 0.69183      | 14.855            |    |
| 20       | 2.8981          | 0.30386       | 2.0556         | 0.70821      | 11.363            |    |

#### Internal Consistency (Item-Total Correlation)

This method is widely used in item analysis for psychological scales due to its high capability in determining the homogeneity of items in measuring a behavioral phenomenon [30].

To calculate the correlation coefficient between individual item scores and the total score, the Pearson Correlation Coefficient was used. The researcher utilized the same analysis sample (400 students) [29]. All items were statistically significant at the (0.05) level with (398) degrees of freedom, as every item exceeded the required correlation value of (0.098).

**Table 3:** Correlation Coefficients between Item Scores and the Total Scale Score

| Item No. | Correlation | Item No. | Correlation | Item No. | Correlation | Item No. | Correlation |
|----------|-------------|----------|-------------|----------|-------------|----------|-------------|
| 1        | 0.434       | 6        | 0.357       | 11       | 0.416       | 16       | 0.471       |
| 2        | 0.307       | 7        | 0.370       | 12       | 0.436       | 17       | 0.460       |
| 3        | 0.448       | 8        | 0.366       | 13       | 0.402       | 18       | 0.461       |
| 4        | 0.388       | 9        | 0.468       | 14       | 0.458       | 19       | 0.489       |
| 5        | 0.483       | 10       | 0.411       | 15       | 0.429       | 20       | 0.451       |

### Item-Domain Correlation

The Stress Scale consists of three main domains. To ensure that the items in each domain accurately represent the domain they belong to, Pearson Correlation was calculated between each item and the total score of its specific domain. All correlation coefficients were statistically significant compared to the table value of (0.098).

**Table 4:** Correlation Coefficients between Items and their Respective Domain Total

| Domain No. | Domain Name           | Item No.            | Correlation with Domain Total                   |
|------------|-----------------------|---------------------|-------------------------------------------------|
| 1          | Affective / Emotional | 1, 2, 3, 4, 5, 6, 7 | 0.579, 0.571, 0.568, 0.628, 0.589, 0.550, 0.621 |
| 2          | Cognitive             | 1, 2, 3, 4, 5, 6, 7 | 0.591, 0.591, 0.544, 0.539, 0.585, 0.578, 0.556 |
| 3          | Social                | 1, 2, 3, 4, 5, 6    | 0.523, 0.552, 0.597, 0.604, 0.650, 0.589        |

### Inter-Domain Correlation Matrix

An internal correlation matrix was extracted to determine the relationship between the domains themselves and the total scale score using Pearson Correlation. All correlations—whether between domains or between domains and the total score—were positive and significant, indicating strong Construct Validity.

**Table 5:** Correlation Matrix of the Stress Scale Domains

| Domains               | Total Stress | Affective | Social | Cognitive |
|-----------------------|--------------|-----------|--------|-----------|
| Total Stress          | 1            |           |        |           |
| Affective / Emotional | 0.529        | 1         |        |           |
| Social                | 0.644        | 0.323     | 1      |           |
| Cognitive             | 0.530        | 0.325     | 0.434  | 1         |

### Psychometric Properties of the Stress Scale

Validity refers to the scale's ability to measure what it was designed to measure. It concerns the extent to which the tool succeeds in its specific measurement task; thus, validity determines the value and suitability of the scale, providing information relevant to the decisions or judgments based upon it [31]. Several indicators were used to verify the scale's psychometric validity (Table 6).

The most effective way to establish face validity is through the assessment of experts and specialists regarding how well the items represent the trait being measured [12]. This was achieved by presenting the scale to (10) experts in psychological counseling, educational guidance, psychology, and measurement and evaluation. The Chi-Square (3.84) value was calculated to determine the degree of agreement.

**Table 6: Results of Face Validity for the Stress Scale Domains**

| Stress Domains | Scale Item Numbers | Total Experts | Agree | Disagree | Calc. | Tabulated | Significance (0.05) |
|----------------|--------------------|---------------|-------|----------|-------|-----------|---------------------|
| Affective      | 1, 2, 3            | 10            | 10    | 0        | 10.00 | 3.84      | Significant         |
|                | 4, 6, 7            | 10            | 9     | 1        | 11.25 | 3.84      | Significant         |
|                | 5                  | 10            | 8     | 2        | 9.00  | 3.84      | Significant         |
| Social         | 1, 2, 3, 4, 5, 6   | 10            | 10    | 0        | 10.00 | 3.84      | Significant         |
| Cognitive      | 1, 3, 5, 6         | 10            | 10    | 0        | 10.00 | 3.84      | Significant         |
|                | 2, 4, 7            | 10            | 8     | 2        | 9.00  | 3.84      | Significant         |

\*Note: Tabulated Chi-Square is 3.84 at a significance level of 0.05 and 1 degree of freedom.

Construct validity involves analyzing the scale scores based on the psychological framework of the trait or a specific psychological concept [32]. It is considered the most rigorous form of validity, confirmed when the scale reliably measures a specific theoretical construct [9].

Indicators of Construct Validity used in this study:

1. Calculation of Item Discrimination Power.
2. Item-Total Score Correlation.
3. Item-Domain Correlation.
4. Inter-Domain Correlation Matrix.

### **Scale Reliability**

Reliability refers to the consistency of scores across different administrations or the ability to measure the same phenomenon multiple times and obtain nearly identical results [33]. This involves applying the test to a group, then re-administering it to the same group after a specific time interval. The Pearson Correlation Coefficient between the two administrations was (0.81), indicating high stability over time [4].



This method measures internal consistency by calculating the correlations between all items, treating each item as a mini-scale [11]. This provides a reliable estimate of stability in most research contexts [28]. The calculated coefficient was (0.83), reflecting strong internal consistency [34].

**Statistical Indicators of the Research Sample:** The following table (Table 7) summarizes the descriptive statistics for the stress scale scores among the study sample.

**Table 7:** Descriptive Statistical Indicators of Stress Scale Scores Among the Study Sample

| Statistical Indicator | Value   |
|-----------------------|---------|
| Arithmetic Mean       | 72.4600 |
| Median                | 74.0000 |
| Mode                  | 74.00   |
| Standard Deviation    | 9.47247 |
| Skewness              | -0.162  |
| Kurtosis              | 0.046   |
| Range                 | 42.00   |
| Minimum Score         | 44.00   |
| Maximum Score         | 86.00*  |

\*Note: Corrected "60.00" to "86.00" based on standard scale range logic (if 44 is the min and 42 is the range), or please verify your raw data.

