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RESEARCH

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The role of different rest periods on post-activation performance enhancement in plyometric preload

Rüzgar Şener[1], Akan Bayrakdar[1], Müjde Atıcı[2], Soner Akgün[3*], Zeynep Senem Söyleyici Öcal[4], Raci Karayiğit[5] and Ali Kerim Yılmaz[6]

Abstract

Background The optimal combination of factors such as rest duration, type of activity, and individual variability for maximizing post-activation performance enhancement (PAPE) following plyometric conditioning activity (plyometric CA) remains a subject of debate. To investigate the effects of different rest periods (4, 8, and 12 min) on performance following plyometric CA, this randomized controlled study was conducted.

Methods Twenty physically active men were included in this study (mean ± SD: age 20.74 ± 1.94 years, with a range of 18–24 years, body weight 70.61 ± 3.01 kg, and height 176 ± 1.8 cm). Participants familiarized themselves with the plyometric CA protocol through a preliminary session involving three sets of ten tuck jumps to ensure proper technique. A familiarization test was performed on the first day. They performed in a vertical jump test with different rest periods (4, 8, 12 min) between tests, set at 48-hour intervals and the randomized design was compared to the control group. The data obtained were analyzed using appropriate statistical tests in SPSS 25 and Microsoft Office Excel.

Results Although no statistically significant differences were observed between conditions ($p > 0.05$), a consistent increasing trend in performance indicators was noted following 4-, 8-, and 12-minute rest intervals. Compared to the control condition, jump height increased by 2.81%, 2.95%, and 3.01%; peak power output (PPO) increased by 1.84%, 1.94%, and 2.59%; and PPO relative to total body mass increased by 2.04%, 2.06%, and 2.15%, respectively.

Conclusions In conclusion, the findings highlight the complexity of rest interval effects on PAPE and suggest the necessity of individualized rest strategies to optimize athletic performance.

Keywords Post-activation performance enhancement (PAPE), Resting, Plyometric, Vertical jump

*Correspondence:
Soner Akgün
sonerakgun@artvin.edu.tr
[1]Faculty of Sport Sciences, Alanya Alaaddin Keykubat University, 07425 Antalya, Türkiye
[2]Faculty of Sport Sciences, Kahramanmaraş Sütçü İmam University, 46100 Kahramanmaraş, Türkiye
[3]Faculty of Sport Sciences, Artvin Çoruh University, 08000 Artvin, Türkiye
[4]Faculty of Sport Sciences, Süleyman Demirel University, 32260 Isparta, Türkiye
[5]Faculty of Sport Sciences, Ankara University, 06560 Ankara, Türkiye
[6]Faculty of Yasar Doğu Sport Sciences, Ondokuz Mayıs University, 55100 Samsun, Türkiye

Introduction

Both acute and chronic increases in physical function are among the goals of practitioners in athletic and clinical settings [1]. While chronic improvements require exercise periodization [2], acute performance increases can be achieved in the short term by various physical and/or psychological strategies applied during training sessions, during or before sporting competition [1]. Studies aimed at improving sports performance have necessitated the inclusion of acute effective methods that increase explosive force production in a short time [3–6]. Among these approaches, post-activation performance enhancement (PAPE) is defined as an acute increase in muscle performance as a result of prior high intensity or ballistic loading [1, 7, 8]. This concept focuses on the assessment of the neuromuscular phenomenon traditionally known as post-activation potentiation (PAP) through direct voluntary performance outcomes (e.g. vertical jump, sprint, force production, etc.) rather than through electrically evoked twitch force measurements [9]. Traditional high or moderate intensity strength exercises are often used to initiate PAPE [10]. Furthermore, PAPE has been reported post plyometric exercises [10], which involve the stretch-shortening cycle to store energy and produce more powerful movement [11, 12].

