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ACUTE EFFECTS OF FAST ECCENTRIC CONTRACTIONS WITH DIFFERENT LOAD ON THE POSTACTIVATION POTENTIATION

AKUTNI UČINKI HITRIH EKSCENTRIČNIH KONTRAKCIJ Z RAZLIČNO OBREMENITVIJO NA POSTAKTIVACIJSKO POTENCIRANJE

ABSTRACT

Background: This study aimed to investigate the acute effects of fast eccentric contractions with different load on the postactivation potentiation (PAP). Methods: Potentiation was performed using 3 sets of 3 repetitions with dynamic contractions (EC90%) at 90% of one repetition maximum (1RM), fast eccentric contractions at 60% (ECC60%), and 40% (ECC40%) 1RM on a sample of 20 students. The procedure was carried out in four sessions with a 7-day rest between sessions. Anthropometric measurements and 1RM assessment using the barbell squat on the Smith machine were conducted in the first session. Acute PAP effects were assessed based on kinematic parameters (h - maximal jump height) using pretest and posttest Countermovement Jump (CMJ) tests in the second, third, and fourth sessions. The rest period between the potentiation stimulus and CMJ was 6 minutes for all conditions. Results: Repeated measures ANOVA showed significant differences in jump height after all three types of potentiation ($p < .001$). Bonferroni post-hoc analysis revealed significant differences between EC90% (2.81 ± 1.08 cm) and ECC60% (2.45 ± 0.8 cm) potentiation ($p < .005$). Additionally, jump height after EC90% and ECC60% was significantly higher compared to ECC40% (1 ± 0.3 cm). Conclusions: The results suggest that dynamic loads of 90% 1RM, along with 60% and 40% via fast eccentric contractions, can be used for acute increases in CMJ height after 6 minutes of rest. Furthermore, potentiation with fast eccentric contractions and moderate load shows similar effects on CMJ height as dynamic submaximal loads, a valuable finding for strength and conditioning coaches.

Keywords: PAP, fast eccentric contraction, explosive strength, CMJ, OptoGait

IZVLEČEK

Ozadje: Namen te študije je bil preučiti akutne učinke hitrih ekscentričnih kontrakcij z različnimi obremenitvami na postaktivacijsko potenciranje (PAP). Metode: Potenciranje je bilo izvedeno s 3 serijami po 3 ponovitve z dinamičnimi kontrakcijami (EC90%) pri 90 % enega maksimalnega ponavljanja (1RM), hitrimi ekscentričnimi kontrakcijami pri 60 % (ECC60%) in 40 % (ECC40%) 1RM na vzorcu 20 študentov. Postopek je bil izveden v štirih sejah s 7-dnevnim premorom med njimi. V prvi seji so bile opravljene antropometrične meritve in ocena 1RM pri počepu s palico na Smithovi napravi. Akutni učinki PAP so bili ocenjeni na podlagi kinematičnih parametrov (h – maksimalna višina skoka) s predtestnimi in potestnimi testi skoka z uporabo protokola Countermovement Jump (CMJ) v drugi, tretji in četrti seji. Odmor med potencirajočim dražljajem in CMJ je bil za vse pogoje 6 minut. Rezultati: Ponovljena analiza variance (ANOVA) je pokazala statistično značilne razlike v višini skoka po vseh treh vrstah potenciranja ($p < .001$). Bonferronijeva post-hoc analiza je razkrila pomembne razlike med potenciranjem EC90% (2.81 ± 1.08 cm) in ECC60% (2.45 ± 0.8 cm) ($p < .005$). Poleg tega je bila višina skoka po EC90% in ECC60% značilno višja v primerjavi z ECC40% (1 ± 0.3 cm). Zaključki: Rezultati kažejo, da lahko dinamične obremenitve pri 90 % 1RM ter hitre ekscentrične kontrakcije pri 60 % in 40 % 1RM povzročijo akutno povečanje višine CMJ po 6-minutnem odmoru. Nadalje je potenciranje s hitrimi ekscentričnimi kontrakcijami in zmerno obremenitvijo pokazalo podobne učinke na višino CMJ kot dinamične submaksimalne obremenitve, kar je dragocena ugotovitev za trenerje moči in kondicije.

Ključne besede: PAP, hitra ekscentrična kontrakcija, eksplozivna moč, CMJ, OptoGait