## CONCLUSION

The research results revealed that the arithmetic mean of the sample's scores on the Psychological Stress Scale was (71.6600) with a standard deviation of (13.81934). To determine the differences between the sample, mean and the hypothetical mean (neutral point) of the scale, a One-Sample T-test was employed. When comparing the arithmetic mean to the theoretical mean of (58), a statistically significant difference was found in favor of the arithmetic mean. The calculated T-value reached (6.990), which is greater than the tabulated T-value of (1.98) at a significance level of (0.05) and (399) degrees of freedom. In addition, the results indicate that students experience high levels of psychological stress. These pressures drive individuals toward negative thinking and a loss of hope, resulting in a outlook characterized by pessimism, despair, withdrawal, and isolation from society. Furthermore, high stress leads to a loss of self-confidence and mistrust of others. Stressed individuals often develop a negative self-image and feel that their future is hopeless, making them unable to cope with life's challenges.

Based on the results, the researcher proposes the following:

1. Institutional Adoption: Utilize the Stress Scale in the Ministry of Education to identify students suffering from high stress levels who are at risk of partial or total dropout.
2. Program Development: Leverage this research to design preventive and therapeutic counseling programs aimed at mitigating school dropout.
3. Capacity Building: Train educational staff and counselors on how to identify and support students facing high-stress conditions.
4. Civil Society Engagement: Activate the role of NGOs to provide material and moral support to students from low-income families or those exposed to violence.

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## A BIBLIOMETRIC ANALYSIS OF RESEARCH ON ENDURANCE IN RACKET SPORTS

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### ABSTRACT

Racket sports are divided into different disciplines (such as tennis, table tennis, badminton, squash and padel). Each of these disciplines requires different biomechanical skills and performance components. The aim of this bibliometric study is to examine studies conducted in the field of sports science between 2003 and 2025 using the keyword “Endurance in racket sports” in the Web of Science (WoS) database. A total of 90 articles relevant to the research topic in the WoS database were visualised using the ‘Analyse Results’ tab and the VOSviewer programme.

Among universities, the University of the Basque Country and the University of León each produced the highest number of publications, with three studies each. In terms of author productivity, Pedro E. Alcaraz produced the highest number of publications, with five studies. When examined by country, Australia ranked first with 21 studies, Spain second with 19 studies, and the United States third with 17 studies. When the number of studies by year is examined, the highest number—12 studies—was published in 2012. It was found that 55 (61.1%) of the 90 studies published in the WoS database using the keyword ‘Endurance in racket sports’ were published by Lippincott Williams & Wilkins. The most frequently used keywords are “racket sports”, “team sports” and “performance”. In conclusion, it is evident that endurance is one of the key components influencing performance in racket sports, and that research in this area is increasing year on year. Furthermore, it can be said that the inclusion of the term ‘athletic performance’ among the keywords in the studies conducted is significant for the performance component.

**Keywords:** Bibliometric analysis, performance sports, endurance.

## RAKET SPORLARINDA DAYANIKLILIK İLE İLGİLİ YAPILAN ARAŞTIRMALARIN BİBLİYOMETRİK ANALİZİ

### ÖZET

Raket sporları kendi içerisinde (tenis, masa tenisi, badminton, squash, padel gibi) farklı disiplinlere ayrılmaktadır. Bu disiplinlerin her biri farklı biyomotor yeti ve performans bileşeni gerektirmektedir. Mevcut bibliyometrik araştırmada spor bilimleri alanında 2003-2025 yılları arasında Web of Science (WoS) veri tabanı üzerinde “Endurance in racket sports” anahtar kelimesiyle yapılmış çalışmaların incelenmesi amaçlanmıştır. WoS veri tabanı üzerinde araştırma konusuyla ilgili 90 makale Analyze Results sekmesi ve VOSviewer programı ile görselleştirme yapılmıştır. Üniversiteler arasında en fazla yayın üçer araştırma ile University of the Basque Country ve Univ Leon üniversiteleri tarafından yapılmıştır. Yazar üretkenliği bakımından Pedro E. Alcaraz beş araştırma ile en fazla yayını yapmıştır. Ülke olarak incelendiğinde en fazla yayın 21 araştırma ile Avustralya ilk sırada, 19 araştırma ile İspanya ikinci sırada, 17 araştırma ile Amerika Birleşik Devletleri üçüncü sıradadır. Yıllara göre araştırma sayıları incelendiğinde en fazla 2012 yılında 12 araştırma yayınlanmıştır. WoS veri tabanında “Endurance in racket sports” anahtar kelimesiyle yayınlanan 90 araştırmanın 55’i (%61,1) Lippincott Williams Wilkins’te yayınlandığı bulgulanmıştır. Anahtar kelime olarak en fazla “racket sports”, “teams sport” “performance” kelimeleri kullanılmaktadır.

Sonuç olarak raket sporlarında dayanıklılık performansı etkileyen temel bileşenlerinden biri olduğu ve bu konuyla ilgili yapılan araştırmaların arttığı görülmektedir. Ayrıca yapılan çalışmalarda anahtar kelimeler içerisinde atletik performans kelimesinin de kullanılması performans bileşeni için önemli olduğu söylenebilir.

**Anahtar Kelimeler:** Bibliyometrik analiz, performans sporları, dayanıklılık.

### GİRİŞ

İnsanların sabit bir yaşam biçiminden kurtulmak istemeleri, sağlıklı bir yaşam sürdürme hedefi ve boş zamanlarını verimli bir şekilde değerlendirebilmeleri için sürekli ve planlı bir şekilde vücutlarını hareket ettirmektedir. Bireylerin bu durumuna egzersiz adı verilmektedir (Civan vd., 2018). Ayrıca Amerikalılar İçin Fiziksel Aktivite Rehberi’nin (2018) ikinci baskısında egzersizin normal büyüme ve gelişme seyrini desteklediği, insanların kendini daha iyi hissetmelerini sağladığı ve kronik hastalık risklerinin azalmasını sağlayabileceği belirtilmiştir.

Tenis dünya çapında ilgiyle takip edilen bir spor branşıdır. Dünya üzerinde binlerce insan tenisle farklı amaçlarla (rekreatif ve profesyonel olarak) ilgilenmektedir. Bu branş hem rekreatif, hem amatör hem de profesyonel düzeyde yapılabilmektedir. İnsanlar müsabakalara katılımcı veya seyirci olarak dâhil olabilmektedir. Bu durumda tenis branşının davetkar yapısını ifade etmektedir. Profesyonel olarak tenis oynayan oyuncular katıldıkları turnuvalardan puan toplamakta ve bireysel sıralamalarını yukarıya taşımaktadırlar. Bireyler tenis kariyeri boyunca çeşitli turnuvalara katılmaktadır. Bu spor branşında Uluslararası Tenis Federasyonu (ITF) tarafından, Profesyonel Tenisçiler Birliği (ATP) tarafından ve Kadınlar Tenis Birliği (WTA) tarafından düzenlenen çeşitli organizasyonlar bulunmaktadır. Bu turnuvalara elit oyuncuların katılması izleyiciler için seyir zevkini daha üst seviyelere çıkarmaktadır (Akdeniz ve Ardahan, 2020).

