ORIGINAL ARTICLE

Effect of conditioning activity absolute intensity on seated shot put performance

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ABSTRACT

Conditioning activities are widely used in sports for improving performance in a subsequent main activity. Therefore, understanding the organization of these exercises is important for athletes. Therefore, the objective this study was to evaluate whether the conditioning activity absolute intensity affects the seated shot put performance. Twenty-four physically active male adults were subjected, every 24 hours apart and in a randomized manner, to the following situations: control (no conditioning activity), seat shot 2 kg ball; seated shot 4 kg ball and; seated shot 6 kg ball. Three minutes after these shots, participants performed the seat shot put main activity (4kg). To record the seat shot put performance, the greatest distance of the six attempts was considered. The shot put distance was greater in conditioning activity compared to the control situation ($p < .05$). There was no difference in shot put distance among conditioning activity situations ($p > .05$). In addition, individual analysis using typical error showed that 63% of the participants responded positively to the conditioning activities. In conclusion, despite the beneficial effect of the conditioning activity in relation to the control situation, there was no effect of the absolute intensity of the conditioning activity on shot put performance.

Keywords: Performance analysis, Training, Post-Activation potentiation.

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INTRODUCTION

Throwing objects of different shapes and masses is a common task in several sports, such as basketball, handball, American football, athletics, among others. In athletics. shot put is a sport in which the athlete throws a 4 kg or 7 kg iron ball, in the female and male categories, respectively, the greatest horizontal distance possible (World Athletics, 2023).

Performance in a sport or motor task is normally measured by physical values such as speed, in a sprint; duration, as in a Marathon; the height or distance of a jump or even the distance reached by an implement, as in throwing modalities in athletics. Throwing activities are characterized by a combined demand on muscular strength and power capabilities (Terzis et al., 2012). Strength is defined as the greatest capacity to generate tension by one or more muscle groups and power as the product of strength and speed, which is manifested by the ability to perform rapid movements in the face of external resistance (Turner & Comfort, 2022).

The conditioning contraction or conditioning activity (CA) are strength and power exercises, performed before the main activity (MA), used to improve the performance of the latter after a period of interval between them (Zimmermann et al., 2019; Evetovich, Conley and McCawley, 2015). CA can trigger a series of mechanisms of acute and temporary increase in physical performance, known as post-activation potentiation (PAP) (Sale, 2002; Evetovich, Conley and McCawley 2015). The mechanisms related to CA-induced PAP will generate greater excitability in the motoneuron group, resulting in greater recruitment of type IIx motor units, decreased pre-synaptic inhibitions and increased nerve impulse conduction speed (Zimmermann et al., 2019; Rodriguez-Falces et al., 2015; Docherty, Robbins, Hodgson, 2004).

In relation to muscular mechanisms, the increase in the activation of the myosin light chain and the increase in calcium (Ca^{++}) activity are mentioned. According to Rassier (2000), phosphorylation of regulatory myosin light chain (RCL) alters the conformation of the cross-bridges, placing the globular myosin heads in a position closer to the thin actin filaments. The second mechanism is associated with calcium (Ca^{++}) which, according to Batista et al. (2010), there is greater release of calcium by the sarcoplasmic reticulum, increasing its concentration in the sarcoplasm. The increase in sarcoplasmic Ca^{++} can lead to greater interaction with troponin, causing greater release of actin sites for connection of myosin cross-bridges. These two mechanisms may result in an increased capacity to generate muscle tension after a brief period of rest before of the MA (Zimmermann et al., 2019; Terzis et al., 2009; 2012, Wilson et al., 2013).

Various exercises, such as squats, jumps, and sprints, as well as their load configurations have been investigated as triggering PAP and acute improvement in physical performance (2013; Evetovich, Conley & McCawley, 2015; Hancock, Sparks & Kulman, 2015; Turner et al., 2015; Sarramian, Turner & Greenhalgh, 2015; Borba, Lopez & D'al Ferro, 2019). However, it seems that the effects of intensity through the manipulation of different values of CA external resistance (absolute intensity) have been little investigated. Thus, the present study aimed to evaluate how the conditioning activity absolute intensity affects performance in the main activity of seat shot put. As indicated in the literature (Borba et al. 2017), CA is expected to improve performance in seat shot put.