Plyometric exercises use different types of jumps (bilateral, unilateral, bounds, hops, and drop jumps) [11, 12] and do not depend on equipment and implements, demonstrating a practical advantage compared to traditional high- or moderate-intensity pliometric CA [8, 13]. Plyometric CA is often preferred to obtain the PAPE effect [12], especially body weight jumping types acutely activate the neuromuscular system by stimulating the musculoskeletal system [10, 14]. Turner et al. [15] reported that the use of plyometric CA is an effective technique to improve sprint performance by triggering PAPE. It has also been reported that PAPE practices increase the potential for strength development [16, 17]. This provides an important advantage especially in sports requiring high speed. However, not only the type of plyometric CA but also the rest period after loading is a critical variable in the emergence of this effect.

Although fatigue develops after plyometric CA, potentiation occurs simultaneously. The ratio between these two processes determines the magnitude of the performance gains [17]. Indeed, insufficient rest time can lead to muscle fatigue becoming dominant and hindering performance gains, while excessively long rest intervals can reduce the effect of neuromuscular stimulation. In this regard, Fontonetti et al. [18] reported that similar or even more favorable improvements in CMJ performance were observed when elite athletes were given the opportunity to set rest periods according to their individual preferences instead of fixed rest periods. Similarly, Xu et al. [19] reported that fixed rest periods of 4, 8 and 12 min resulted in different performance outcomes when individual differences were taken into account. Furthermore, Blazevich and Babault [1] emphasized that individual characteristics such as training history, muscle fiber composition and strength capacity significantly influence the PAPE effect and therefore rest periods should be determined individually.

On the other hand, it was suggested that the rest period after plyometric CA influences the magnitude of PAPE [10, 20]. Apparently, PAPE is only reported when potentiation is greater than fatigue [10], because fatigue and potentiation occur simultaneously in this process [21]. Boullosa [7] suggested that a pronounced PAPE effect occurs 5–10 min after CA. However, PAPE may be influenced by the type of CA, and improvement in voluntary muscular performance may be reported 0.3–4 min after a plyometric CA [10]. For example, improvement in countermovement jump (CMJ) performance was reported 1–5 min after multiple sets of plyometric CA performed by professional rugby union players [22]. However, no effect was observed in rest periods longer than 5 min in the same study [22]. In another study conducted on male university soccer players, a significant increase in CMJ performance was found after plyometric CA [23]. On the other hand, Pereira et al. [24] reported that no positive results were obtained in the PAPE effect evaluated at rest intervals of 7 and 15 min after plyometric CA in elite runners. The inconsistencies between these reported findings [22–24] and the limited number of studies examining the effect of PAPE, especially after plyometric CA [10], make it difficult to understand the temporal dynamics of performance responses following such conditioning and increase the need for new research in the field.

The aim of this study was to investigate the temporal response of PAPE following a plyometric CA supported by a plyometric CA at rest intervals of 4, 8, and 12 min. To investigate the effects of different rest periods (4, 8, and 12 min) on performance following plyometric CA, this study was conducted.

Material and method

Participants

The participants were university students with a regular sports background, actively training in various sports disciplines at intermediate to advanced levels. Twenty active men were included in this study (mean ± SD: age 20.74 ± 1.94 years, age range 18–24 years, body weight 70.61 ± 3.01 kg, and height 176 ± 1.8 cm). The participants were recruited from the Faculty of Sports Sciences, and all were members of university teams or licensed athletes competing at regional or national levels. Inclusion criteria were absence of any injury or illness (PAR-Q), regular training of at least 3 units per week, and regular participation in competitions. All subjects were informed about the potential risks and benefits of the available procedures and signed a written informed consent form. The Alanya Alaaddin Keykubat non-interventional clinical research ethics committee approved this study. All procedures were conducted in accordance with the Declaration of Helsinki for studies involving human subjects (December 2013, Brazil).

Statistical software (G*Power, Düsseldorf, Germany) was used to calculate the sample size. The 2-way analysis of variance (ANOVA) was planned with a total sample size of 16 subjects, given a medium overall effect size (ES) f = 0.25, α-error ≤ 0.05, and desired power (1-ß error) = 0.8. To avoid the effects of any possible attrition on statistical power, 20 subjects were included in the study.