Dayanıklılık bireylerin fiziksel ve fizyolojik olarak yorgunluğa karşı dayanma yetisidir. Sportif bağlamda ise organizmanın uzun süreli aktiviteler esnasında yorgunluğa karşı direnç göstermesi ve yüksek şiddetli yüklenmeleri uzun süre sürdürebilir bir şekilde devam ettirebilme kapasitesi olarak tanımlanmaktadır (Sevim, 1995). Farklı bir tanıma göre dayanıklılık uzun süre yorgunluk faktörüne karşı bir işi sürdürebilme yeteneğidir. Dayanıklılık sporcunun genetik özelliklerinden, yapmış olduğu antrenman türünden ve hayat kalitesinden etkilenmektedir (Tetik, 2019).

Raket sporları kendi içerisinde farklı branşlara (badminton, tenis, masa tenisi, squash vb.) ayrılmaktadır. Bu branşların her biri farklı karakteristik özellikler gerektirmektedir. Raket sporları sporcuların kondisyon durumuna bağlı çeviklik, el göz koordinasyonunun önemli olduğu aerobik ve anaerobik enerji sistemlerinin kullanıldığı spor branşlarıdır. Bu branşlar hem elit düzeyde hem de rekreasyonel amaçlı oynanmaktadır. Sporcuların kondisyon durumları müsabakaların sonuçlarını belirlemektedir (Lees, 2003). Bireylerin tekrarlayan antrenmanlarla birlikte alt ve üst ekstremitelerinin dayanıklılığı ve çevikliği sağlanmalıdır. Kondisyonel yapıları iyi olan bireyler rakibine göre daha şanslı olmaktadır. Bu bireyler rakiplerine göre daha hızlı hareket edebilmekte, daha hızlı düşünebilmekte, oyuncular uzun süreli puanlardan sonra daha hızlı toparlanabilmekte, daha düşük düzeyde yorgunluk yaşamakta, yaralanma olasılıkları daha az olmakta ve kuvvette devamlılıkları daha iyi olmaktadır. Farklı bir ifade ile kazanmak ile kaybetme durumu arasındaki fark oyuncuların kondisyonel özelliklerine bağlı olmaktadır (Ölçücü vd., 2010). Mevcut araştırmada spor bilimleri alanında 2003-2025 yılları arasında Web of Science (WoS) veri tabanı üzerinde “Endurance in racket sports” anahtar kelimesiyle yapılmış çalışmaların incelenmesi amaçlanmıştır.

## **MATERYAL VE METOT**

Mevcut araştırma web of Science (WoS) veri tabanı üzerinde raket sporlarında dayanıklılık (Endurance in racket sports) ile ilgili yapılmış 90 makale VOSviewer programı aracılığıyla görselleştirilmiştir.

### **Verilerin Elde Edilmesi**

Mevcut araştırma, raket sporlarında dayanıklılık ile ilgili, WoS veri tabanı üzerindeki makaleler çalışmaya dâhil edilmiştir. WoS veri tabanı üzerinde, “Endurance in racket sports” anahtar kelimesi yazılarak elde edilen araştırmalar incelenmiştir. Araştırmada WoS veri tabanı üzerinde sırasıyla aşağıda belirtilen filtreleme işlemleri yapılmıştır.

### **Araştırmaya Dahil Etme Kriterleri**

Araştırmada doküman türü olarak makale seçilmiştir. Kategori olarak spor bilimleri, alıntı konuları olarak spor bilimleri ve dil olarak İngilizce seçilmiştir.

Araştırma kriterlerine uygun verilerin seçim sürecinde sistematik derlemeler ve meta-analizler için tercih edilen raporlama öğeleri (PRISMA) protokolü kullanılmıştır (Moher vd., 2009; Page vd., 2021). Endurance in racket sports anahtar kelimesiyle ilk taramada 144 makale ile başlayan araştırma uygulanan filtremeler sonucunda 90 makale araştırmaya dahil edilmiştir.

### **Araştırmaya Dahil Edilmeme Kriterleri**

Araştırmada doküman türü olarak makale dışındaki çalışmalar dahil edilmemiştir. Araştırma kategorisi olarak spor bilimleri haricindeki çalışmalar, alıntı konusu olarak spor bilimleri haricindeki alıntı konuları ve yazım dili İngilizce dışındaki araştırmalar çalışmaya dahil edilmemiştir.

### **Veri Toplama Araçları ve Verilerin Analizi**

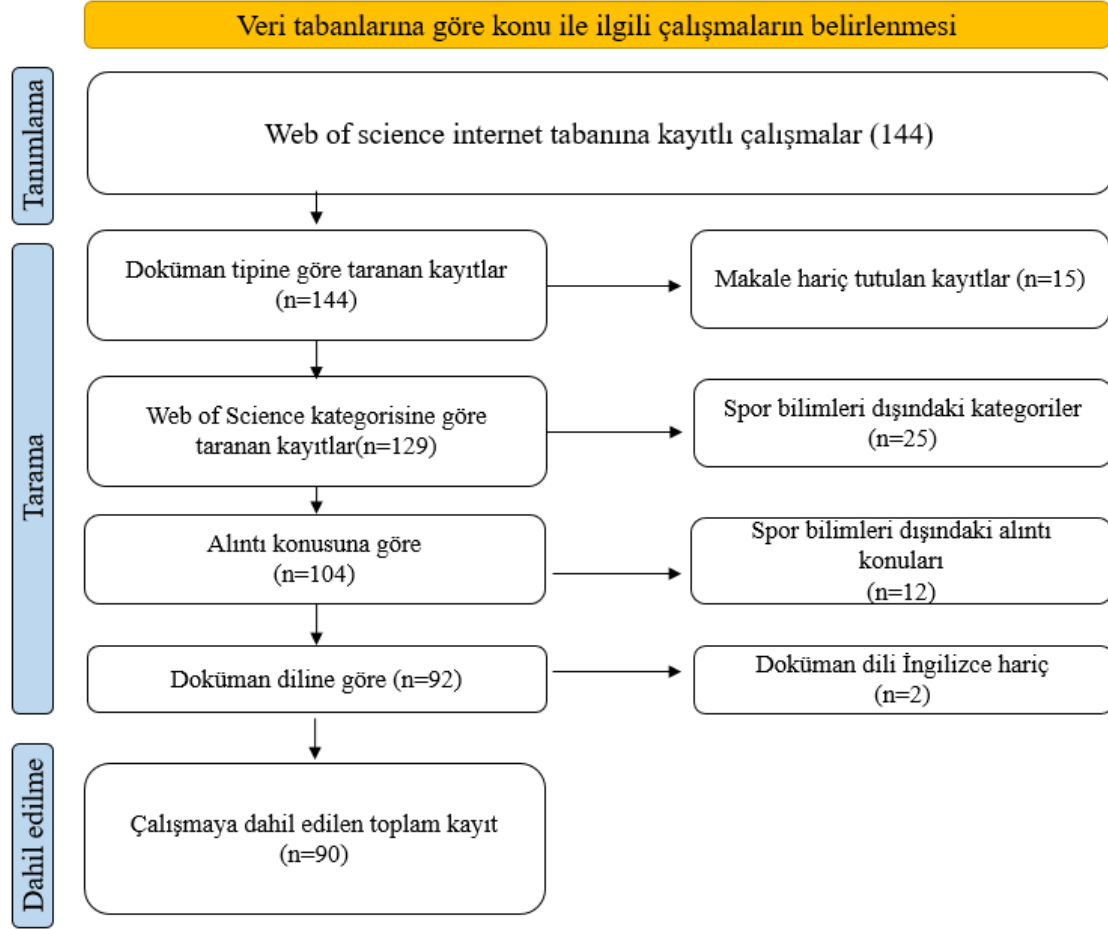
Mevcut araştırmada, elde edilen bulgular WoS veri tabanı analiz sonuçları sekmesi aracılığıyla ve VOSviewer yazılımı aracılığıyla incelenmiştir. Araştırmada, WoS veri tabanı üzerinden elde edilen araştırmaların analiz edilmesi ve değerlendirilmesi sürecinde, bibliyometrik analiz yöntemi tercih edilmiştir. Bibliyometrik analiz yöntemi bilimsel araştırmaların geçmişe yönelik bir şekilde, sayısal olarak, istatistiksel ve betimsel bir şekilde incelenmesi amacıyla kullanılmaktadır (Celestino vd., 2024; Mezquita vd., 2024). Mevcut araştırmada bibliyometrik analizlerin uygulanmasında VOSviewer programı kullanılmıştır. VOSviewer programı bibliyometrik verilerin görselleştirilmesi amacıyla kullanılmaktadır. Bu program aracılığıyla araştırmaların bibliyometrik haritaları görsel olarak hazırlanabilmektedir (Van Eck ve Waltman, 2010).

