 DOI: http://dx.doi.org/10.1590/S1980-6574201800040003

Original Article (short paper)

Bench press exercise performed as conditioning activity improves shot put performance in untrained subjects

Diego de Alcantara Borba[1,2], João Batista Ferreira-Júnior[3], Marcos Vinicius Dias Ramos[1], Rafael de Leon Dumont Gomes[1], Juliana Bonhen Guimarães[1], João Roberto Ventura de Oliveira[1]

[1]Universidade do Estado de Minas Gerais, UEMG, Departamento de Ciências do Movimento Humano, Ibirité, MG, Brazil; [2]Universidade de Itaúna, Faculdade de Educação Física, Itaúna, MG, Brazil; [3]Instituto Federal do Sudeste de Minas Gerais, IFMG, Rio Pomba, MG. Brazil

Abstract — **Aims:** The aim of the present study was to evaluate the effect of bench press exercise performed as conditioning activity on the shot put performance in untrained subjects. **Methods:** Twelve healthy men (26 ± 6 years; 1.8 ± 0.1 m; 73.5 ± 10.4 kg; 13.2 ± 5.2% body fat), with no experience in shot put, were randomly assigned into two conditions: 1) Control: subjects performed six shot put attempts, and 2) Bench press exercise: subjects performed six shot put attempts 7 min post 2 sets of 5 repetitions maximum (RM) of bench press exercise. A metal ball of 4 kg was used for shot put attempts, and subjects were instructed to perform each shot put according to the static shot put technique. **Results:** Shot put performance was greater after bench press condition when compared with control condition (8.2 ± 1.2 m vs. 7.8 ± 0.8 m, respectively, $p < 0.05$). In addition, eight out of 12 volunteers positively responded to the conditioning activity. **Conclusion:** The results suggest that bench press exercise performed as a conditioning activity improves shot put performance in untrained subjects. Moreover, the conditioning activity should be individually set.

Keywords: athletics; post-activation potentiation; preparatory activity.

Introduction

Athletes use to perform conditioning activities (CA) before training or competition in the expectation that such activities lead to performance improvement. Indeed, it has been suggested that strength or power exercises performed as CA can improve physical performance[1-3]. This transient potentiation effect of conditioning activities on performance is caused by physiological changes called post-activation potentiation (PAP)[4,5].

The main alterations triggered by the strength or power CA are an increase on motor units recruitment, improvement of synchronization and conduction velocity of nerve impulses, inhibition of antagonist muscles [6,7,8], enhancement in the interaction mechanism of cross-bridge formation and an increase of cytosolic Ca2+ concentration[9,10]. Such changes would allow more coordinated and faster movements[11,12]. Thus, athletes from sports modalities that require high strength, power and speed can benefit from PAP induced by CA. Terzis, Karampatsos, Kyriazis, Kavouras, Georgiadis[13] found an improvement of shot put performance 1 min after 3 countermovement jumps in experienced shot putters. Evetovich, Conley, McCawley[2] also found an increase on shot put distance 5 min after 3 repetitions maximum (RM) of bench press exercise. An important aspect to be highlighted is that both studies evaluated athletes. To the best of our knowledge, no study has evaluated the effect of bench press exercise performed as CA on shot put performance in untrained men. The evaluation of this issue could be important from a practical standpoint since muscular strength is a physical capacity that can limit performance and learning of shot put.

In addition, to date, studies investigating the effects of CA on shot put performance have not taken into account the individual responses to CA reducing its practical applicability. As described above, the PAP depends on the individual characteristics[6,7]. Thus, it seems more appropriate to evaluate the effects of PAP protocols individually, since in the same group there may be subjects responding positively and others not[14]. Therefore, the aim of the current study was to evaluate the effect of bench press exercise performed as conditioning activity on shot put performance in untrained subjects. Based on the PAP mechanisms, it was hypothesized that bench press exercise would lead to greater shot put performance.