Study design

Participants were involved in the measurements a total of five times (Fig. 1). On the first day, a familiarization test was performed, and the participants were introduced to and supervised during the 3 × 10 tuck jumps plyometric CA. Then, participants were instructed to perform repeated countermovement jumps (CMJ) continuously for 15 s, aiming to achieve the maximum possible number of jumps within this time frame. In addition, body weight, height, and body composition measurements of all participants were taken on the familiarization test day. After the familiarization test day, participants performed control (CONTROL), plyometric preload with 4 min rest (PLIO4), plyometric preload with 8 min rest (PLIO8), and plyometric preload with 12 min rest (PLIO12) trials in a randomized, cross-over, counterbalanced study design. There was a 48-hour rest interval between test days. All tests were performed between 11:00 and 12:00, 2–3 h after breakfast. Participants were asked to standardize their breakfast before each test day. They were asked to note their breakfast before each test, and to repeat this for the other test days. Participants were warned not to consume alcohol and caffeine 24 h before the tests. Participants were first asked to do a general warm-up for 15 min, comprising 10 min of jogging (10 min run at ~60–70% HRmax) and 5 min of dynamic warm-up stretches suitable for the lower extremities. After the warm-up, a protocol of 3 × 10 tuck jumps was performed. After 0 (no rest), 4, 8, and 12 min of passive rest, a 15-second vertical jump test was performed. In the control session participants completed the same standardized warm-up and 3 × 10 tuck jumps as in the other experimental conditions. However, they performed the 15-second repeated CMJ test immediately after the last jump repetition, without any rest period. This session served as the 0-minute recovery condition. In the repeated CMJ test, the highest jump height, average height, and power drop percentage were calculated.

Data collection

All measurements were performed in the laboratory of the Faculty of Sports Sciences, Ankara University, in an environment of 22 degrees Celsius and 50% humidity, which is considered optimal. These conditions ensure precise measurement outcomes. The participants' height was measured using a wall-mounted stadiometer (Holtain, UK) with an accuracy of ± 1 mm. Body weights were measured using an electronic scale (Tanita TBF401A, Japan) with an accuracy of ± 100 g. Body fat percentage measurements were performed using the Jawon Segmental body composition analyzer Avis 333 Plus (Korea), which has an accuracy of ± 100 g for weight measurement. Participants were asked to come for body weight measurements having an empty stomach and without drinking water. This was completed by holding the hand electrodes for approximately 10 s and ensuring firm contact with the arms at a 30° angle. The measurements were then recorded for calculations. Body mass index (BMI) measurements were evaluated using the kg/m² formula.