The results of the present study may contribute to a better understanding of the effects of AC intensity on the performance of physical exercises aimed at health, as well as sports performance before training and competition. Understanding the effects of CA can contribute to more effective prescription of physical exercise.

MATERIALS AND METHODS

Ethical procedures and sample

Twenty-four male volunteers participated in the research (Age: 25 ± 7 years; Body mass: 73 ± 13 kg; Height: 1.8 ± 0.1 m; Frequency of physical exercise: 4 ± 2 times a week; Duration: 90 ± 64 min.), after signing the Free and Informed Consent Form delivered by the responsible researcher. The procedures respected the standards of resolution 466/12 for research with human. The present study was approved by the University of Minas Gerais Stat (UEMG) Research Ethics Committee (no: 6.548.895).

For the sample calculation, the Gpower 3.1.9.2 software was used a priori, using the following parameters: effect size = 0.25 (based in Borba et al., 2018; 2019); significance level = .05 and power (1-β) = 0.8; F-test family for repeated measures. The inclusion criteria were: 1) individuals between 18 and 40 years old; 2) physically active individuals. Subjects who did not complete all experimental situations and/or presented any illness or injury that interfered with the exception activities during the stipulated experimental period were excluded from the sample.

Experimental design

This is an experimental and cross-sectional study with repeated measures, in which the subjects participated in four experimental situations, in addition to familiarization with the procedures, in a randomized manner and with a 24-hour interval between them:

a) Control (main activity only - official 4 kg shot put implement).
b) 2 kg ball throw followed by official shot put implement (2kg+4kg).
c) 4 kg shot put implement followed by the official shot put implement (4kg+4kg).
d) 6 kg ball throw followed by official shot put implement (6kg+4kg).

The first exercise is the CA and the second the MA. The greatest distance in six attempts was recorded as the seat shot put performance (meters).

Procedures

1st) On the first visit, the subject answered the readiness questionnaire to practice physical exercise. If the subject was in the habit, he was subjected to anthropometric measurements. Such measurements were carried out in the Physiology and Metabolism Laboratory located at the UEMG. Next, the subject was familiarized with the CA and MA.

2nd) In the second and other visits, the subject underwent experimental interventions in a randomized manner. The interval between the CA and MA was three (3) minutes. In the control situation, there was no CA, only the MA. The experimental situations took place in a flat, grassy area measuring approximately 100 m^2 located at the UEMG. Both CA and MA consisted of six throws. To record the seat shot put performance, the greatest distance of the six MA attempts was considered.

CA familiarization session

Two series of three throws were performed with each overload of CA (2kg, 4kg or 6 kg) in this order. Every three throws were given a 30-second interval. In the seat shot put, the volunteers remained seated in a chair with their back resting against the backrest; feet fixed on the ground holding the implement with both hands at chest height, touching the thumbs to the sternum; elbows open (away from the midline of the trunk) as suggested by Borba et al. (2019). Without losing contact with the back of the chair and feet with the ground, the participant threw the ball (or shot put 4kg implement) with both hands, extending the elbows. The throwing angle was established using a goniometer (Universal, CARCI®, Brazil) positioned with the centre at the midpoint of the shoulder, so that the side of the trunk and the arm form an angle of 20º. Furthermore, a horizontal ruler was placed and adjusted in front of the participant to guide the angle and direction of the throw. This form of throwing was chosen in order to minimize the participation of the lower limbs. Furthermore, the seat shot put technique is an easy for beginners to assimilate and learn (Jayaraman, 2015). All procedures were carried out between 2:00 pm and 4:00 pm, Monday to Friday.