Makalelerin değerlendirilme sürecinde, WoS veri tabanı üzerinden elde edilen analiz sonuçlarından yararlanılmıştır. WoS veri tabanı analiz sonuçları sekmesinde, raket sporlarında dayanıklılık ile ilgili yayınlanan makale sayıları, yayın yapan yazarların isimleri, anahtar kelime ile ilgili ülkelerin yayın sayıları, yapılan yayınların yayınlandığı dergi isimleri elde edilmiştir. Çalışmada elde edilen verilerin görselleştirilmesi için VOSviewer programı kullanılmıştır.

VOSviewer programı aracılığıyla görsellerin oluşturulması için sırasıyla belirtilen aşamalar uygulanmıştır. Bibliyografik verilere dayalı bir harita oluşturma sekmesi, bibliyometrik veri



dosyalarından verileri okuma sekmesi, Web of Science dosya yükle sekmesi, analiz tipi ve analiz birimi sırasıyla seçilmiştir. VOSviewer programı aracılığıyla ortak yazar bağlantısı, yazarların üniversite bağlantısı, yazarların ülke bağlantısı ve anahtar kelime bağlantısı haritalandırılmıştır. WoS analiz sonuçları ve VOSviewer programı aracılığıyla elde edilen veriler araştırmanın bulgular bölümünde ayrıntılı olarak açıklanmıştır.



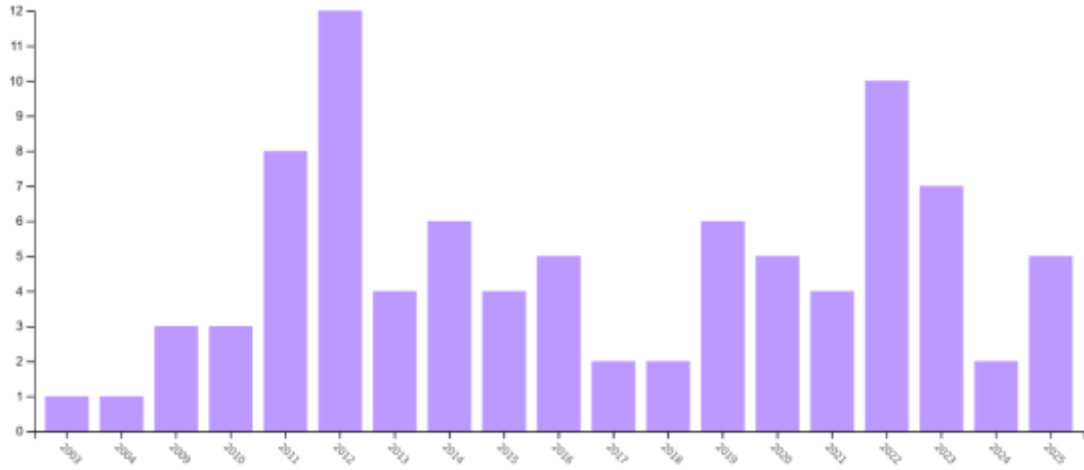
**Şekil 1.** Endurance in racket sports anahtar kelimesiyle ilgili yapılan araştırmaların PRISMA tablosu (yazar tarafından uyarlanmıştır) (Moher vd., 2009; Page vd., 2021).

## BULGULAR

Bu bölümde araştırmadan elde edilen bulgular verilmiştir. Şekil 1. Endurance in racket sports anahtar kelimesiyle ilgili yapılan araştırmaların PRISMA tablosu, Şekil 2. 2003-2025 yılları arası Endurance in racket sports ile ilgili makale sayısı, Şekil 3. 2003-2025 yılları arası Endurance in racket sports ile ilgili yayın yapan yazarlar, Şekil 4. Ülkelerin yayın sayıları, Şekil 5. 2003-2025 yılları arası Endurance in racket sports ile ilgili yapılan yayınların yayınlandığı

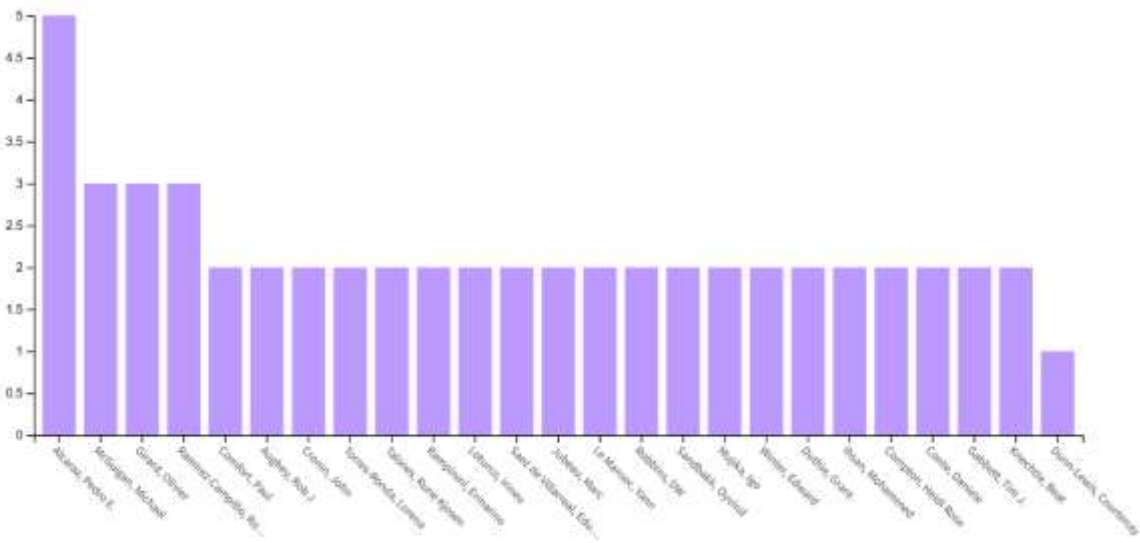
dergi isimleri, Şekil 6. Ortak yazarların ilişki bağlantısı, Şekil 7. Yazarların üniversite bağlantısı, Şekil 8. Ortak yazarların ülke bağlantısı sunulmuştur.