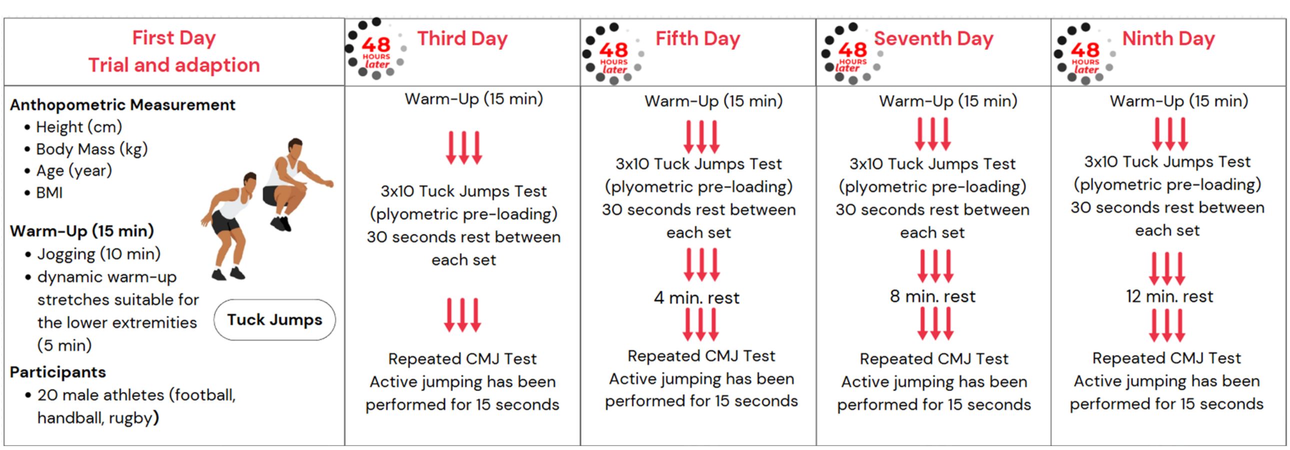

Fig. 1 Study design

Table 1 Anthropometric characteristics of participants

Variables	$\bar{x}$±SD
Age (years)	20.7 ± 1.9
Height (cm)	176.9 ± 1.8
Body Mass (kg)	70.61 ± 3.01
Body Fat Percentage (%)	15.7 ± 1.4
Body Mass Index (kg/m^2)	22.55 ± 2.20

$\bar{x}$: mean, SD: Standard Deviation

Determination of vertical jump performance

In this study, multiple sets (3 × 10 repetitions) of tuck jumps were performed as preload practice. Participants performing a multi-set (3 × 10) tuck jump were given a 30-second rest period between sets [25]. During the tuck jump, participants were instructed to pull their knees up toward their own abdomen and to minimize the contact time with the ground between repetitions.

The vertical jump performance of the participants was measured using the Smartjump device, a photocell-connected mat (Fusion Sport, Australia). The participants were positioned on the mat with their feet shoulder-width apart, with their knees bent at a 90° angle, and leaning forward with their arms fixed at the waist [26]. The participant tried to jump as high as possible for 15 s without interruption. The maximum and minimum jump heights were determined, within 15 s, to assist in calculating the arithmetic mean of all jump heights [27].

Statistical analysis

All statistical analyses were performed using SPSS software (version 26.0; SPSS, Inc., Chicago, IL, USA) and presented as means (± SD). In addition, 95% confidence intervals (95% CI) were calculated for mean values and mean differences. Statistical significance was set at $p < 0.05$. Shapiro–Wilk and Mauchly's tests were applied to assess normality and sphericity of variance in the sample data. The data were found to be normally distributed. To assess the assumption of homogeneity of variances, Levene's test was performed, and the results indicated that the variances were homogeneous across groups ($p > 0.05$). The effect of a plyometric preload protocol with 3 × 10 tuck jumps and different rest intervals on 15-second vertical jump performance was tested with repeated measures two-way analysis of variance (ANOVA). In addition, the effect size (η^2) was calculated.

Results

Table 1 provides descriptive information about the physically active males participating in the study.

Table 2 presents the ANOVA results evaluating the effects of different rest periods on PPO/Total Mass (Watt/kg), PPO (W), and jump height (cm). In terms of PPO/Total Mass, the mean was 47.04 ± 4.07 for the control group, 48.00 for the 4 min rest group 48.01 for the 8 min, and 48.05 for the 12 min. This indicates that resting time increased the Peak Power Output (PPO)/total mass ratio value. However, the F value (0.293) and the p-value (0.830) indicated no statistically significant difference. The effect size (η^2 = 0.012) shows that there is a small effect. When examining the PPO (W) values, it was observed that the average of the control group was 3302.60 ± 554.70, while the averages of the other groups were 3363.33 (4 min), 3366.55 (8 min), and 3388.25 (12 min) (Fig. 2). An increase in PPO values is observed with an increase in resting time; however, the F-value (0.091) and the p-value (0.965) show that there is no significant difference. The effect size (η^2 = 0.004) was also identified as small. In terms of jump height, the mean of the control group was 35.55 cm, while the mean of the 4-minute rest group was 36.55 cm, the 8-minute rest group was 36.60 cm, and the 12-minute rest group was 36.62 cm. Although an increase in jump height

Table 2 Plyometric preconditioning and jump height values across different rest durations