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INTRODUCTION

Post-Activation Potentiation (PAP) is defined as a physiological phenomenon that leads to an acute increase in muscle force as a result of its prior activation (Borba et al., 2017; Dello, Martone, & Padulo, 2016). Prior activation, or the previous potentiation stimulus, is achived by performing an exercise with a load that is biomechanically identical or similar to the main movement executed afterward, but without the load (Seitz & Haff, 2016). Thus, the essence of PAP lies in the effect of heavier loads that cause a high level of neural stimulation, resulting in the recruitment of more motor units and a higher frequency of neural impulses (Blazevich & Babault, 2019). These positive physiological effects on the neuromuscular system, triggered by the previous potentiation, typically last acutely for 8 - 12 minutes (Kilduff et al., 2007). Despite numerous studies investigating the occurrence and effects of PAP, the exact physiological mechanisms have not yet been fully clarified (De Hoyo et al., 2015; Blazevich & Babault, 2019). The scientific community has proposed two main mechanisms: 1) phosphorylation of regulatory light chains of myosin, which makes actin and myosin sensitive to calcium released from the sarcoplasmic reticulum during subsequent muscle contractions (Tilin & Bishop, 2009; Bauer et al., 2019); and 2) Increased synaptic excitation of higher-order motor units, i.e., increased postsynaptic potentiation and subsequent increase in muscle force generation based on enhanced recruitment of fast motor units (Xenofondos et al., 2010) In addition to these two mechanisms, there are indications that PAP also contributes to changes in the pennation angle (Tilin & Bishop, 2009. The assumption is that after applying the potentiation exercise, the pennation angle of the muscle fibers decreases, which consequently results in greater force transmission through the tendon and ultimately to the bone.

Research has shown that PAP can be induced by various methods, including maximal voluntary isometric contractions, dynamic, concentric, and eccentric contractions, as well as post-tetanic contractions induced by the use of electrical stimulation on the muscle (Sale, 2002). Numerous studies have investigated the effect of submaximal loads (80-90% 1RM) through dynamic contractions on PAP (Wilson et al., 2013). The results have shown that performing squats (90% of 1RM) x 4 repetitions with dynamic (eccentric-concentric) muscle contractions has positive effects on Countermovement Jump (CMJ) height after a 3-minute rest (Bauer et al., 2019). A significant mean increase in CMJ height of 1.7 cm was also observed in a sample of 12 active athletes who performed squats at 85% 1RM x 3 repetitions (Evetovich, Conley, & McCawley, 2015). Furthermore, an increase in CMJ height of 1-3% was recorded in athletes after performing the last squat at 90% of 1RM with a 5-minute rest, while the effects were absent in recreational athletes (Chiu et al., 2003). However, the results of one meta-analysis showed that 104 (58.1%) out of 179 studies that used 80-90% 1RM loads had positive effects on PAP (Dobbs, Tolusso, Fedewa, & Esco, 2019). This suggests that the effects of submaximal dynamic loads may have limited application, which (Suchomel et al., 2019) attributed to significant mechanical and metabolic load. In contrast, eccentric contractions allow for the development of greater force with lower energy expenditure, which may represent an alternative strategy for inducing PAP with potentially less fatigue (Beato, Stiff, & Coratella, 2021).

Inducing PAP through eccentric muscle contractions can be performed in several ways, including supramaximal loads (i.e., Eccentric Overload) (Wagle et al., 2017), isoinertial machines (i.e., Flywheel) (Beato et al., 2021), depth jumps (Bridgeman et al., 2017), expanders or elastic bands (Aboodarda et al., 2013), adjusting external loads during the exercise by a coach or assistant (i.e., Accentuated Eccentric Load - AEL) (Tseng et al., 2021; Ditch, 2024), and releasing the load at the end of the eccentric phase of the landing (Sheppard et al., 2008).

The accentuation of the eccentric phase through AEL as a method has been examined in several studies, with varying loads and application modalities showing different effects on jump height. The optimal load for increasing jump height in trained athletes has been identified as 20% of body mass (BM) during depth jumps, with a significant effect observed after a two-minute recovery period (Bridgeman et al., 2017). Similar positive effects were recorded in young athletes after jumps with an additional load of 15% BM (Lloyd et al., 2021), as well as with the application of elastic resistance at 30% BM (Aboodarda et al., 2013). Additionally, CMJ with extra loading in the eccentric phase (20% and 40% BM) did not significantly enhance jump height but contributed to greater power output (Godwin et al., 2021). In contrast, applying a 10 kg load, which was released after the eccentric phase of the jump, led to a significant increase in jump height (Sheppard et al., 2008). An increasing number of studies are examining the use of flywheel inertial devices as an eccentric potentiation method. This modality has demonstrated effectiveness in enhancing jump height (Cormier et al., 2021), with protocols involving half-squats under moderate and high loads leading to significant improvements (Beato et al., 2021; Keijzer et al., 2020). However, only few studies have analyzed isolated eccentric contractions in the context of potentiation. While a half-squat with 85% 1RM in the eccentric phase alone did not significantly affect CMJ performance after a 2-minute recovery (Kannas et al., 2024), a 70% 1RM load induced a positive PAP effect after 3 minutes (Bogdanis et al., 2014). These findings highlight the importance of optimizing load, recovery duration, and eccentric phase velocity for effective PAP induction. Despite numerous studies on PAP, the optimal methods and loads for maximizing the effects of this phenomenon are still not fully understood, particularly in the context of eccentric contractions of varying intensities and speeds. Considering this, the aim of this study was to examine the acute effects of fast excentric contraction with different loads on PAP represented by the CMJ height. It was hypothesized that (1) moderate (ECC60%) and light (ECC40%) loads with fast eccentric contractions would lead to an acute increase in CMJ height, and (2) submaximal dynamic (EC90%) loads would have a greater acute effect on CMJ height compared to moderate ECC60% and light ECC40% loads with fast eccentric contractions.