Measurements

To describe the characteristics of the participants, height and body mass were measured using a digital scale with a stadiometer (Welmy®, Brazil) on the first day of the visit. Both body mass (kg) and height (m) were measured, with the volunteer wearing light clothing and barefoot. When stepping on the scale, the participant stood with their eyes facing the horizon. The researcher then recorded body mass and then positioned the stadiometer over their head to measure height. The participants' age, sex, weekly frequency, duration and type of physical exercise were also recorded. The estimated time for these measurements was 10 to 15 minutes and carried out by the same evaluator.

The seat shot put distance (MA performance), was measured with a tape measure to the nearest meter and centimetre. The zero point of the tape measure was positioned on the edge of the seat. The measuring tape was then stretched to the edge of the mark made by the implement on the ground closest to the zero point.

As control variables, rating of perceived exertion (RPE), total quality of recovery (TQR) and ambient dry temperature were collected. RPE was measured using the Borg scale from 0 to 10 adapted by Foster (2001), in which 0 means rest or not at all tiring and 10 means maximum effort. It would be applied five minutes after each experimental session. The TQR, in a similar sense, is a scale that starts at number 6, not recovered at all, and progresses to number 20, fully recovered, being applied at the beginning of the experimental sessions (Kenttä & Hassmén, 1998). The ambient temperature was checked at the during of each experimental session using a mercury thermometer.

Statistical analysis

Data were presented as mean ± standard deviation. Repeated measures ANOVA was used to compare performance between situations. The Mauchly and Shapiro-Wilk tests were used to analyse the sphericity and normality of the data. To determine the location of differences, Scheffe post hoc was used. The significance level for statistical difference adopted was less than 5%. The effect size of differences between situations in a pairwise manner was estimated using Cohen's d calculation for paired samples. Data were analysed using JAMOVI software version 2.3.28.

Furthermore, the volunteers' individual response to the intervention was assessed using typical error (Healy and Comyns, 2017). The mean and standard deviation (SD) of the control situation shot put distance for each participant were calculated. The positive effect of CA was considered when the high try shot put distance was 1.5 x SD greater than the average in the control situation. When the high try subject's performance was 1.5 x SD lower than the average in the control situation, the effect of CA was considered negative. Finally, if shot put performance was within ± 1.5 x SD of the mean, it was considered non-responsive to CA.

RESULTS

The repeated measures ANOVA indicated that the shot put distance was greater in situations with CA compared to control ($F = 7.03$; $p = < .001$; $\eta^2p = 0.023$). There was no statistical difference between the other comparisons ($p > .05$). In addition, there was no statistical difference for the variable TQR (F = 1.78; $p = .16$), RPE (F = 2.29; $p = .08$) and ambient temperature (F = 1.03; $p = .38$) among situations.

Table 1. Comparison of the seat shot put distance among experimental situations.

Situations	Mean	Standard deviation (m)
Control	3.88	0.510
2KG*	4.05	0.557
4KG*	4.06	0.568
6KG*	4.08	0.609

*Note. *Higher than control (p < .05). Cohen effect size: Control x 2kg = 0.7; Control x 4kg = 0.75; Control x 6kg = 0.71.*

Individual analysis using typical error indicated that the majority of participants responded positively to the CA, especially the 2kg situation. There was no negative response to the effects of CA (Table 2).

Table 2. Individual response to conditioning activity protocols.