Variables	Group	*n*	$\bar{x}$±SD	Percentage Change	F	*p*	η^2 (Effect Size)	95% CI (lower bound)	95% CI (upper bound)
PPO / Total Body Mass *(W/kg)*	Control	20	47.04 ± 4.07	-	0.293	0.830	0.012 *(Low)*	45.08	49.01
	4-Min Rest		48.00 ± 4.21	2.81%				45.96	50.03
	8-Min Rest		48.01 ± 3.77	2.95%				46.19	49.83
	12-Min Rest		48.05 ± 3.58	3.01%				46.32	49.78
PPO *(W)*	Control		3302.60 ± 554.70	-	0.091	0.965	0.004 *(Low)*	3035.24	3569.96
	4-Min Rest		3363.33 ± 516.07	1.84%				3114.59	3612.07
	8-Min Rest		3366.55 ± 533.10	1.94%				3109.60	3623.49
	12-Min Rest		3388.25 ± 518.91	2.59%				3138.14	3638.36
Jump Height *(cm)*	Control		35.55 ± 4.35	-	0.285	0.836	0.012 *(Low)*	33.45	37.65
	4-Min Rest		36.55 ± 4.60	2.04%				34.33	38.77
	8-Min Rest		36.60 ± 4.04	2.06%				34.66	38.55
	12-Min Rest		36.62 ± 3.95	2.15%				34.71	38.52

$\bar{x}$: mean, SD: Standard Deviation, PPO: Peak Power Output, Min: Minutes, Watt: W

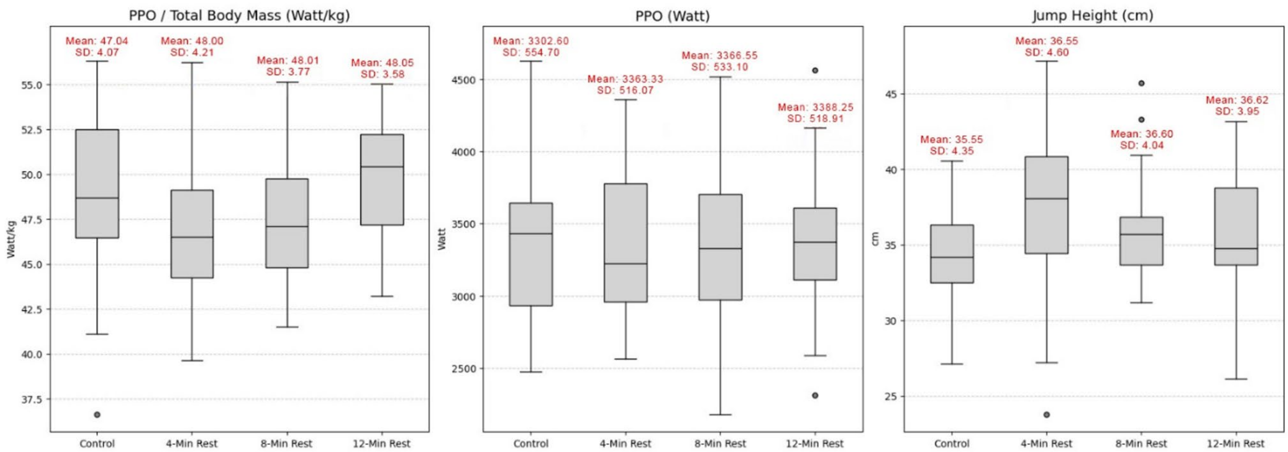

Fig. 2 Averages of PPO/total body mass, PPO, and jump height at different rest durations

was observed as the rest periods increased, the F-value (0.285) and p-value (0.836) showed that there was no statistically significant difference. The effect size ($\eta^2 = 0.012$) reveals that there is a small effect here as well.

Discussion

The aim of this study was to investigate the effects of different rest periods (4, 8, and 12 min) on PAPE. According to the hypothesis of this study, a plyometric CA may support the PAPE effect, and this effect is expected to last up to 12 min following the plyometric CA. Our findings support this notion, although the expected performance improvements were not statistically significant. Overall, rest periods do not seem to have a significant effect on PPO/Total Mass, PPO, and jump height; however, they appear to create a positive trend in all three variables.

