Original Article

Behavior of creatine kinase in a variable resistance session

ÁLVARO HUERTA OJEDA, PhD^{1, 3, 5)*}, SERGIO GALDAMES MALIQUEO, Mg^{2, 3, 5)},
GUILLERMO BARAHONA-FUENTES, Mg^{1, 3)}, JORGE CANCINO LÓPEZ, PhD⁴⁾

¹⁾ Facultad de Educación, Universidad de Las Américas: Av. 7, Norte 1348 del Mar 2531098, Chile

²⁾ Facultad de Ciencias de la Actividad Física y del Deporte, Universidad de Playa Ancha de Ciencias de la Educación, Chile

³⁾ Grupo de Investigación en Salud, Actividad Física y Deporte ISAFYD, Escuela de Educación Física, Universidad de Las Américas, Chile

⁴⁾ Laboratorio de Ciencias del Ejercicio, Escuela de Kinesiología, Facultad de Medicina, Universidad Finis, Chile

⁵⁾ Centro de Capacitación e Investigación Deportiva Alpha Sports, Chile

Abstract. [Purpose] The purpose of this study was to determine the behavior of creatine kinase before and after the execution of a pre-activation protocol with intra-set variable resistance in order to generate post-activation potentiation in female athletes. [Participants and Methods] Six sprint women were part of the study. The study had a quasi-experimental intra-participant design. The experimental condition included a pre-activation with intra-set variable resistance + 1 minute rest + 30-m sprint × 3. The variables were metabolic creatine kinase, total creatine kinase, and 30-m sprints. [Results] Both the experimental condition and the control condition showed an increase in creatine kinase and total creatine kinase 24 hours post-effort. Only the experimental condition showed improvement in 30-m sprints after the pre-activation with intra-set variable resistance. [Conclusion] All those sessions oriented to increasing strength levels with a pre-activation protocol through intra-set variable resistance must consider rests longer than 24 hours between sessions in order not to increase creatine kinase in female athletes significantly.

Key words: Resistance training, Creatine kinase, Athletes

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INTRODUCTION

Evidence shows that strength training is beneficial for good health¹⁾ and sports performance²⁾. However, researchers have concluded that an increase in strength levels also brings with it an increase in blood biomarkers of muscle damage (BBMD) post-effort³⁾. For that reason, finding training methods that increase the strength level in trained and untrained participants⁴⁾, but that minimize the alterations in BBMD, is of utmost importance in current trainings⁵⁾.

An efficient way to increase strength levels in both trained and untrained participants is the use of variable resistance (VR)⁴⁾. This training methodology has three application procedures: i) intra-sessions variable resistance (I-sVR), ii) intra-repetition variable resistance (I-RVR), and intra-series variable resistance (I-SVR)⁶⁾. That is how some research has proven that the use of intra-repetition variable resistance through the use of elastic bands connected to the bar increases the strength levels of some athletes⁷⁾. Meanwhile, others have presented evidence on the benefits of using VR as pre-activation in order to acutely increase muscular strength levels (post-activation potentiation)^{4, 8)}, increasing sports performance in 20-m⁹⁾, 30-m²⁾, and/or 40-m sprints¹⁰⁾.

At the same time, there is evidence that stress biomarkers such as Cortisol tend to increase more in female than male

*Corresponding author. Álvaro Huerta Ojeda (E-mail: achuertao@yahoo.es)

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athletes after a competition¹¹). Furthermore, blood concentrations of creatine kinase (CK) and late muscular pain in females could be influenced by menstrual phases¹²). These data might be enough to state that, depending on the gender, the use of VR as a training method to increase strength levels may trigger different alterations in BBMD^{4, 11}). Therefore, our primary goal in this research was to determine the behavior of CK before and after the application of a pre-activation protocol with I-SVR to generate post-activation potentiation (PAP) in female athletes.