Methods

Subjects

The sample size was determined using the GPower software (version 3.1.2; Franz Faul, Universitat Kiel, Germany), considering the following specifications: family test = t-test, statistical test = difference between two dependent means (matched pairs), tails = two, d effect size = 0.9, $\alpha = 0.05$, power $(1-\beta) = 0.8$. Twelve untrained men (age: 26 ± 6 years; height: 1.8 ± 0.1 m; body weight: 73.5 ± 10.4 kg; body fat: 13.2 ± 5.2%) volunteered for this study. The inclusion criteria were subjects: a) between 18 and 40 years, b) who accomplished all technical requirements of the static shot put, c) with at least six months of experience with bench press exercise, and d) who answered no to all questions of the Par-Q physical activity readiness questionnaire[15]. All subjects were informed of the procedures and risks before giving written informed consent to participate in the study. Approval for study procedures was obtained from The Research Ethics Committee of the State University of Minas Gerais (1.306.982). The procedures respected the research resolution with human of the National Health Council, Brazil.

Experimental design

Two to three days prior the beginning of the experimental conditions, volunteers attended the laboratory on two occasions for study procedures familiarization and for physical characteristics measurement. To evaluate the effect of the bench press exercise on the shot put performance, volunteers performed six attempts of a static shot put 7 min following each of the two conditioning protocols, in a randomized and balanced fashion, 2 to 3 days separating each condition. The conditioning activities were: 1) Control (CON) - subjects performed no conditioning activity; 2) Bench press (BP) - subjects performed 2 sets of 5 RM of bench press exercise. All visits took place at the same time of the day to minimize the circadian effects. The subjects were instructed to maintain their normal daily activities, but they were asked to not perform strenuous exercise 24 h before each visit. In addition, they were instructed not to take caffeine, supplements, and alcohol during the study period.

Familiarization sessions

Each familiarization session consisted of 4 sets of the10 shot put (implement of 4 kg). In order to facilitate the learning of static shot put technique, the first set of the first familiarization session was preceded by 10 throws using a ball of 400 g, which contained the same circumference of the official implement. At the end of the second familiarization session subjects had to accomplish all technical requirements of the static shot put, which were: a) the implement kept in the palm of the hand, pressed against the neck and below the ear, elbow abducted and kept away from the trunk, trunk slightly rotated laterally, with feet shoulder width apart; b) hip and trunk rotation before the onset of arm movement, and c) elbow extension of the throwing arm, keeping the elbow high and thumb down, extension of the ankles, knees, and trunk at the end of the throw. They were considered able to continue in the study when they carried out at least four attempts consecutively according to the technical requirements of the static shot put. The volunteers received verbal instruction and demonstration of the correct static shot put technique whenever necessary. The static shot put was chosen in order to minimize the lower limbs involvement. In addition, this technique consists of fast assimilation and easy learning for novice subjects[16].

Anthropometrics measurements

Body mass and height were measured using a stadiometer (Welmy®, Santa Bárbara D'Oeste, SP, Brazil). The skin folds of the triceps, pectoral, subscapular, subaxilla, abdominal, suprailiac and mid-thigh were measured using a plicometer (Cescorf®, Porto Alegre, RS, Brazil), and body fat were estimated according to the Jackson and Pollock[17].

5 RM test

The load of the BP protocol was determined by the 5 RM test according to Baechle and Earle[18]. Volunteers warmed-up by performing 1 min of free dynamic stretching. Then, the 5 RM load was achieved with no more than six attempts with 3 min of rest between attempts. A load was adjusted with weight plates starting at 1 kg. The test was interrupted when the subject reached concentric failure. Subjects returned to the laboratory 2 h later to perform the 5 RM retest. Test-retest reliability coefficient (intraclass correlation coefficient [ICC]) was 0.99.