Participant	Control mean	Control standard deviation	Inferior limit	Superior limit	2kg	4kg	6kg
P1	4.04	0.36	3.51	4.58	Positive	Positive	Neutral
P2	4.06	0.18	3.79	4.33	Positive	Neutral	Neutral
P3	4.59	0.14	4.37	4.80	Positive	Positive	Positive
P4	3.93	0.20	3.62	4.23	Neutral	Positive	Neutral
P5	3.81	0.10	3.66	3.96	Positive	Neutral	Positive
P6	3.67	0.21	3.35	3.99	Neutral	Neutral	Positive
P7	3.44	0.19	3.15	3.72	Neutral	Neutral	Neutral
P8	3.41	0.27	3.00	3.81	Neutral	Neutral	Positive
P9	3.58	0.18	3.30	3.85	Neutral	Positive	Positive
P10	3.37	0.07	3.25	3.48	Positive	Positive	Positive
P11	3.18	0.11	3.01	3.35	Positive	Positive	Neutral
P12	2.95	0.09	3.51	4.58	Positive	Neutral	Neutral
P13	2.93	0.36	2.38	3.47	Positive	Positive	Positive
P14	3.05	0.07	2.94	3.15	Positive	Positive	Positive
P15	3.85	0.32	3.36	4.33	Neutral	Neutral	Neutral
P16	4.05	0.29	3.61	4.49	Positive	Positive	Positive
P17	3.23	0.12	3.06	3.41	Positive	Positive	Positive
P18	4.33	0.36	3.79	4.87	Neutral	Neutral	Neutral
P19	4.03	0.15	3.80	4.26	Positive	Positive	Positive
P20	3.13	0.07	3.03	3.23	Positive	Positive	Positive
P21	4.67	0.54	3.86	5.47	Positive	Positive	Positive
P22	3.20	0.28	2.78	3.62	Neutral	Positive	Neutral
P23	3.61	0.19	3.33	3.89	Neutral	Positive	Neutral
P24	3.88	0.25	3.50	4.26	Positive	Neutral	Positive
Positive responses to conditioning activity					66%	62%	58%

DISCUSSION

The objective of the present study was to evaluate whether the absolute intensity of the conditioning activity (CA) would affect shot put performance. The results indicated that the CA seat shot put distance situations were greater compared to the control situation, which indicates the presence of post-activation potentiating (PAP) phenomenon. However, the CA absolute intensity did not interfere int the seat shot put performance.

Previous studies have also found improvement in shot put performance following CA protocols. Terzis et al. (2012) evaluated the effect of three counter-movement jumps and, at another time, a 20 m sprint on the shot put distance in subjects trained. The shot put distance was greater after the jumps (15.85 ± 2.41 m vs. 15.45 ± 2.36 m, p = .0003) and the sprint (15.90 ± 2.46 m vs. 15.34 ± 6 2.41 m, p = .0007) compared to the control situation. The authors attribute the results to PAP caused by the CAs performed.

In the same sense, Borba et al. (2018) would evaluate the effect of two sets of five maximum repetitions on the bench press on the shot put distance in untrained male subjects. The shot put distance was greater in the bench press CA in the compared to the control situation (8.2 ± 1.2 m vs. 7.8 ± 0.8 m; p = .009). Once again, the authors attribute the acute improvement in performance to PAP mechanisms triggered by CA.

Still on this topic, Evetovich, Conley and McCawley (2015) investigated the effect of three maximum repetitions in the bench press and three maximum repetitions in the squat on shot put performance in university athletes of both sexes. Contrary to previous studies, there was no effect of CA squats on shot put distance. However, the shot put distance increased after performing the bench press CA compared to the control situation (11.91 ± 1.81 m vs. 11.77 ± 1.81; $p \leq .05$). The authors attribute the result to the specificity of the muscle group involved in CA of the upper limbs (bench press) compared to CA performed on the lower limbs (squat). Furthermore, despite probably having increased central activation, it can be thought that the lack of CA effect on the lower muscles is due to the non-activation of the local muscular mechanisms involved in throwing. Therefore, it can be imagined that central and muscular mechanisms have different importance in PAP, at least for the main throwing activity.

In general, the mechanisms related to PAP are related to the increase in the conduction speed of nerve impulses to the muscle and greater activation of type IIx motor units (Rodriguez-Falces et al., 2015). CA generates greater excitability in the set of motoneurons, resulting in greater recruitment of motor units, decreased pre-synaptic inhibitions and increased nerve impulse conduction speed (Docherty, Robbins, Hodgson, 2004),. At the muscular level, studies indicate that CA improves the positioning of contractile filaments and greater availability of ion calcium (Ca^{++}) from the sarcoplasmic reticulum (Rodriguez-Falces et al., 2015; Docherty, Robbins, Hodgson, 2004). Thus, all these adjustments increase the muscle's ability to generate tension and speed movements.