METHODS

Participants

The sample consisted of 20 male students, from University of Banja Luka. The main characteristics were age = 21.4 ± 0.6 yrs, body mass = 88.8 ± 8.4 kg, height = 184.5 ± 5.4 cm, and body fat percentage: 16.3 ± 3.4%). The inclusion criteria for participation in the testing were: participants in normal health status, regularly involved in minimum two trainings with weights per week, free of muscle injuries in the last 6 months prior to testing, and with at least three years of experience in strength training with weights. All participants were informed about the potential risks and benefits of the testing and provided written consent for voluntary participation in the study. All procedures were conducted in accordance with the Helsinki Declaration (Williams, 2008). The ethical aproval for this study was approved by the Ethics Committee of the Faculty of Physical Education and Sport, University of Banja Luka (11.1/989/24).

Study design

The study had a pre-experimental design (one-group pretest-posttest). All measurements were conducted across 4 separate sessions with a 7-day break between each session (Figure 1). Anthropometric measurements and 1RM assessment in the barbell squat on the Smith machine were performed during the first session. The assessment of the acute effects of 3 different types of potentiation was carried out in the second, third, and fourth sessions. In the second session, a load of 90% of 1RM was used through dynamic (eccentric-concentric) contractions. In the third and fourth sessions, loads of 60 and 40% of 1RM were applied through fast eccentric contractions, respectively.

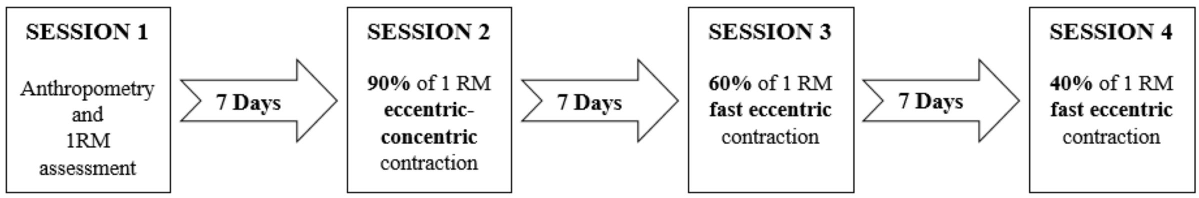

Figure 1. Study design.

Study procedures

All testing sessions were conducted at the Sports Institute, in the biomechanics laboratory of the Faculty of Physical Education and Sport, University of Banja Luka, in the morning (between 9:00 and 11:00 AM), to minimize variations in the participants circadian rhythms. In the first session, after familiarizing the participants with the experimental protocol, their body height was taken using stadiometer (SECA 206, Germany) with an accuracy of 0.1 cm and body composition using bioelectrical impedance (Tanita BC-418MA, Tokyo, Japan). At the beginning of each session, a standard warm-up protocol was carried out, consisting of 10 minutes of cycling on an ergometer (Monark, Sweden) at a constant load (1 W*kg of body weight). Immediately following the cycling, participants performed calistenics and mobility exercises and dynamic stretching for 6 minutes. Before the actual test protocols, participants performed 2 progressive warm up sets of 4 repetitions using the Smith machine with 40 and 60 kg (about 30% and 40% of 1RM), with a 3-minute rest between sets.

Assesment of 1RM

The 1RM assessment in the back squat was conducted under laboratory conditions on a modified Smith machine, specifically designed for this study. The Smith machine had standard dimensions and was equipped with four ball bearings, which reduced the friction coefficient to a negligible level. The average 1RM value was 148.4 ± 20.4 kg. The squat was performed with feet positioned parallel, slightly wider than hip-width, and to a depth of 90° in the knee joint. The knee joint angle of 90° was measured using the SG12F goniometer (Leica Vetronix, Germany), while the squat depth was individually controlled using a specially designed stopper placed behind the participant during the exercise (Figure 2). Participants performed a total of 12 repetitions with 5 different loads: 50, 60, 70, and 80% × 3 repetitions, and 90% × 1 repetition, based on the self-reported 1RM provided by each participant before testing. Participants were required to perform each repetition at the maximum possible speed in the concentric phase of the movement, while the researcher provided additional verbal motivation. Linear encoder

(Hontko HPSM1, New Taipei City 23545, Taiwan) was attached to the barbell, recording the displacement velocity of the barbell at sampling frequency of 1000 Hz. The vertical displacement of the bar and the load was recorded using a custom-written computer program (National Instruments LabVIEW, 2010, Austin, TX, USA), which low-pass filtered the signal using a recursive Butterworth filter with a cutoff frequency of 10 Hz. The derivation of data from the signal allowed for the calculation of the average velocity (Vmean), which, along with the load variable (kg), was used to obtain the load-velocity (L-V) profile. L-V profiles were assessed based on the calculated individual linear regressions using L and Vmean data at 5 different load magnitudes. Further, based on the multiple-point method and the recommended minimal velocity threshold (MVT) for the loaded back squat exercise, according to García-Ramos et al. (2023)**,** the 1RM was estimated for each participant.