Tablo 1’de ortak yazarların toplam bağlantı kuvveti, Tablo 2’de yazarların üniversite bağlantısı kuvveti, Tablo 3’de anahtar kelime bağlantı kuvveti sunulmuştur.



Şekil 2. 2003-2025 yılları arası Endurance in racket sports ile ilgili makale sayısı

Endurance in racket sports anahtar kelimesiyle 2003 yılında bir makale, 2025 yılında ise beş makale yayınlanmıştır. En yüksek makale sayısı ise 2012 yılında 12, en düşük 2003 ve 2004 yıllarında bir makaledir.



Şekil 3. 2003-2025 yılları arası Endurance in racket sports ile ilgili yayın yapan yazarlar

Endurance in racket sports anahtar kelimesiyle Pedro E. Alcaraz beş çalışma çalışma ile en fazla yayın yapan yazardır.



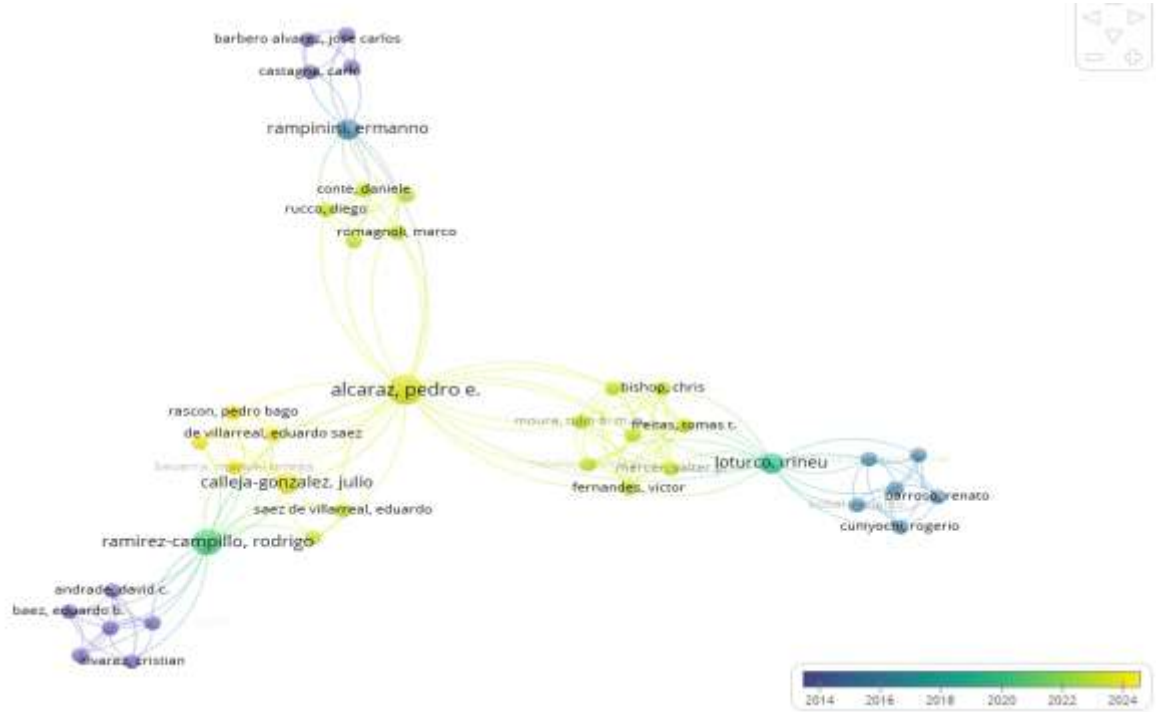
Şekil 4. Ülkelerin yayın sayıları

Endurance in racket sports anahtar kelimesiyle en fazla araştırmayı 21 yayın ile Avustralya yapmıştır.



Şekil 5. 2003-2025 yılları arası Endurance in racket sports ile ilgili yapılan yayınların yayınlandığı dergi isimleri

Endurance in racket sports ile ilgili yayınlanan 90 çalışmanın 55 tanesi (%61,1'i) Lippincott williams & wilkins'de yayınlanmıştır.



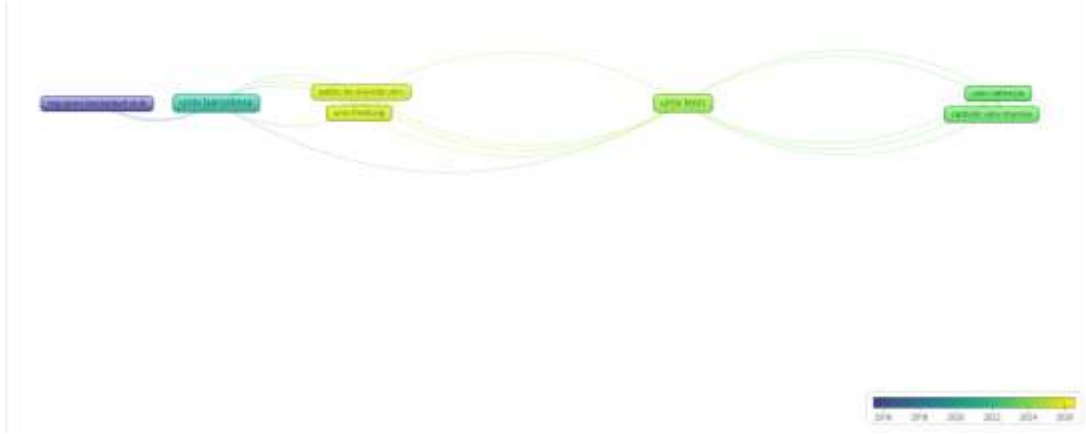
Şekil 6. Ortak yazarların ilişki bağlantısı

Pedro E. Alcaraz yazarların ortak ilişki bağlantı noktasını oluşturmaktadır.