Adding, Zhi et al. (2005) reports that greater manifestations of PAP occur in trained individuals, due to the fact that this group has greater ease in recruiting type IIx motor units compared to untrained individuals. Kristiansen et al. (2016), explain that this fact occurs because this motor unit has a greater capacity for phosphorylation of myosin light chains, along with a CA. However, untrained individuals may also experience a PAP improved performance after performing CA (Borba et al., 2018; 2019), which corroborates the results of the current study.

The present study obtained results similar to those in the literature, showing an improvement in seat shot put performance after the CA protocols, which probably activated one or more PAP mechanisms. However, differently from the literature, the present study sought to evaluate different degrees of absolute CA intensity on strength/power performance. However, the results did not indicate a different effect between absolute intensities in triggering PAP in a throwing activity. It was expected that greater CA intensities would result in greater distances, due to the greater probability of greater recruitment of type IIx motor units, for example.

Perhaps the best explanation for the lack of difference in performance between CA situations is due to the impossibility of identifying the value of the relative intensity imposed on each participant. For example, Fukutani et al. (2014) showed, in plantar flexion, the extent of PAP was significantly larger as the conditioning contraction intensity increased up to 80% maximal voluntary contraction (MVC). In contrast, the extent of PAP in thumb adduction increased significantly only up to 60% MVC ($p < .05$), but not at higher intensities. Thus, these results indicate that the effects of CA intensity depend on the group or muscle action evaluated.

Still on this topic, the difficulty in throwing probably varied among participants due to differences in strength capacity among them. In other words, the relative muscular tension during the throwing of the 2 kg ball in a weaker subject could be similar to the tension generated by a stronger subject when throwing the heavier ball, which would equalize the situations among the participants. Therefore, the relative intensities used would be similar in terms of the magnitude of the PAP mechanisms. Finally, the results of the present study also do not rule out the hypothesis that greater differences between the intensities of CAs are necessary. The values used in the present study were in the range of 100 to 200% difference between the CA loads. It may be that greater intensities are necessary to find differences among situations used.

Regarding individual analysis (typical error), the present study showed that the majority (63%) of participants responded positively to the intervention with CA. This type of analysis is mainly justified in the sporting world. It is important as some athletes may respond, be indifferent, or even reduce performance after a CA (Zimmermann et al., 20219). For example, on a track and field relay race team, it is possible that two of the best athletes of the four members present negative responses to CA. However, the coach assumes that CA is beneficial for the group. Thus, the decision could harm its best athletes and compromise the team's results. Therefore, it is suggested that in addition to the average CA results, analysing individual responses is relevant in the sporting context.

The present study is not free from limitations. As described, the physiological mechanisms associated with PAP were not measured. Therefore, it is suggested that new studies add measures to the physiological variables related to PAP. Furthermore, the present study was not able to identify the relative intensity applied by the volunteers. Therefore, it was not possible to guarantee similar tensions between participants in each situation.

CONCLUSION

The results of the present study indicated that the conditioning activity absolute intensity does not affect seat shot put performance. However, the conditioning activities were able to trigger post-activation potentiating, since the seat shot put distance was greater compared to the control situation. Overall, participants responded positively to the conditioning activity effects. Future studies with higher the conditioning activity intensities, prescription based on relative intensity, as well as measurements of the physiological mechanisms that trigger post-activation potentiating are indicated to improve the understanding of the conditioning activities effects on physical and sports performance.

AUTHOR CONTRIBUTIONS

Borba, D. A.: Design of the study question; construction of the study design; data analysis; article writing; review of the article final text. Ribeiro, L. Construction of the study design; data analysis; data collection; article writing; review of the article final text. Lacerda, L. T. Construction of the study design; data analysis; article writing; review of the article final text. Brandão, C. F. C. M.: Article writing; review of the article final text. Vieira, Y. L. M.: Data collection; review of the article final text. Drummond, L. R.: Article writing; review of the article final text.

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No potential conflict of interest were reported by the authors.

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