Figure 2. The Smith machine used for testing and potentiation

PAP assesment

The assessment of the effects of different types of potentiation on PAP was conducted during the second, third, and fourth sessions based on the pre- to posttest changes in maximum jump height of CMJ. The CMJ test is widely used in sports science and practice to assess explosive strength and the functional capabilities of the lower limb muscles, demonstrating a high level of validity and reliability (Marković et al., 2004). Jump height was measured using an infrared system OptoGait (Microgate, Bolzano, Italy) following a standard manufacturer's protocol (Microgate S.R.L., 2023). OptoGait is an advanced system for analyzing gait, running, and jumping biomechanics, utilizing optical sensors to precisely measure various kinetic parameters. The reliability of this system has been confirmed in multiple scientific studies (Lee et al., 2014; Gomez, Vallejo & Losa-Iglesias, 2016).

The pre-experimental procedure is shown in (Figure 3). In second, third, and fourth testing session, participants performed an initial CMJ test consisting of 3 repetitions, with the best result used for further analysis. Then, after a 3-minute rest, potentiation was attempted by 3 reps of back squat at 90% of 1RM through a dynamic contraction in the second session, and fast eccentric contractions at 60% and 40% of 1RM in third and fourth session, respectively. Following potentiation, a 6-minute passive rest period was implemented, after which the post-test CMJ was conducted with 3 repetitions, again selecting the best result for further analysis. The potentiation treatment procedure was repeated in 3 sets with 3-minute rest intervals between sets. Potentiation through fast eccentric contractions was performed by instructing participants to descend rapidly through the eccentric phase of the movement until reaching a 90° knee joint angle. After each repetition, two assistants lifted the load to an initial standing position.

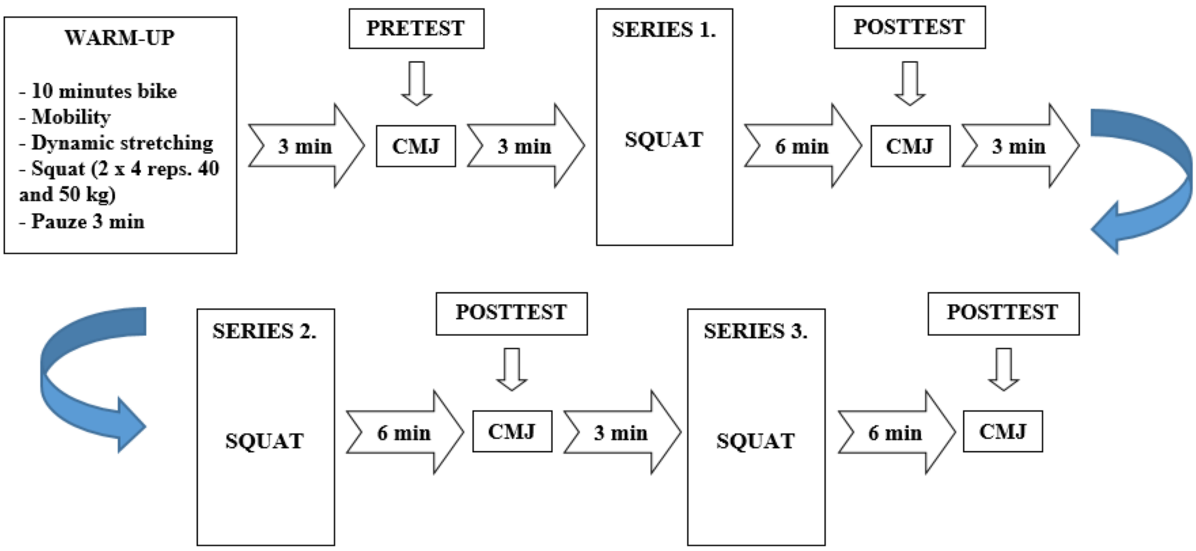

Figure 3. Schematic representation of the experimental procedure

Statistical analysis

All statistical analyses were conducted using JASP statistical software (version 0.18.3, Amsterdam, Netherlands). Descriptive data are presented as mean and standard deviation. The normality of data distribution was assessed using the Shapiro–Wilk test, and all variables were normally distributed. The effect of potentiation on jump height (i.e., PAP) was determined using a repeated-measures analysis of variance (ANOVA) with Bonferroni correction. The level of statistical significance was set at $p < 0.05$. Differences in the effects of various types of potentiation on the acute changes in CMJ height were analyzed using the Student's t-test for dependent samples. Effect sizes (ES) were represented by eta squared (η^2), where $\eta^2 = 0.01$–0.05 indicated a small effect, $\eta^2 = 0.06$–0.13 a medium effect, and $\eta^2 > 0.14$ a large effect. Additionally, the partial effect size was reported using Cohen's d, which was interpreted as trivial (<0.2), small (0.2–0.5), moderate (0.5–0.8), large (0.8–1.2), and very large (>1.2) (Sullivan & Feinn, 2012).

