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THE INFLUENCE OF REST INTERVALS ON COUNTERMOVEMENT JUMP PERFORMANCES FOLLOWING LOW-INTENSITY LOADED COUNTERMOVEMENT JUMPS

VPLIV INTERVALOV ODMORA NA IZVEDBO SKOKA Z NASPROTNIM GIBANJEM PO SERIJI SKOKOV Z NASPROTNIM GIBANJEM NIZKE INTENZIVNOSTI Z OBREMENITVIJO

ABSTRACT

The purpose of the study was to determine the influence of varying rest intervals on countermovement jump (CMJ) performances following low-intensity loaded countermovement jumps (LCMJs). Twenty-nine collegiate football players (age: 19.4 ± 1.1 years; height: 179.0 ± 5.1 cm; weight: 73.1 ± 8.0) from Tuzla University volunteered to participate in the study. They performed ten LCMJs using 15% of their 1 repetition maximum (1RM) squat. The subjects then executed a CMJ every 2 minutes until a total of 6 jumps had been completed. One-way repeated measures ANOVA showed significant differences in countermovement jump heights at various rest intervals, $F(2.23, 62.3) = 40.5$, $p < 0.01$, $\eta\rho^2 = .591$. A Bonferroni post hoc test revealed that the CMJs performed after 4 minutes (CMJ, standard deviation = 39.5, 4.38 cm) were superior among all pairwise comparisons after 10 LCMJs. In conclusion, the low-intensity LCMJs performed by the college football players led to the highest CMJ performances 4 minutes after the LCMJs.

Key words: rest intervals, jump, football players

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IZVLEČEK

Namen raziskave je bil ugotoviti vpliv različnih intervalov odmora na izvedbo skoka z nasprotnim gibanjem (CMJ) po seriji skokov z nasprotnim gibanjem nizke intenzivnosti z obremenitvijo (LCMJ). V raziskavi je prostovoljno sodelovalo 29 nogometašev študentov iz Tuzle (starost: 19,4 ± 1,1 let; višina: 179,0 ± 5,1 cm; teža: 73,1 ± 8.0 kg). Izvedli so 10 skokov LCMJ ob 15 % maksimalne vrednosti ene ponovitve (RM) počepa. Nato so športniki izvedli skok CMJ vsaki dve minuti, dokler niso opravili skupaj šest skokov. Enosmerna ANOVA za ponovljene meritve je pokazala pomembno razliko pri višini skoka z nasprotnim gibanjem pri različnih intervalih odmora, $F(2,23; 62,3) = 40,5$; $p < 0,01$; $\eta\rho^2 = .591$. Z Bonferronijevim post hoc testom smo ugotovili, da je bil skok CMJ, izveden po 4 minutah (CMJ, standardni odklon = 39,5; 4,38 cm) najboljši od vseh parnih primerjav po izvedenih 10 skokih LCMJ. Zaključimo lahko, da so nogometaši študenti pri izvajanju skokov LCMJ nizke intenzivnosti najbolje izvedli skok CMJ v 4. minuti po opravljenih skokih LCMJ.

Ključne besede: intervali odmora, skok, nogometaši

INTRODUCTION

Performing a preload stimulus before an actual activity can enhance the output of acute muscle force resulting in the occurrence of a phenomenon called post-activation potentiation (PAP) (Robbins, 2005). PAP can be attributed to the physiological reactions of the body from increased phosphorylation of myosin light chains and increased motor neuron excitability (Hodgson, Docherty, & Robbins, 2005). Using loaded ballistic exercises as stimuli may be effective in terms of PAP production. A study on the short-term effects of selected exercises and loads in contrast training on vertical jump performances showed that 30% of 1 repetition maximum (1RM) squat of a loaded countermovement jump (LCMJ) produced the greatest gains in countermovement jump (CMJ) height when compared to 60% of a 1RM squat LCMJ and a 60% of 1RM half-squat intervention (Smilios, Pilianidis, Sotiropoulus, Antonakis, & Tokmakidis, 2005). Similarly, Burkett, Phillips and Ziuraitis (2005) found that five repetitions of a weighted box jump warm-up utilising a 10% body weight external load were most effective in increasing vertical jumps. Another study involving the use of low-intensity (25–35%) and moderate-intensity (45–65%) explosive half-squats in warm-up protocols revealed that both interventions increased CMJ performance by 3.5% and 6.3%, respectively (Sotiropoulos et al., 2010).