Conditioning activity protocols

Prior the experimental conditions, the volunteers warmed-up by cycling for 5 min on a cycle ergometer (Maxx Pro®, Indaiatuba, SP, Brazil) with a cadence of 80 rpm and a load of 0.5 kg, followed by 1 min of upper-body dynamic stretching. For the control protocol, the subjects performed no conditioning activity. The BP protocol consisted of 2 sets of 5 RM of bench press exercise and 3 min of rest between the sets. The same investigator conducted all conditioning activity procedures.

Shot put performance assessment

Shot put performance was measured by using a millimeter tape. The zero ends of the tape was placed at the nearest mark made in the ground, and then the tape was pulled through to the center of the circle. The shot put performance was considered the distance from the closest mark made by the implement up to the point where the tape crosses the inside edge of the circumference of the circle. The volunteers performed six throws 7 min after each conditioning protocols using a metal ball of 4 kg. It was given 1 min of rest between each throw. The throw with the longest distance was considered for statistical analysis.

Statistical analyses

Distribution normality and homogeneity of the data were initially assessed by using the Shapiro-Wilk and Levene's tests, respectively. Data were expressed as the mean ± standard deviation, and the level of significance adopted for all analyses was $P < 0.05$. The paired t-test was used to compare the distance of the best throw between both CON and BP conditions. Cohen's d effect size was calculated from the difference between the CON and BP conditions divided by the pooled standard deviation to examine the magnitude of conditioning activity effect[19]. The obtained d values were used to define trivial ($d < 0.2$), small ($0.2 < d < 0.5$), medium ($0.5 < d < 0.8$) and large ($d > 0.8$) effect sizes[19]. In addition, individual responses were assessed by taking into account a threshold of 1.5 times the typical error[14,20]. Subjects who had shot put performance greater and lower than 1.5 times typical error were considered positive and negative responders, respectively[14]. Finally, if throws performance were within 1.5 times the typical error, the subject was considered nonresponder[14].

Results

Shot put performance was higher after the BP protocol (8.2 ± 1.2 m) when compared to the CON protocol (7.8 ± 0.8 m) (t = 3.15, p = 0.009; power = 0.8, *d* = 0.4, Figure 1).

Figure 2 shows the individual responses to BP protocol. Eight volunteers were positive responders (A-H), one was a negative responder (I) and three were considered non-responders (J-L).

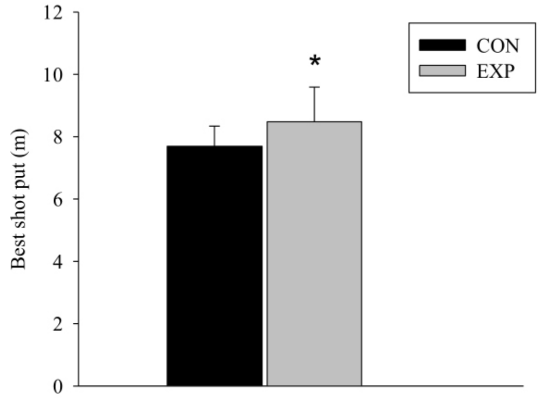

Figure 1. Mean ± SD of the shot put CON and PB situation.[*] p< 0.05, maior que CON).