RESULTS

All three types of potentiation resulted in a statistically significant increase in CMJ height: EC90% ($F = 33.27$, $p < 0.001$, $\eta^2 = 0.63$), ECC60% ($F = 16.53$, $p < 0.001$, $\eta^2 = 0.46$), and ECC40% ($F = 4.99$, $p < 0.05$, $\eta^2 = 0.20$) (Table 1). Since the ANOVA results showed a violation of sphericity in the Mauchly test ($p < 0.05$) for ECC60% and ECC40%, the Greenhouse-Geisser correction was applied to minimize the likelihood of a Type I error. Post-hoc analysis revealed that the EC90% load (mean = 131.6 ± 17.2 kg) and ECC60% (mean = 88.7 ± 11.8 kg) had a statistically significant effect on vertical jump height after all three series. The average jump height after potentiation at EC90% increased by 2.81 ± 1.08 cm, representing a 7.3% improvement. (Figure 3). After analyzing the individual sets, the average increases in jump height were 1.5, 1.8 cm with a small effect size, and 2.6 cm with a moderate effect size, corresponding to 3.8%, 4.6%, and 6.6% in the first, second, and third sets, respectively. Furthermore, the average jump heights after the third set differ significantly compared to the jump heights after the first ($p = 0.002$) and second sets ($p = 0.038$), while there is no significant difference between the first and second sets.

Similar to EC90%, after potentiation with moderate load using fast eccentric contraction (ECC60%), significant differences were observed after all three series, $p < 0.001$, but with a small effect size. The average increase in CMJ height was 2.45 ± 0.8 cm, which is 6.8%, while the increases after the individual sets were 1.2, 1.6 and 1.9 cm, corresponding to 3%, 4%, and 4.7% after the first, second, and third sets, respectively (Figure 3). Jump height results between the series were not significantly different.

In comparison to the previous two potentiations, the low load, ECC40% (mean = 60.1 ± 10 kg) using fast eccentric contraction had the smallest effect on average jump height, 1 ± 0.3 cm, or 2.5%. Furthermore, ECC40% did not have a significant effect on CMJ height after the first two sets. After the third set, jump height was significantly higher, but with a small effect size compared to the pretest, 0.8 cm or 2% (Figure 3). Moreover, the average jump height did not significantly differ between the sets.

Table 1. Descriptive statistics and within-group differences at pretest and posttest.

	Pretest CMJ			**Posttest CMJ**			
Potentiation	**Mean**	**Std. Dev.**	**Series**	**Mean**	**Std. Dev.**	**t**	***d***
EC90%	39.6	4.6	PSTS1	41.1	5.0	5.96	0.29 ***
			PSTS2	41.4	4.8	6.60	0.35 ***
			PSTS3	42.2	5.1	8.26	0.51 ***
ECC60%	40.1	4.2	PSTS1	41.3	4.0	6.23	0.28 ***
			PSTS2	41.7	4.5	6.23	0.37 ***
			PSTS3	42.0	4.5	5.81	0.44 ***
ECC40%	40.2	4.2	PSTS1	40.4	4.4	0.86	0.04
			PSTS2	40.3	4.4	0.59	0.03
			PSTS3	41.0	4.3	5.90	0.17 ***

Notes. EC90% - eccentric-concentric contraction with 90% 1RM, ECC60% - fast eccentric contraction with 60% 1RM, ECC40% - fast eccentric contraction with 40% 1RM, PSTS1 - posttest series 1, PSTS2 - posttest series 2, PSTS3 - posttest series 3.t - obtained t-value; d - Cohen's effect size, *** Significant at $p < 0.001$.

The results showed that all analyzed differences, pretest and the highest jump heights in the posttest (Δ), significantly differ (Table 3). A moderate effect was observed when comparing (ΔEC90%) and (ΔECC60%), 0.36 cm, with a statistical significance of $p = 0.015$. The analysis of the differences between the changes in jump height (ΔEC90%) and (ΔECC40%), 1.81 cm, revealed a significant difference with an effect size *d* (95% CI: 1.23 - 2.78). Additionally, the effect of ECC60% is significantly greater on average jump height compared to ECC40%, 1.45 cm, with an effect size of *d* (95% CI: 1.31 - 2.92) (Figure 4).