When the literature is examined, recovery time stands out as one of the important factors affecting PAPE vertical jump performance. These factors include individual responses [17], fatigue level [21], training history [1], biological age [28], muscle fiber type [29], and muscle strength [16]. The rest period after plyometric CA [30], the type of plyometric CA, the intensity, and the biomechanical similarity of the subsequent activity are also important considerations [31]. In terms of the type of pre-conditioning, traditional moderate and high-intensity strength exercises, plyometric exercises, and maximal isometric contractions are used [10]. Different types of plyometric exercises, or traditional high intensity exercises, can produce different PAPE effects. This observation aligns with the findings of Sharma et al. [23], who noted a greater reduction in CMJ height one minute after heavy-resistance exercise compared to after plyometric exercise. Although the underlying mechanisms were not explored in their study, our results support the proposition by Seitz and Haff [10] that the PAPE effect may manifest sooner following a plyometric conditioning activity. In addition, the effect of individuals' training levels on performance is an important factor as emphasized in the literature. It is expected that well-trained individuals can overcome the fatigue caused by plyometric exercises faster and perform at a higher level [17]. This situation emphasizes the necessity of including plyometric exercises in the training programs of physically active males. In our study, although the participants were licensed athletes, their average vertical jump heights were below elite athlete levels. This may have influenced the results, particularly in terms of their fatigue response. This could explain why statistically significant differences were not observed despite performance trends. The importance of vertical jump performance, especially in sporting disciplines such as volleyball, is directly related to the ability of physically active males to gain an advantage over their opponents [32]. It has been reported that plyometric exercises positively affect quickness and vertical jump performance. However, in this study, when the effects of different rest periods on the ratio of PPO to Total Mass, PPO, and jump height were evaluated, no significant statistical differences were observed among the three variables ($p > 0.05$). Relative PPO normalizes power output by body mass, enabling more accurate comparisons among individuals of varying sizes and improving sensitivity in heterogeneous populations compared to absolute PPO values. However, an increasing trend was observed for these parameters as rest time increased. This finding indicates that appropriate rest duration contributes to performance enhancement, but studies with larger samples are needed [33]. In addition, plyometric exercises vary depending on the adaptation level of individuals and the structure of the training program [34]. It has been emphasized that traditional plyometric training may not be sufficient for physically active males with a certain level of jumping ability [35]. In this context, taking individual differences into consideration and creating personalized training plans can enhance performance improvement [36]. Rest strategies should also be taken into consideration.

In the study, the preference for plyometric CA is a common practice in the literature, particularly due to their potential to increase explosive power and jumping performance [10]. In our study, performance measurements were analyzed after 4, 8, and 12-minute rest intervals, and while a trend toward performance improvement was observed with longer rest periods, these differences were not statistically significant. These results support the notion that the effects of plyometric CA protocols may vary between individuals and depending on rest periods [17]. Additionally, as noted in Seitz and Haff's [10] meta-analysis, while plyometric activities contribute to performance improvements, the optimal rest period and protocol design may vary depending on individual differences. Therefore, while the findings of our study support the use of plyometric CA, they also highlight the need for more detailed and individualized examination of the effects of rest periods and protocol parameters on performance. Future studies should aim to maximize performance-enhancing effects by comparing different variations of plyometric CA protocols and rest strategies.