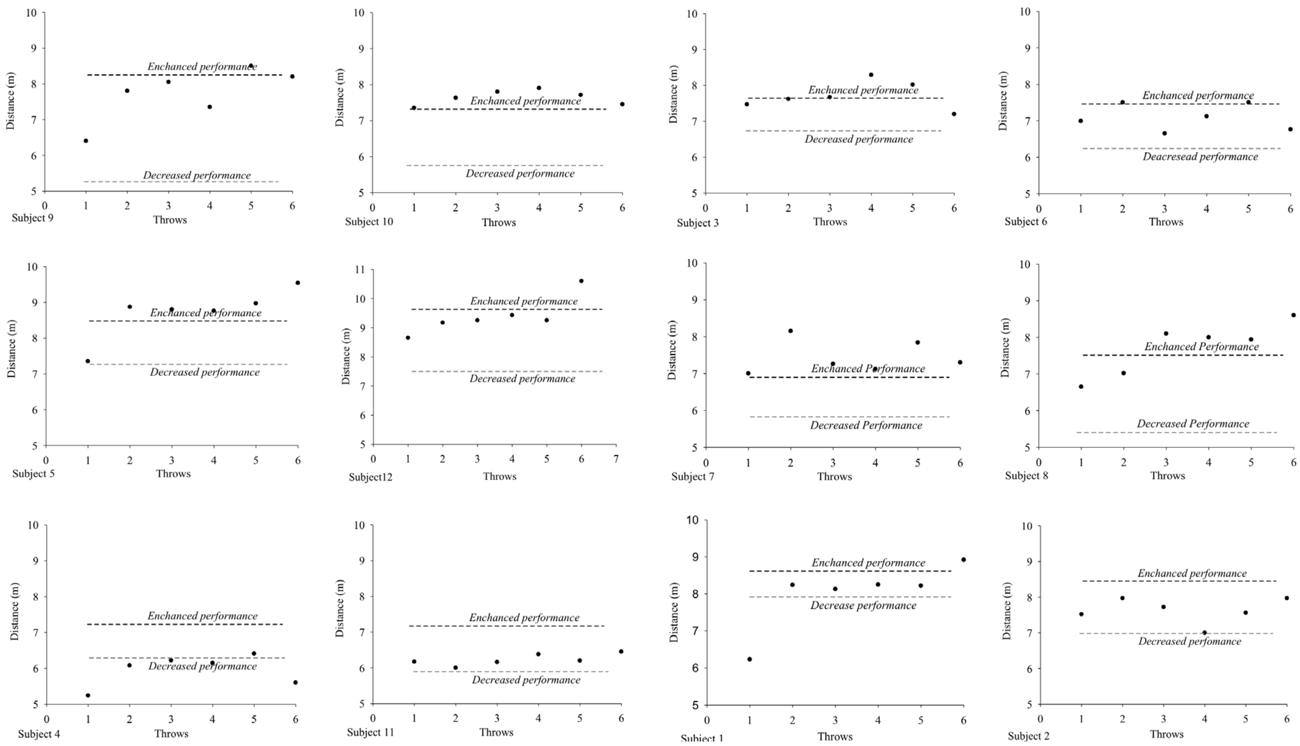

Figure 2. Individual response to the BP protocol. Each point represents a throw. Throws above the upper dashed line represent improved performance while throws below the lower dashed line represent performance worsening. Throws between dashed lines shows that there was no response to CA.

Discussion

Assessing the effect of CA is of interest for coaches, and strength and conditioning trainers, since it is performed before various types of main exercises, ranging from leisure to high-performance exercises. CA is also performed by subjects from different levels of training, from untrained subjects to athletes. Thus, the present study aimed to evaluate the effect of bench press exercise performed as conditioning activity on shot put performance in untrained subjects. It was observed an improvement of 5.13 % in the shot put performance in untrained subjects 7 min post 2 sets of 5 RM bench press exercise. Additionally, there was an individualized response to BP protocol. This result may be attributed to the mechanisms of PAP[4,5,7], since muscle strength may be enhanced to post a maximal voluntary contraction.

Angle and velocity of implement release are the main biomechanical parameters that affect shot put performance[21,22]. These both parameters are determined mainly by the rear-knee extension[23]. Certainly, the greater the strength and power produced on rear-knee, greater the force transferred to hip rotation and then to shot put release[23]. The BP protocol evaluated in the current study is an exercise that involves upper joints and muscles used in shot put. During the bench press exercise, horizontal adduction and elbow extension movements are performed, with activation of the pectoralis major, deltoid and triceps brachii muscles[24,25]. During the final phase of the shot put, the implement is vigorously pushed up and forward, in which subjects performed shoulder horizontal adduction and elbow extension[26]. Additionally, PAP is more likely to occur if the conditioning activity is specific to the main exercise[27,28]. Therefore, the bench press exercise appears to be a suitable CA to activate PAP mechanisms and improve shot put performance by increasing implement velocity release. On the other hand, the possible effect of CA composed of knee flexion exercise was not investigated. Thus, further studies should evaluate if combining both knee flexion and shoulder horizontal adduction exercises result in the greater shot put performance. Moreover, further studies are required to assess the effect of conditioning activities on shot put biomechanical parameters.