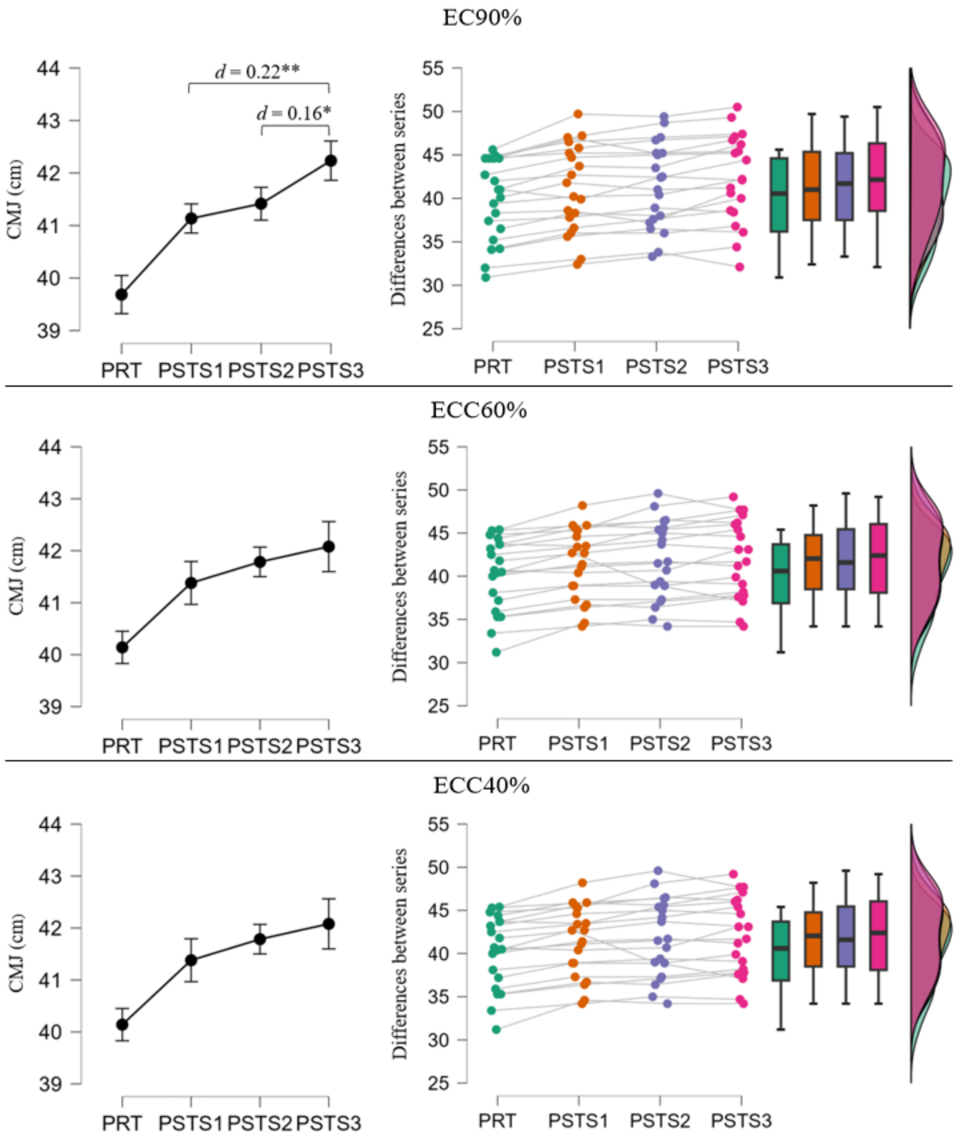

Figure 3. Differences between pretest and posttest across three series after applying three types of potentiation. Legends: PRT – pretest, PSTS1 - posttest series 1, PSTS2 - posttest series 2, PSTS3 - posttest series 3, d - Cohen's effect size, ** Significant at $p < 0.01$, * Significant at $p < 0.05$.

Table 2. Between-type differences in potentiation at the pretest and posttest.

Potentiation		t-test	*p*	Cohen's *d*
Δ EC90%	Δ ECC60%	2.68	<0.05*	Moderate
Δ EC90%	Δ ECC40%	9.02	<.001***	Very large
Δ ECC60%	Δ ECC40%	9.51	<.001***	Very large

Notes. ΔEC90% - differences between pretest and posttest, ΔECC60% - differences between pretest and posttest, ΔECC40% - differences between pretest and posttest, t - obtained t value, *** Significant at $p < 0.001$.

A difference of 0.36 cm was observed when comparing (ΔEC90%) and (ΔECC60%), accompanied by a moderate effect size. Data indicates that in most cases, higher CMJ values were achieved following the EC90% protocol compared to ECC60%, suggesting a more pronounced potentiation effect at submaximal intensity (Figure 4). All participants achieved significantly greater jump heights following ECC90% potentiation compared to ECC40%, where recorded changes were mostly minimal or close to zero, as confirmed by the observed difference of 1.81 cm in CMJ height increase, accompanied by a very large effect size. CMJ height was significantly higher after ECC60% potentiation compared to ECC40%. All subjects demonstrated an average increase of 1.45 cm in CMJ height after ECC60%, corroborating individual differences illustrated with an exceptionally large effect size (Figure 4).