Tablo 1. Ortak yazarların toplam bağlantı kuvveti

| Yazar                    | Makale | Alıntı | Toplam Bağlantı Kuvveti |
|--------------------------|--------|--------|-------------------------|
| Pedro E. Alcaraz         | 4      | 53     | 25                      |
| Rodrigo Ramirez-Campillo | 3      | 92     | 16                      |
| Irineu Latourco          | 2      | 46     | 15                      |
| Oliver Girard            | 3      | 74     | 11                      |
| Julio Calleja-Gonzalez   | 2      | 12     | 10                      |

Pedro E. Alcaraz 25 bağlantı gücü ile bağlantı kuvveti en yüksek yazardır.



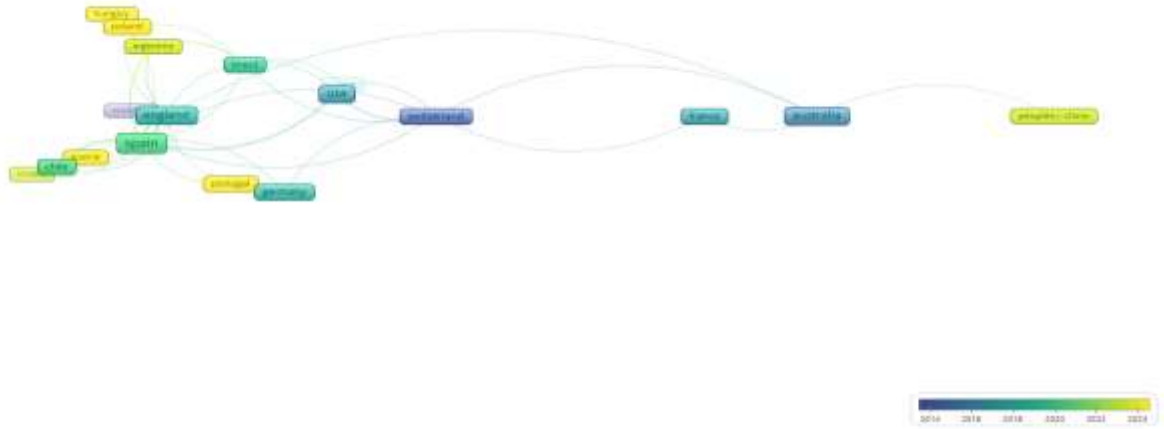
Şekil 7. Yazarların üniversite bağlantısı

Pablo de Olavide Üniversitesi ve Freiburg Üniversitesi 2024 yılından itibaren üniversitelerin ortak bağlantı noktası olmuştur.

Tablo 2. Yazarların üniversite bağlantısı kuvveti

| Yazar                            | Makale | Alıntı | Toplam Bağlantı Kuvveti |
|----------------------------------|--------|--------|-------------------------|
| University of the Basque Country | 3      | 17     | 12                      |
| Univ Leon                        | 3      | 18     | 10                      |
| Federal University of São Paulo  | 2      | 46     | 9                       |

University of the Basque Country 12 bağlantı kuvveti ile en yüksek bağlantı gücüne sahiptir.



Şekil 8. Ortak yazarların ülke bağlantısı

İspanya 14 makale, 587 alıntı ve 24 toplam bağlantı kuvvetine sahiptir.

**Tablo 3.** Anahtar kelime bağlantı kuvveti

| Yazar                | Görüntülenme | Toplam Bağlantı Kuvveti |
|----------------------|--------------|-------------------------|
| Racket Sports        | 11           | 43                      |
| Team Sports          | 4            | 16                      |
| Performance          | 4            | 14                      |
| Resistance Training  | 3            | 12                      |
| Athletic Performance | 4            | 11                      |

Çalışmalarda anahtar kelime olarak ilk sırada Racket Sports 43 bağlantı kuvvetine, ikinci sırada Team Sports 16 bağlantı kuvvetine ve üçüncü sırada Performance 14 bağlantı kuvvetine sahiptir.

### TARTIŞMA ve SONUÇ

Mevcut çalışma WoS veri tabanı üzerinden “Endurance in racket sports” anahtar kelimesi ile tarama yapılmıştır. Çalışmada anahtar kelimeyle ilgili ilk olarak 144 makale tespit edilmiş ve bu makalelerin 90 tanesi çalışmaya dahil edilmiştir. Çalışmada verilerin analizi için WoS analiz sonuçları sekmesinden ve VOSviewer uygulaması aracılığıyla verilerin analizi yapılmıştır. Yıllara göre yayın sayıları, yazarların yayın sayıları, anahtar kelime ile ilgili ülkelerin yayın sayıları, kurumların yayın sayıları, yayınların yayınlandığı dergi isimleri, yayınların yıllara göre ortak yazar bağlantısı, yazarların üniversite bağlantısı, anahtar kelime bağlantısı verilmiştir. Raket sporlarında dayanıklılık ile ilgili 2003-2025 yılları arasında en fazla yayın beş çalışma ile Pedro E. Alcaraz’a aittir. Ülke olarak en fazla çalışma 21 yayın ile Avustralya’ya ait olduğu bulunmuştur. Yazarların ülke bağlantısı incelendiğinde İspanya 14 makale, 587 alıntı ve 24 toplam bağlantı kuvveti ile ilk sıradadır. Mevcut çalışma ile ilgili yayınlanan 90 çalışmanın 55 tanesi (%61,1’si) Lippincott williams & wilkins’de ait olduğu tespit edilmiştir.

Sonuç olarak raket sporlarında dayanıklılık performansı etkileyen temel bileşenlerinden biri olduğu ve bu konuyla ilgili yapılan araştırmaların arttığı görülmektedir. Ayrıca yapılan çalışmalarda anahtar kelimeler içerisinde atletik performans ve performans kelimelerinin de kullanılması performans bileşeni için önemli olduğu söylenebilir.

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## THE ROLE OF SOCIAL MEDIA IN BUILDING AN ATHLETE'S IMAGE

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### ABSTRACT

This study examines how social media platforms shape and enhance the public image of athletes. With the rise of digital tools such as Instagram, sports professionals are no longer limited to traditional media channels when communicating with their audiences. The paper focuses on athlete self-presentation and explores how professional athletes construct their online identities by combining professional achievements, personal storytelling, and lifestyle representations. The research applies qualitative content analysis to publicly available Instagram posts published by Robert Lewandowski (a world-famous Polish footballer) between January 1, 2026 and July 28, 2026. The analysed content was organized into thematic categories including professional performance, personal life, sponsorship, lifestyle representation, emotions, and motivational communication. The case study highlights how Lewandowski manages his digital identity through a combination of sporting achievements, controlled personal exposure, and strategic communication. The findings indicate that social media contribute primarily to the construction of a disciplined, professional, and successful athlete image through visual representations of sporting performance, commitment, lifestyle, and personal values. However, the analysed posts provided limited detailed information about nutrition, recovery strategies, or specific health practices. Instead, the athlete's health-related image was created mainly through associations with discipline, physical preparation, and dedication to sport. The study demonstrates that intentional self-presentation on social platforms can increase athletes' visibility, strengthen relationships with followers, and support personal branding. This research contributes to a better understanding of digital identity construction in professional sport and highlights the important role of social media in contemporary athlete image management.