Maximal voluntary contractions may improve jump, sprint and throw performance. Terzis, Karampatsos, Kyriazis, Kavouras, Georgiadis[13] found an increased shot put performance 1 min after three countermovement jumps in experienced shot putters (Control: 15.45 ± 2.36 m, CA protocol: 15.85 ± 2.41 m). Evetovich, Conley, McCawley[2] also found an increase on throw distance in college athletes 5 min post 3 RM of bench press exercise (Control: 11.77 ± 1.81, CA protocol: 11.91 ± 1.81 m). Karampatsos, Terzis, Polychroniou, Georgiadis[29] reported greater distance in the hammer throw 1 min post both three countermovement jumps (Pre: 62.92 ± 4.43 m vs. Post: 64.42 ± 5.13 m) and 20 m sprint (Pre: 64.87 ± 3.90 m vs. Post: 65.30 ± 4.02 m) in experienced male throwers. Similarly, the results of the present study suggest that maximal muscle action of upper limbs leads to acute improvement of shot put performance in Beginners.

It has been reported a greater PAP manifestation in trained individuals probably due to their high capacity to recruit type IIx motor units, which are most affected by PAP mechanisms[30]. This type of motor unit has a greater ability to phosphorylate the myosin light chains before CA[31]. However, PAP can also occur in untrained subjects. A recent meta-analysis[32] reported a moderate effect of CA on muscle strength in trained subjects and small effects in untrained subjects. The result of the present study is in agreement with Seitz and Half[32] since bench press protocol caused a small effect (d = 0.4) on the shot put performance.

The PAP phenomenon and consequently the acute performance improvement is mainly attributed to the myosin light phosphorylation increased by an intense muscular action. This mechanism involves modulation of the intrinsic nature of actin-myosin interactions following muscle contraction[9,10]. PAP also involves changes in conduction, stimulation and recruitment capacity of muscle fibers, such as speed improvement of nerve impulse conduction to muscle fiber[8] and an increase in recruited motor units number, especially type IIx[6,7]. Thus, the highest performance observed in the BP condition may be due to the physiological changes described above. However, caution is needed with this hypothesis, since none of these physiological mechanisms was assessed in the current study.

As demonstrated, eight out of 12 volunteers positively responded to the CA. This individualized response to BP protocol is in agreement with other studies[27,33] and can explain the small effect size observed in the current study (d = 0.4). To date, it is unclear why CA does not benefit some individuals. Some hypotheses may emerge from the findings of the present study. One is that performing a CA can result in fatigue. According to Rassier and Macintosh[34], the balance between the PAP and fatigue mechanisms determines the performance of a main activity. If there is an imbalance in favor of fatigue, muscle performance will be impaired. On the other hand, if the imbalance is in favor of PAP mechanisms, performance will increase. Taking into account that the sample of the present study was composed of untrained, with different fitness levels and that CA and rest before the main activity were the same for all subjects, it is possible that fatigue overlapped the PAP mechanisms in those subjects who did not present a positive response to AC. Another factor that may explain the individual responses to CA is the predominance of the motor unit type. Previous studies have shown a greater PAP in subjects with higher percentage of type II fibers, indicating that this type of motor unit is more susceptible to PAP[35,36]. Individual responses to CA suggest that the prescription of CA must be individualized.