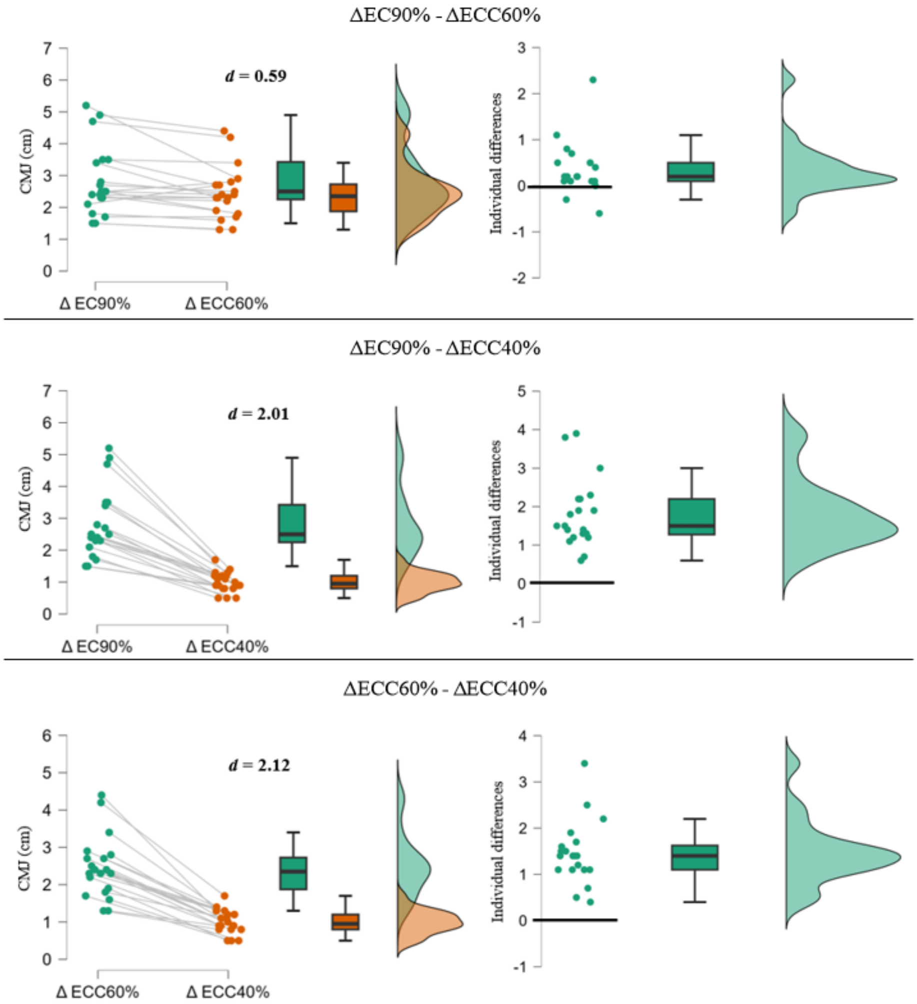

Figure 4. Differences between the acute effects of 3 types of potentiation on CMJ height Legend: ΔEC90% - differences between pretest and posttest, ΔECC60% - differences between pretest and posttest, ΔECC40% - differences between pretest and posttest, d - Cohen's effect size.

DISCUSSION

This study was designed to examine the effects of 3 different types of potentiation on the acute effects of CMJ height in students. Assumption was that: (1) moderate (ECC60%) and light (ECC40%) loads with fast eccentric contractions would lead to an acute increase in CMJ height, and (2) submaximal dynamic (EC90%) loads would have a greater acute effect on CMJ height compared to moderate ECC60% and light ECC40% loads with fast eccentric contractions. The results showed that all three loads significantly affected vertical jump height, with the greatest effect observed after the application of EC90%, with an average jump height increase of 2.81 ± 1.08 cm. The potentiation with ECC60% showed a significantly smaller acute effect on the increase in CMJ, 2.45 ± 0.8 cm, compared to EC90%, but significantly greater than the jump height after ECC40%, 1 ± 0.3 cm. In this regard, the hypotheses of this study were confirmed.

The average increase of 7.3% after potentiation with EC90% and a 6-minute rest suggests that this modality has the potential to acutely and significantly increase vertical jump height. The serial increases of 3.8%, 4.6%, and 6.6% after the first, second, and third sets, respectively, suggest that at least 3 sets of potentiation are needed to optimally induce PAP. These findings are consistent with the results of previous studies (Evetovich, Conley & McCawley, 2015; Bauer et al., 2019; Dobbs, Tolusso, Fedewa & Esco, 2019). Dynamic contractions with submaximal loads, such as 90% of 1RM, activate large motor units, and thus a large percentage of fast-twitch type II fibers, which are crucial for generating high force. Furthermore, generating high force during the potentiation exercise significantly influences the display of explosive strength in subsequent conversion exercises (Seitz et al., 2016). Therefore, previous research, which is supported by the results of this study, has shown that dynamic contractions with submaximal loads lead to an acute increase in CMJ height, and thus have acute effects on PAP (Tillin & Bishop, 2019).