The rest interval between PAP stimulus and actual activity can also play an important role in PAP. According to Robbins (2005), no gains in movement output are observed if the degree of fatigue is equal to or higher than that of the PAP. The resting period must be long enough for the individual to have achieved ample recovery from fatigue but must also be short enough to ensure that the acute potentiating effects on neuromuscular function caused by the loading stimulus have not yet subsided (Sale, 2007). A meta-analysis conducted by Wilson et al. (2013) showed better PAP gains between 7–10 minutes of rest interval than 3–7 minutes.

Understanding the PAP mechanism on LCMJs may assist practitioners in designing interventions to increase muscle performance. However, there seems to be a paucity in the literature on low-intensity LCMJ. This study aimed to contribute to scientific knowledge by studying PAP using a unique protocol. To the researchers' knowledge, there is no existing study on PAP involving a low-intensity plyometric stimulus using a LCMJ and its effects on the rest times of collegiate football players. Thus, the purpose of this study was to find the optimal rest interval that would produce a PAP response in the muscles of the lower body after performing a low-intensity LCMJ.

METHODS

Participants

Twenty-nine collegiate football players (age: 19.4 ± 1.1 years; height: 179.0 ± 5.1 cm; weight: 73.1 ± 8.0) from Tuzla University volunteered to participate in this study. They had competitive experience of 6.5 ± 2.1 years and had no history of neuromuscular disease or reported injury for the past six months. All participants signed a consent form and were informed about the purpose of the study, testing protocols, research benefits and potential risks. The Ethical Committee of Tuzla University approved the study with procedures conforming to the principles of the Declaration of Helsinki on human experimentation.

Protocol

The study was conducted over three sessions separated by 48 hours at the Exercise Science Laboratory of the Faculty of Physical Education and Sport, Tuzla University. The first day was dedicated to data gathering which included body height, body weight and body fat percentage. At the second session, the subjects were tested for their 1RM back squat. A general warm-up (GW) followed by a 1-minute light walk and dynamic stretching (DS) were implemented before the testing. The GW consisted of five minutes of running at a pre-set pace, which is equivalent to 12 circles around an 86 m circumference area. For the first four circles, the subjects finished each circle in 30 seconds. This was followed by the completion of 25 seconds per circle for the next four circles. In the last four circles, the subjects were required to finish each circle at 20 seconds. After 1 minute, the subjects executed 7 minutes of DS that consisted of: 1. straight leg march; 2. butt kicks; 3. carioca; 4. high knees; 5. reverse lunge with twist; 6. power shuffle; and 7. jogging followed by squats. DS 1-4 and 7 were done for 2 sets of 20 seconds. DS 5 was performed for 2 sets of 10 repetitions and DS 6 was executed for 2 sets of 20 metres. The rest interval between the sets and exercises was 10 seconds. Before testing for the 1RM back squat, the subjects were first informed of the proper form and technique in order to avoid any occurrence of injuries. In the RM squat testing, the subjects stood with a shoulder-width foot stance with the bar placed at the back of their shoulders. The subjects then bent their hips and knees while maintaining a normal lordotic posture and descended at an approximately 90 degree knee angle. Upon reaching the recommended depth, the subjects reascended to the starting position. The subjects were asked to avoid bouncing in the bottom position and letting their knees bend over their toes. An Olympic bar was used during this test and the maximum weight lifted without assistance represented the 1RM. The subjects performed: 1. estimated 50% of 1RM of 8–10 repetitions followed by a 1 minute rest; 2. estimated 70% of 1RM of 6–8 repetitions followed by 2 minutes' rest; 3. estimated 90% of 1RM of 2–3 repetitions followed by 3 minutes' rest; and 4. an estimated 100% of 1RM.