In addition, the present study is not without limitations. The mechanisms associated with PAP were not evaluated. Thus, further researches should investigate the physiological changes linked to bench press protocol. In addition, as previously described, CA potentiating effects are more pronounced in trained subjects. Due to the small availability of this population, the present study investigated untrained subjects, which would not be the ideal to evaluate the PAP phenomenon, due to the strength and technique variability among this subjects[32]. On the other hand, the typical error analysis used in the preset study allowed minimizing the individual effects in PAP triggering.

Conclusion

The results of the present study suggest that untrained subjects can increase shot put performance 7 min post bench press exercise. Considering that not all subjects profit from CA, it is suggested that the CA should be individually set. Future studies should evaluate the effect of other conditioning activities on shot put performance (i.e., conditioning activities involving lower limbs), as well as other athletic modalities. In addition, other populations should be investigated, such as adolescents, women, and athletes.

References

1. Turner AP, Bellhouse S, Kilduff LP, Russell M. Postactivation potentiation of sprint acceleration performance using plyometric exercise. J Strength Cond Res 2015;29(2):343-50.
2. Evetovich TK, Conley DS, McCawley PF. Postactivation potentiation enhances upper- and lower-body athletic performance in collegiate male and female athletes. J Strength Cond Res 2015;29(2):336-42.
3. Kümmel J, Bergmann J, Prieske O, Kramer A, Granacher U, Gruber M. Effects of conditioning hops on drop jump and sprint performance: a randomized crossover pilot study in elite athletes. BMC Sports Sci Med Rehabil 2016;8(1):2-8.