Fatigue effects are thought to predominate immediately after exercise [17]. Therefore, a precise timetable for increases in performance is required. Short rest periods (0–3 min) should be long enough, for the strengthening effects to be greater than the fatigue effects, but not so long that these effects fall back to baseline. To establish this timeline, rest periods ranging from 10 s [37] to over 20 min [38], have been investigated, yielding ambiguous results. Rest periods (4, 8, and 12 min) were chosen as they were considered most appropriate to elicit PAPE. Rest periods around 5.5 min have been suggested as optimal for eliciting PAPE according to Xu et al. [19], indicating that slightly shorter rest durations may maximize performance enhancement compared to longer intervals. This evidence highlights the importance of carefully selecting rest durations tailored to individual responses. A rest period of 4 min was selected because it represents one of the shortest durations capable of eliciting PAPE, although previous studies have reported mixed findings [37]. Following four minutes of rest, an increase in CMJ height was observed, which became more pronounced after eight and twelve minutes of rest. This finding coincides with our study's observation that jump height tended to increase in all resting conditions compared to the jump height in the control group. However, these increases were not statistically significant ($F = 0.285$, $p = 0.836$, $\eta^2 = 0.012$), indicating a small effect size. The findings align with those of Kilduff et al. [39], who reported increased CMJ performance at 8 and 12 min after 3RM preload stimulation in professional rugby players. In contrast, Barreto et al. [8] reported significant elevations in CMJ values only 1 min after plyometric conditioning activity, suggesting that the PAPE effect can appear earlier after plyometric CA. Similarly, Tobin and Delahunt [22] observed that CMJ performance was higher after 1 min of rest compared to 3 and 5 min, suggesting that plyometric CA provides an immediate improvement in performance. Exercise induces both strengthening and fatigue effects; significant increases were also reported at 18.5 min PAPE [40], but not at 20 min [38]. These varying results may be due to methodological differences and characteristics of the subjects tested. Seitz and Haff [10] emphasized that optimizing rest periods is critical for enhancing performance, recommending an ideal window between 3 and 7 min to balance fatigue and potentiation. Studies show that recovery time plays a critical role in PAPE applications. Karabel and Makaracı [41] reported that 8 min of recovery after acute plyometric exercise improved unilateral jump performance, while 6 min improved postural control. Similarly, Ferreira et al. [42] found that 8 to 12 min of recovery significantly increased jump height in MMA athletes, whereas shorter durations were ineffective. Petré et al. [43] highlighted that 10 min of recovery after HIIT reduced strength and explosive performance, but 6 h or more of rest showed no negative effects. Additionally, Heynen et al. [44] demonstrated that elite female volleyball players required 6 h of recovery after back squats or depth drops for the PAPE effect to manifest. All these findings suggest that recovery time in PAPE protocols should be carefully tailored according to the type and intensity of exercise to maximize performance benefits.

Consistent with the findings in the literature that the PAPE effect usually occurs 5 min after conditioning activity (CA) [7, 20], it was hypothesized that the plyometric CA applied in our study could increase CMJ performance at the 4th, 8th and 12th minutes. However, although the findings were not statistically significant, it was not possible to accept this hypothesis based on the p value alone. However, the increase in mean jump height observed in the 4th, 8th and 12th minutes after plyometric CA is noteworthy. This is similar to the PAPE effect demonstrated in previous studies with the jump increases observed after plyometric CA [8, 22]. In addition, studies in the literature reporting significant increases in CMJ performance 8 min after plyometric CA [23] support our findings at 8 and 12 min. Therefore, a more comprehensive evaluation based not only on p-value but also on effect size and mean differences supports the hypothesis that plyometric CA can improve CMJ performance up to 12 min after practice. However, further studies that take into account individual differences and measurement sensitivities are needed to strengthen this interpretation.

Conclusions

This study examined the effects of 4-, 8-, and 12-minute recovery periods on PPO, PPO/Total Mass, and jump height after plyometric CA. Although statistically significant differences were not obtained, an increase in performance indicators was observed across all parameters as the rest period increased. This indicates that recovery periods of 4-, 8-, and 12-minutes may be more beneficial for performance. However, it should be noted that this effect depends on many variables, such as inter-individual differences and levels of training and fatigue. The results suggest that the effect of rest periods on performance should be considered individually, and both practical benefits and statistical significance should be taken into account when planning training.