**Keywords:** athlete branding, social media, Instagram, digital identity, athlete self-presentation, sports communication.

### INTRODUCTION

The rapid growth of social media has significantly transformed communication within the sports industry. In the past, athletes depended primarily on traditional media, such as television, newspapers, and radio, to communicate with the public and shape their reputation. Today, platforms such as Instagram, Facebook, TikTok, and X enable athletes to interact directly with millions of followers without the involvement of journalists or media organizations. This shift has changed not only the way sports personalities communicate but also the process of building and maintaining their public image (Filo et al., 2015; Doyle et al., 2022).

Social media have become an essential tool for athlete self-presentation and personal branding. Professional athletes use these platforms to share both sport-related and personal content, creating a more comprehensive image of themselves (Geurin-Eagleman & Burch, 2016; Woods et al., 2023). Posts documenting training sessions, competitions, sporting achievements, travel, family life, and selected aspects of everyday activities allow audiences to gain insight into the



lives of elite athletes. Such communication helps establish stronger relationships with fans while simultaneously increasing athletes' visibility and commercial value.

The growing importance of personal branding has also changed the expectations of sponsors and sports organizations. Athletic success alone is no longer sufficient to ensure commercial attractiveness. Companies increasingly seek athletes who maintain an active and credible online presence, demonstrate positive values, and engage effectively with their audiences. Consequently, social media profiles have become valuable marketing assets that influence sponsorship opportunities, fan engagement, and long-term career development. Effective online communication therefore requires a balance between authenticity, professionalism, and strategic image management (Doyle et al., 2022; Xie et al., 2023).

A key component of how athletes use social media is building a public persona centered on health and discipline. By showcasing their training habits, dedication to sport, and professional lives, elite competitors shape public views on fitness and athletic rigor. While these platforms often lack specific details on nutrition or recovery, athletes link themselves to wellness through imagery of peak performance and commitment (Jara Pazmino & Pack, 2023; Bredikhina et al., 2022). Additionally, by sharing their emotional journeys through highs and lows like injuries or losses, they offer a more authentic perspective on the world of professional athletics.

Despite these opportunities, maintaining a public presence on social media also presents challenges. Athletes operate under constant public scrutiny, and their online activity can have immediate consequences for their reputation and commercial partnerships. Every published post contributes to the construction of their digital identity, making strategic communication an essential component of contemporary sports careers (Bredikhina et al., 2022; Woods et al., 2023).

The aim of this study is to examine the role of social media in building the public image of athletes, with particular emphasis on Instagram as a platform for strategic self-presentation. Using a qualitative content analysis of selected Instagram posts published by Robert Lewandowski, the study investigates how professional achievements, lifestyle representations, emotions, sponsorship, and aspects of everyday life contribute to athlete branding and audience engagement.

The findings are intended to enhance understanding of digital identity construction in professional sport and to demonstrate how social media support image management, personal branding, and the construction of professional athlete identities.

## **MATERIALS AND METHODS**

### **Research Design**

This study used a qualitative content analysis approach to examine how social media contribute to the construction of an athlete's public image. This method enables systematic identification of themes, meanings, and communication patterns within visual and textual materials (Schreier, 2012). The approach was selected to explore how athletes use social media for self-presentation, personal branding, and communication of lifestyle-related values.

### **Research Material**

The research material consisted of publicly available Instagram posts published on the official account of Robert Lewandowski between **January 1, 2026 and July 28, 2026**. The period was selected to analyse contemporary strategies of athlete self-presentation during an active stage of his professional career.

Robert Lewandowski was selected as a case study due to his international recognition, extensive social media presence, and consistent use of Instagram as a tool for communication with fans and personal brand development. The analysis included permanent Instagram content, such as photographs, videos, reels, and carousel posts. Temporary Instagram Stories were excluded because they are not permanently available for systematic analysis.

### **Data Collection and Coding Procedure**

The collected posts were manually analysed and classified into thematic categories based on previous research on athlete branding and social media communication (Geurin-Eagleman & Burch, 2016; Doyle et al., 2022).

The following categories were used:

- **Sport performance and training** – content related to matches, training sessions, preparation, and professional achievements.
- **Lifestyle and professional identity representation** – content presenting aspects of everyday life, personal values, discipline, professional commitment, and elements associated with an athlete's public lifestyle.

- **Emotions** – expressions of motivation, gratitude, success, failure, and personal reflections.
- **Personal life** – family, leisure activities, travel, and experiences outside professional sport.
- **Sponsorship and commercial content** – brand collaborations and promotional activities.
- **Educational and motivational content** – messages promoting discipline, physical activity, and positive lifestyle behaviours.

Posts containing more than one theme were assigned to multiple categories.

### **Data Analysis and Ethical Considerations**

The collected material was analysed through thematic analysis, focusing on recurring communication patterns and strategies used to construct Robert Lewandowski's digital identity. Particular attention was given to the representation of health-related behaviours and the ways in which professional achievements, personal storytelling, and commercial communication contributed to his public image.

The study used only publicly available content from Robert Lewandowski's verified Instagram account. No private information was collected, and no interaction with the athlete or social media users was conducted.

## **RESULTS AND DISCUSSION**

### **Professional Image and Sports Performance**

The analysis of Robert Lewandowski's Instagram content between January 1, 2026 and July 28, 2026 shows that professional identity represents the central element of his online self-presentation. The largest proportion of analysed posts focused on football-related activities, including matches, training sessions, competition preparation, team achievements, and professional milestones. These publications consistently reinforced his image as an elite football player with a strong commitment to sporting excellence.

The presentation of sporting activities was not limited to final results or public achievements. Many posts emphasized the process behind success, including preparation, effort, teamwork, and dedication. Through images and messages connected with training, competitions, and professional experiences, Lewandowski communicated values such as discipline, perseverance, ambition, and continuous development.

These findings correspond with previous research indicating that athletes use social media not only to present achievements but also to create narratives about dedication, identity, and personal development (Doyle et al., 2022). In this context, football performance functions as the foundation of Lewandowski's digital identity and provides the main framework for his personal brand.

### **Professional Identity and Lifestyle Representation**

Beyond football-related content, the analysis showed that Lewandowski's Instagram contributes to the construction of a broader image of a disciplined and professionally oriented individual. Posts presenting training, preparation, travel connected with professional activities, and selected moments outside competition created an image of a highly organized athlete whose lifestyle is closely connected with sporting success.