A load reduction or increment of 5–10% from the previous set was administered in the succeeding sets until 1RM had been achieved as evaluated by a trained tester. The rest interval after step 4 of the RM testing was 3 minutes. In the third session, the subjects performed a GW. Two minutes after the GW, the subjects performed 10 LCMJs which was 15% of a 1RM squat. The 10 LCMJs were performed one after another without rest between each repetition. The starting position for each LCMJ was similar to the CMJ protocol. However, the hands were placed on the bar resting on the back of the shoulders with the subjects being encouraged to keep the bar on their shoulders during the LCMJs. The weight of the bar used in the LCMJs corresponded to the appropriate weight to achieve 15% of 1RM squat. After the LCMJs, one CMJ trial was recorded every 2 minutes until 12 minutes post-LCMJ. In the CMJ testing, the subjects were asked to start from an upright position with straight legs and with their hands on their hips and execute a downward quick knee flexion of approximately 90 degrees before take-off. The subjects were instructed to land in an upright position, keeping their legs straight. However, the subjects were encouraged to bend their knees once foot contact had been achieved to reduce joint stress. The CMJ height in centimetres (cm) was estimated using a portable optical measurement device called the OptoJump System (Microgate, Bolzano, Italy).

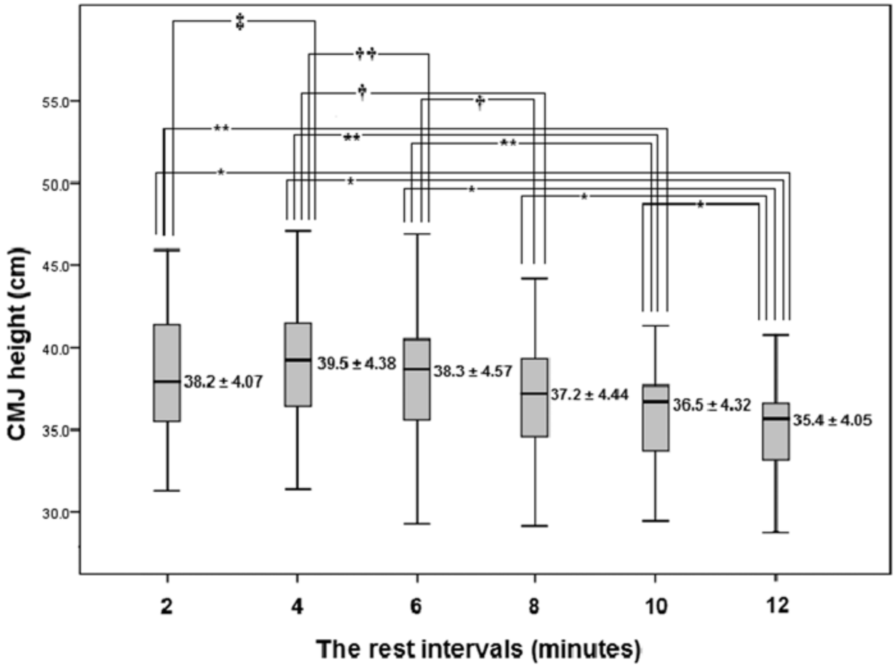
Analyses

Data are displayed as a mean, standard deviation. One-way repeated measures ANOVA was employed to establish significant differences in CMJs performed at various rest intervals. A Bonferroni post-hoc contrast was utilised to determine any significant pairwise comparisons. Partial eta-squared was used to estimate the effect size. Alpha was set at a 0.05 level of significance.

RESULTS

The CMJ heights at different rest intervals after the LCMJs are displayed in Table 1. Degrees of freedom were adjusted using Greenhouse-Geisser estimates of sphericity at $\varepsilon = .445$ after detecting violations in sphericity, Mauchley's $W = 0.76$, $\chi2\ (14) = 67.2$, $p = .000$. Results from one-way repeated measures ANOVA showed a significant difference in CMJs at various rest intervals, $F(2.23, 62.3) = 40.5$, $p < 0.01$, $\eta\rho^2 = .591$.

The Bonferroni post hoc test revealed that the CMJ at 2 minutes was lower than the CMJ at 4 minutes ($p = .003$), but was higher than the CMJ after 10 minutes ($p = .021$) and 12 minutes ($p = .000$). The CMJ at 4 minutes posted better outcomes than the CMJ at 6 minutes ($p = .002$), 8 minutes ($p = .000$), 10 minutes ($p = .000$) and 12 minutes ($p = .000$). The CMJ at 6 minutes showed higher values than the CMJ at 8 minutes ($p = .000$), 10 minutes ($p = .000$) and 12 minutes ($p = .000$). Better CMJ distances at 8 minutes



* Values significantly different from those obtained by the rest interval at 12th min.; $p < 0.05$.