4. Suchomel TJ, Lamont HS, Moir GL. Understanding Vertical Jump Potentiation: a Deterministic Model. Sports Med 2015:1-12.
5. Hancock AP, Sparks KE, Kullman EL. Postactivation potentiation enhances swim performance in collegiate swimmers. J Strength Cond Res 2015;29(4):912-7.
6. Hodgson MJ, Docherty D, Zehr EP. Postactivation Potentiation of Force Is Independent of H-Reflex Excitability. Int J Sports Physiol Perform 2008;3:219-31
7. MacIntosh BR, Robillard ME, Tomaras EK. Should postactivation potentiation be the goal of your warm-up? J Appl Physiol Nutr Metab 2012;(37):546–50.
8. Rodriguez-Falces J, Duchateau J, Muraoka Y, Baudry S. M-wave potentiation after voluntary contractions of different durations and intensities in the tibialis anterior. J Appl Physiol 2015;118:953-64.
9. Russell LM, Stull JT. Myosin light chain phosphorylution in fast and slow skeletal muscles in situ. Am J Physiol 1984;247 (Cell Physiol. 16):462-71.
10. Grange RW, Vandenboom R, Houston ME. Physiological significance of myosin phosphorylation in skeletal muscle. Can J Appl Physiol 1993;18(3):229-42.
11. Gullich A, Schmidtbleicher D. MVC-induced short-term potentiation of explosive force. New Stud Athlet 1996;11(4):67-81.
12. Young WB, Jenner A, Griffiths K. Acute enhancement of power performance from heavy load squats. J Strength Cond Res 1998;12: 82-4.
13. Terzis G, Karampatsos G, Kyriazis T, Kavouras SA, Georgiadis G. Acute effects of countermovement jumping and sprinting on shot put performance. J Strength Cond Res 2012;26(3):684-90.
14. Healy R, Comyns T M. The application of postactivation potentiation methods to improve sprint speed. J Strength Cond Res 2017;39(1): 1-9.
15. McArdle WD, Katch FI, Kacth VL. Fisiologia do exercício. Rio de Janeiro. Ed. 5: Guanabara Koogan; 2003.
16. Jayaraman S. Progression of technique the shot - the spin. Star Phys Education 2015;1(5):1-14.
17. Jackson AS, Pollock ML, Ward A. Generalized equations for predicting body density of men. Br J Nutr 1978;40:497-504.
18. Baechle TR, Earle RW. Essentials of strength and conditioning. Champaign: Human Kinetics; 2008.
19. Cohen J. Statistical power analysis for the behavioral sciences (2nd edition). Hillsdale. Ed 2: Lawrence Erlbaum Associates; 1988.
20. Whelan N, O'regan C, Harrison AJ. Resisted sprints do not acutely enhance sprinting performance. J Strength Cond Res 2014;28(7):1858-66.
21. Sugumar, C. A Biomechanical Analysis of The Shot Put Performance, Global J Res Analysis 2014;3(5):118-119.
22. Ariel G, Penny A, Probe J, Finc A. Biomechanical analysis of the shot put event at the 2004 Athens Olympic Games. ISBS/Beijing, China 2005;271-274.
23. Błażkiewicz M, Łysoń B, Chmielewski A, Wit A. Transfer of Mechanical Energy During the Shot Put, J Human Kinetics 2016;52:139-146.
24. Kristiansen M, Samani A, Madeleine P, Hansen EA. Muscle synergies during bench press are reliable across days. J Electro Kinesiology 2016;30:8-88.
25. Gomo O, Tillaar RVD. The effects of grip width on sticking region in bench press. J Sports Sci 2016;34(3):232-38.
26. Hermannn GW. An electromyographic study of selected muscles involved in the shot put. The Research Quarterly 1962;33(1):85-93
27. Vanderka M, Krcmar, M, Longova K, Walker, S. Acute effects of loaded half-squat jumps on sprint running speed in track and field athletes and soccer players. J Strength Cond Res 2016;30:1540–1546.
28. Yoshimoto T, Takai Y, Kanehisa H. Acute effects of different conditioning activities on running performance of sprinters. Springerplus 2016;5:1203.
29. Karampatsos BG, Terzis G, Polychroniou C, Georgiadis G. Acute effects of jumping and sprinting on hammer throwing performance. J Phys Educ Sport 2013;13(1):3-5.
30. Gourgoulis V, Aggeloussis N, Kasimatis P, Mavromatis G, Garas A. Effect of a submaximal half-squats warm-up program on vertical jumping ability. J Strength Cond Res 2003;17:342-4.
31. Zhi G, Ryder JW, Huang J, Ding P, Chen Y, Zhao Y, et al. Myosin light chain kinase and myosin phosphorylation effect frequency-dependent potentiation of skeletal muscle contraction. Proc Natl Acad Sci 2005;102(48): 17519-24.
32. Seitz LB, Haff GG. Factors modulating post-activation potentiation of jump, sprint, throw, and upper-body ballistic performances: a systematic review with meta-analysis. Sports Med 2015:1-10.
33. Ferreira-Júnior JB, Guttierres APM, Encarnação IGA, Lima JRP, Borba DA et al. Effects of Different Conditioning Activities on 100-m Dash Performance in High School Track and Field Athletes. Percep Motor Skills 2018;0(0):1-15.
34. Rassier DE, Macintosh BR. Coexistence of potentiation and fatigue in skeletal muscle. Brazilian J Med Biol Res 2000;33(5):499-508.
35. Hamada T, Sale DG, MacDougall JB, Tarnopolsky MA. Postactivation potentiation, fiber type, and twitch contraction time in human knee extensor muscles. J Appl Physiol 2000;88:2131-2137.
36. Hamada T, Sale DG, MacDougall JD, Tarnopolsky MA. Interaction of fibre type, potentiation and fatigue in human knee extensor muscles. Acta Physiol Scan 2003;178(2):165-173.

Acknowledgments

We thank the support of the group of teachers of the Physical Education and Sports Department of the Technological Education Federal Center of Minas Gerais, Brazil, Campus I, especially to Prof. Dr. Ailton Vitor Guimarães.

Corresponding author

Diego de Alcantara Borba
Adress: Hipólito da Costa, 74, Santa Maria, Belo Horizonte, MG.
Postal code: 30 525 020
Email: diegoalcantara1@yahoo.com

Manuscript received on April 12, 2018
Manuscript accepted on August 3, 2018