Limitations

The study's limitations include the participation of only active male physically active males, and the results do not consider individuals with different gender identities and training backgrounds. Reasons for excluding female participants include controlling for hormonal cycle effects due to the 10-day measurement period, ensuring measurement consistency, and limitations related to time and resources. Rest periods (4, 8 and 12 min) were chosen within a certain range, but whether these periods were optimal was not determined, nor were the effects of shorter or longer rest periods investigated. Although the experimental design was cross-looped, participants were not checked to ensure that they were fully rested after each trial. As a result, the variation in fatigue levels between individuals was underestimated. In addition, it should be noted that the participants did not rest following the warm-up phase, which might have induced residual fatigue before the jumping trials. This could have influenced the overall performance outcomes, and future studies may consider controlling post-warm-up recovery duration to minimize this possible confounding factor. It should be noted that more comprehensive results could be obtained by using different testing protocols or techniques for evaluating vertical jump performance. The rest periods of the control group were evaluated independently of a specific activity, thus providing limited information about the effects of the rest periods. In addition, the biomechanical similarities of plyometric exercises to subsequent activity were not examined, making it difficult to fully understand the PAPE effect. Another limitation is that the general performance level of participants was below that of elite athletes, which may have influenced the fatigue responses and the manifestation of performance improvements. Future studies including participants of varying performance levels would help clarify the impact of training status on PAPE. These limitations provide opportunities for future research with a larger population and the use of different methods.

Future research directions

Including individuals of different genders and training backgrounds, and a large sample size will increase the generalizability of the findings. It is also recommended to focus on different rest periods (15 –20 min) to investigate their effects on performance more comprehensively. Controlling the fatigue levels of the participants in the cross-over experimental design may contribute to obtaining clearer results. The use of different test protocols and techniques in the evaluation of vertical jump performance will lead to more diversified findings. Associating the control group's rest periods with different activities, rather than evaluating them independently, may yield more insights into the control group's impact. Examining the biomechanical similarities of plyometric CA will help to understand the effect of PAPE.

Applied implications

The findings of this study suggest that these findings were not statistically significant; however, a positive trend was observed, which should be interpreted as indicative rather than conclusive. These findings may contribute significantly to the development of training programs and the enhancement of athletic performance. In particular, associating plyometric exercises with rest intervals can help coaches and physically active males plan training strategies more effectively. Optimizing rest durations may reduce fatigue and enable physically active males to achieve higher performance. Additionally, considering the varying effects of rest intervals on individuals with different training backgrounds can be an important step in designing personalized training programs. Such tailored programs can allow physically active males to maximize their performance based on their individual needs. These findings may also help physically active males improve fatigue management strategies during training periods and achieve optimal performance on competition day.

Abbreviations

PAP	Post-activation Potentiation
PAPE	Post-activation Performance Enhancement
CA	Conditioning Stimulus
CONTROL	Participants Performed Control
PLIO4	Plyometric Preload with 4 min Rest
PLIO8	Plyometric Preload with 8 min Rest
PLIO12	Plyometric Preload with 12 min Rest
PPO	Peak Power Output

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Author contributions

Conceptualization, RŞ, AB, MA, SA, ZSSÖ, RK; methodology, RŞ, AB, SA; software, AB, SA; validation, RŞ, AB, SA, RK.; formal analysis, SA, ZSÖS, RK; investigation, RŞ, AB, MA; resources, AB, ZSSÖ, RK; data curation, RŞ, SA, RK.; writing-original draft preparation, RŞ, AB, MA, SA, ZSSÖ, RK, AKY; writing-review and editing, RŞ, AB, MA, SA, ZSSÖ, RK, AKY; visualization, RŞ, AB, SA, RK.; supervision: RŞ, AB, MA; project administration, AB, MA, SA, ZSSÖ. All authors have read and agreed to the published version of the manuscript.

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Data availability

Data supporting the findings of this study are available through the corresponding author, but restrictions apply to the availability of these data used for the current study and are therefore not publicly available. However, data are available from the corresponding author (sonerakgun@artvin.edu.tr) upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Alanya Alaaddin Keykubat University (Date: 04.12.2023, Approval No: 2023/07). Participants, who were informed about the purpose of the study, data collection and management, and the anonymity of measurements, signed informed consent forms. The data were processed with full respect for the anonymity of the participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

Not applicable.

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