** Values significantly different from those obtained by the rest interval at 10th min.; $p < 0.05$.

† Values significantly different from those obtained by the rest interval at 8th min.; $p < 0.05$.

†† Values significantly different from those obtained by the rest interval at 6th min.; $p < 0.05$.

‡ Values significantly different from those obtained by the rest interval at 4th min.; $p < 0.05$.

were discovered than at 12 minutes (p = .000). Lastly, the CMJ at 10 minutes was higher than the CMJ at 12 minutes (p = .000).

DISCUSSION AND CONCLUSION

The purpose of this study was to discover the rest interval at which potentiating effects in muscles would occur after a set of 10 LCMJs. Results of the study showed that the 4 minute rest interval led to the highest gains in CMJs with respect to other rest interval times. In the study, the time between 2nd to the 4th minute reveals the possibility of the existence of fatigue which masked the potentiating effects. However, sufficient recovery may have been achieved after 4 minutes of rest which showed positive effects on performance. Succeeding rest intervals displayed a decreasing trend in CMJ height, probably due to the decaying level of PAP. The findings of the study are in contrast with the meta-analysis of Wilson et al. (2013) which identified a better PAP existence between 7–10 minutes of rest than between 3–7 minutes after a heavy preconditioning activity. This inconsistent finding with the current study could be related to the utilisation of a light training stimulus which reduced the existence of fatigue at a smaller rest interval time.

PAP is the occurrence of enhanced muscle output following contractile history (Robbins, 2005). This phenomenon is closely linked to another theory called the fitness-fatigue theory. According to the fitness-fatigue theory, fatigue after exercise is characterised by a large magnitude and a short duration as opposed to fitness after effects, or in this case PAP, which has a small magnitude but a longer duration (Chiu & Barnes, 2003). The superior results posted at 4 minutes imply the optimum rest interval which may elicit a PAP response in the lower body when it comes to the use of LCMJ at 15% of 1RM squat as a stimulus. Numerous factors could have contributed to the results of the experiment. First of all, the light intensity but high volume exercise could have produced sufficient stimulus in the muscle to significantly increase the level of potentiation without causing a surge in fatigue levels (Smilios et al., 2005). Second, aside from less fatigue, the ballistic nature of the LCMJ itself may have contributed to the improvement in performance. In this study, jump height was the variable tested to determine if there was a PAP response in the muscle. Therefore, it was logical to use a functional intervention with movements very similar to the main exercise to be performed (Burkett et al., 2005). Tahayori (2009) suggested that an LCMJ intervention produces a positive effect on the force-velocity relationship by affecting the temporal aspects of the jump and timing of the movement sequence. Lastly, because the LCMJ is a plyometric exercise, muscle force output benefits could possibly be due to the storage of elastic energy in the muscle units (Clevidence, 2008).

In this study, the subjects were experienced football players. High-level athletes are believed to respond well to PAP because they are more tolerant to fatigue (Xenofondos et al., 2010). However, some studies using plyometric activities at a high level do not show any improvements (Mcbride et al., 2005; Till & Cooke, 2009). One possible explanation of the non-performance enhancement could be attributed to the lack of stimulation in low-intensity movements to produce PAP from athletes who are accustomed to high-resistance exercise.

One limitation of the study is that the scope of the study included analyses of only the acute effects of low-intensity LCMJ on jump height. Long-term effects and other parameters in movement abilities were not addressed. Hoffman et al. (2005) suggested that long-term training with loaded jumps may have the ability to induce a positive long-term muscular enhancement and improve sport performance factors other than the CMJ. The study also failed to detect mechanical values such as twitch contractions and rate of force development which may determine muscle contractile history across CMJ performances (Xenofondos et al., 2010). Finally, utilising various % RM loads in LCMJs and determining the PAP response at different rest intervals may provide valuable information to practitioners. The limitations of the current study may warrant further consideration in future studies.

In conclusion, performing a single set of 10 repetitions of LCMJs at 15% of 1RM squat produced a significant improvement in the CMJ performance of football players due to potentiating effects on the muscle. However, it should be noted that the PAP response was highest after 4 minutes of rest, following which the performance gradually started to degrade.

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