The analysed content did not primarily focus on detailed health-related information such as nutrition plans, recovery methods, or specific wellness practices. Instead, associations with a healthy and disciplined lifestyle were created indirectly through representations of physical activity, professional commitment, and athletic performance.

This finding suggests that athletes do not necessarily need to provide explicit health education content to be perceived as healthy or disciplined figures. Visual representations of dedication, physical preparation, and professional behaviour may be sufficient to create such associations. Therefore, social media contribute to the construction of athlete identity not only through information but also through symbolic representations of lifestyle and values.

### **Personal Life and Family Image**

Another important theme identified in the analysis was the presentation of personal life. Posts related to family, including moments with Anna Lewandowska and their daughters, contributed to creating a more accessible and human dimension of the athlete's public image.

The inclusion of personal content allows athletes to present themselves beyond their professional role and establish stronger emotional connections with followers. By showing selected aspects of family life and everyday experiences, Lewandowski's communication combines the image of a successful football player with the image of a family-oriented person.

However, personal content remained carefully controlled. The athlete did not provide unrestricted access to private life but selected specific moments that supported his overall public identity. This demonstrates the balance between authenticity and privacy management in contemporary athlete self-presentation.

### **Emotional Expression and Audience Engagement**

The analysis also identified the role of emotional communication in strengthening relationships with followers. Posts connected with victories, important career moments, gratitude, motivation, and reflections after sporting events contributed to presenting the athlete as a person with experiences and emotions beyond competition.

Such communication can increase perceptions of authenticity because followers gain access to aspects of the athlete's personality that are not visible during matches. Previous research highlights that social media enable athletes to combine professional and personal narratives, creating stronger relationships with audiences (Filo et al., 2015).

Simultaneously, there was an apparent strategic management of emotional displays. The athlete picked specific instances and communications to reinforce a stable and advantageous public profile, illustrating that authenticity in sports communication is often intertwined with conscious brand management.

### **Sponsorship and Commercial Communication**

The analysed material confirmed the importance of commercial partnerships in Lewandowski's digital communication. Sponsored content was integrated into his broader personal narrative rather than appearing as separate advertising material. Brand collaborations were commonly connected with themes such as professionalism, quality, performance, and success.

This approach reflects current trends in athlete branding, where commercial effectiveness depends on the perceived credibility and authenticity of the athlete. Previous studies indicate that social media allow athletes to increase commercial value by developing personal brands that combine professional achievements with individual values (Bredikhina et al., 2022; Doyle et al., 2022).

The findings demonstrate that Instagram functions not only as a communication channel with fans but also as an important platform for managing sponsorship relationships and strengthening market value.

### **Overall Discussion**

The results demonstrate that Robert Lewandowski's Instagram functions primarily as a tool for personal branding and digital identity construction. The dominant element of his online presence is football performance, while other dimensions, including family life, lifestyle, emotional communication, and commercial partnerships, strengthen and diversify his public image.

The study shows that successful athlete branding requires a balance between professional visibility, authenticity, and strategic communication. Social media allow athletes to control their narratives and communicate directly with audiences; however, effective image management depends on careful selection of content and maintaining consistency over time (Doyle et al., 2022; Woods et al., 2023).

Although health-related elements were not a dominant form of communication in the analysed posts, the athlete's image was indirectly associated with discipline, physical preparation, and professional lifestyle. This indicates that athletes may construct perceptions of health and

positive values through representations of commitment and performance rather than through explicit educational messages.

Overall, the analysis confirms that social media have become an essential element of contemporary athlete branding. A carefully managed online presence can strengthen relationships with followers, increase commercial opportunities, and support the development of a credible and recognizable athlete identity.

## **CONCLUSION**

Focusing on Robert Lewandowski's Instagram posts from early to mid-2026, this study explored the impact of social media on the public image of professional athletes. It found that these platforms are indispensable for branding, self-presentation, and maintaining a direct connection with the public.

The data suggests that his online persona is shaped by a combination of sporting accomplishments, personal stories, lifestyle glimpses, and marketing efforts. While posts about his football career solidify his reputation as an elite player, sharing personal milestones and family experiences adds depth to his overall image.

The study also shows that professional identity is the central element of Lewandowski's digital presence. Through consistent representation of discipline, commitment, ambition, and performance, social media support the construction of an image of a highly professional and successful athlete. Although detailed health-related information, such as nutrition plans or recovery methods, was not a dominant element of the analysed content, associations with a healthy and disciplined lifestyle were created indirectly through representations of physical activity, preparation, and professional commitment.

The findings highlight the importance of authenticity and emotional communication in developing relationships with followers. By combining sporting achievements with selected aspects of private life, athletes can create stronger connections with audiences while maintaining control over their public image. At the same time, social media communication remains a strategic process in which visibility, authenticity, privacy, and commercial interests must be carefully balanced.

This study confirms that effective management of an athlete's digital identity can increase visibility, strengthen audience engagement, and support commercial opportunities. However, the construction of a positive online reputation requires continuous attention because every published message contributes to the perception of the athlete's personal brand.

The study has several limitations. First, it focuses on a single athlete and one social media platform, which limits the generalizability of the findings. Second, the qualitative approach provides an in-depth interpretation of communication strategies but does not examine audience reactions through quantitative engagement measures. Future research should compare athletes from different sports and cultural contexts, as well as combine content analysis with audience engagement data.

Overall, this research demonstrates that social media play a crucial role in contemporary sports communication. Athletes are no longer only competitors but also personal brands whose online presence shapes their reputation, commercial value, and relationship with audiences.

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## AWARENESS-BASED INTERVENTIONS IN CANCER: GLOBAL TRENDS AND A THEMATIC ANALYSIS

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### ABSTRACT

Cancer remains a major global health issue, ranking as the second leading cause of death worldwide. This study aims to examine research in the field of cancer and on awareness-based interventions using bibliometric analysis and scientific mapping methods.

This study employs bibliometric analysis and scientific mapping methods. The data were collected through a search of the Web of Science (WoS) database conducted on April 10, 2026. Analyses of countries, authors, institutions, journals, and keywords were performed using the Bibliometrix package in R.

A total of 1,932 publications were identified in the study. The highest number of publications related to cancer and mindfulness-based interventions (12.2%, n = 236) was recorded in 2025. The journals with the most publications were “Psycho-Oncology” (14.73%, n = 81) and “Mindfulness” (14.55%, n = 80). The most frequently used keywords in the studies were “mindfulness” and “cancer,” which were commonly used alongside all other keywords. The United States emerged as the country with the highest number of publications on the subject. Additionally, the most cited publication, with 8,552 citations, was authored by Brown and Ryan.

This study provides a comprehensive review of the literature on mindfulness-based interventions in cancer care, highlighting current research trends in the field. The findings indicate that these interventions are playing an increasingly important role in supporting psychosocial well-being and that further evidence is needed to support their integration into clinical practice.

**Keywords:** Cancer, awareness, interventions, oncology, bibliometric analysis