A similar effect was observed after the application of potentiation with fast eccentric contractions and a 60% 1RM load, ECC60%, while the effect after the application of ECC40% was the smallest, but still practically significant. After potentiation with ECC60%, the average vertical jump height increased by 6.8%, which, compared to the jump height after potentiation with EC90%, is not a large practical difference, but still statistically significant. The average CMJ height after potentiation with ECC40% was 2.5% higher. Although these values are the lowest compared to the average jump heights after the previous two potentiations, EC90% and ECC60%, they still represent a significant practical acute increase. The serial increase in average vertical jump height after potentiation with ECC60% was lower than after EC90%, with increases of 3%, 4%, and 4.7% after the first, second, and third sets, respectively. interestingly, potentiation with ECC40% had an acute effect on increasing the average CMJ height only after the third set, by 2%.

According to our knowledge, this study represents the first investigation into the acute effects of fast eccentric contractions with moderate and low loads on post-activation potentiation (PAP) using this specific methodological potentiation framework. Although direct comparisons with previous research are challenging due to methodological differences, the observed PAP effects align with previous findings in the context of accentuated eccentric loading (AEL). Furthermore, the findings of this study confirm prior research on AEL potentiation, which has shown that PAP responses are load-dependent, although the results vary depending on the methodological implementation. While (Bridgeman et al., 2017) reported optimal improvements in countermovement jump (CMJ) with loads of 20% body mass (BM) during drop jumps, our results, using percentages of maximal load in a fast eccentric regime, suggest alternative relationships between potentiation and acute effects. The absence of effects in the early sets with ECC40% aligns with the findings of (Aboodarde et al., 2014), where loads of 20–30% BM improved kinetic force parameters but did not lead to an increase in jump height. However, potentiation in the third set with ECC40% is consistent with the results of (Popp Marin et al., 2021) on submaximal loading using resistance bands, potentially indicating a delayed manifestation of PAP effects when potentiation occurs at lower intensities. Discrepancies with (Godwin et al., 2021), who reported an increase in power without an improvement in jump height using eccentric phases with dumbbells, may be due to the 6-minute pause between load application and the subsequent vertical jump. The progressive improvement in vertical jump height across three sets following the intervention with ECC90% and ECC60% suggests cumulative neurophysiological adaptations, potentially through enhanced heavy myosin chain kinetics (Walker et al., 2016) and increased sensitivity of actin-myosin cross-bridges (Tillin & Bishop, 2019). Furthermore, this 6-minute rest period appears to reflect both the potentiation of neurophysiological excitability (Seitz & Haff, 2016) and the mechanisms of elastic energy storage (Kubo et al., 2002), with the third set achieving optimal temporal summation of these effects after potentiation with EC90% and ECC60%. However, the reduced response following potentiation with ECC40% in the initial sets indicates that there are load levels optimal for mechanical stimulation, where lower intensities may not have sufficiently activated high-threshold motor units or generated adequate tendon recoil forces (Bridgeman et al., 2017; Lloyd et al., 2021). These findings indicate a key interdependence between load magnitude, rest intervals, and movement patterns in the process of optimizing PAP through fast eccentric contractions.

Limitations

The sample size could have been larger and varied in terms of fitness levels, which would have allowed for the assessment of acute effects of different types of potentiation on CMJ height across more time frames, and after varying durations of rest periods. This might have revealed potentially greater effects of light loads after shorter rest periods than the 6 minutes used in this study. Including female participants could also highlight potential differences in response to all three types of potentiation. Additionally, using force platforms, as the gold standard for testing vertical jumps, would certainly have generated more variables for analysis and evaluation of acute PAP effects. Increasing the number of series could also be considered for further research.

CONCLUSION

Moderate load potentiation through fast eccentric contraction (ECC60%) can be effectively used for the acute increase in CMJ height. Furthermore, ECC60% induces similar acute effects on PAP as submaximal load through dynamic contraction (EC90%) during the back squat after a 6 minutes rest. However, it is important to highlight that PAP can also be triggered by applying potentiation with a small load through fast eccentric contraction (ECC40%). Although the subsequent increase in jump height was the smallest compared to the previous two types of potentiation, it is still practically significant. A 6-minute rest period between the potentiation exercise and CMJ can be considered optimal for achieving acute PAP effects after potentiation with EC90% and ECC60%. The increase in effect in later series suggests that multiple series may contribute to improving jump height. Given that this is the first study to investigate the acute effects of fast eccentric contractions with moderate and small loads on PAP in such a methodological framework of potentiation, further research is needed to confirm and expand these findings.

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Data availability statement: Data is available upon request: nemanja.zlojutro@ffvs.unibl.org.

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