PARTICIPANTS AND METHODS

Six female sprinters were part of the study (age=20.4 ± 2.0 years, body mass 56.5 ± 5.8 kg, height=163 ± 0.5 cm, % body fat=21.9 ± 2.9%, back squat 1RM=98.9 ± 14.4 kg, back squat/body mass=1.75 ± 0.2). All female sprinters and their coaches were informed about the objective of the research and the possible risks it entailed. They all signed a written consent before the application of the protocols. The written consent and the research were approved by the Committee of Bioethics at Playa Ancha University, Chile (record number 006/2017).

The study had a quasi-experimental intra-participant design. Before performing the baseline evaluations of the experiment (metabolic creatine kinase (MB-CK), total creatine kinase (Total-CK), one repetition maximum (1 RM), and 30-m sprints), the female sprinters had a wash-up period of 48 hours. Also, during the wash-up and the entire experiment, the participants were asked to abstain from drinking caffeine or any other substance that could increase their metabolism. The BBMD was measured 24 hours before and 24 hours after the application of the experimental condition, and control conditions were MB-CK and Total-CK. The blood analysis for MB-CK and Total-CK was performed through an enzymatic method. Every measurement and analysis was carried out at the Children's Hospital of Viña del Mar, Chile. Both the baseline evaluation and the control and experimental condition were performed 48 hours apart and done between 9 and 11 AM. The baseline warm-up (1 RM, and 3 × 30-m sprints), the control condition (with no VR), and the experimental condition (with VR) consisted of 10 minutes of jogging, 5 minutes of dynamic stretching of the lower limb, and 3 × 80-m of accelerations. The baseline included two evaluations: 1) 3 × 30-m sprints with a 2-minute pause (the average of the 30-m sprint repetitions was used for the statistical analysis as a baseline). The 30-m sprints were assessed using a Chrono Jump[®] photocell and the Chrono Jump software version 1.4.6.0[®]. 2) after a 30-minute break, 1RM was measured in back squat using a Chrono Jump[®] linear encoder and the Chrono Jump software version 1.4.6.0[®]. After a 10-minute break, four back squat repetitions were evaluated between 0.6–0.7 m·s⁻¹. The resistance needed to move the bar in the back squat between 0.6–0.7 m·s⁻¹ was equivalent to 60% 1RM¹³) (the average of the four back squat repetitions was used as the baseline for the statistical analysis).

The experimental condition included three series with I-SVR. Each series started with a pre-activation of back squats: 22% 1RM × 5 repetitions (equivalent to 1.0–1.1 m·s⁻¹) + 60% 1RM × 4 repetitions (equivalent to 0.6–0.7 m·s⁻¹) + 1 minute pause + 30-m sprint × 3 repetitions with a 2-minute pause. The break between the series was 2 minutes. At the end of each series, the capillary lactate concentrations ([La]) were measured post-effort. [La] was measured with an h/p/Cosmos Sirius[®] Germany test meter. The control condition consisted of 3 series without I-SVR. Each series had a 30-m sprint × 3 repetitions with a 2-minute pause. The break between the series was 2 minutes. Just like the experimental condition, at the end of each series [La] post-effort was measured. For the tabulation and data analysis, Excel 2013[®] and the statistic software SPSS version 19[®] were used. The normal distribution of the results was determined with a Shapiro-Wilk test. A repeated measures analysis of variance (ANOVA) was used to evaluate the effect of pre-activation with and without I-RVR on the 30-m sprints performance, [La], and the velocity on the back squat. The size of the effect (ES) for all cases was measured using a partial Eta-squared test. The BBMD measured were analyzed using a student-t-test, while the ES was measured using a Cohen-d test. The statistical significance of all analyses was accepted when p≤0.05.

RESULTS

At the end of the intervention, only the experimental condition showed improvement in 30-m sprints (p<0.05) (Table 1), while the BBMD and the [La] showed an increase in both the experimental condition and the control condition (p<0.05) (Tables 1 and 2). Finally, the experimental condition did not show any changes in the velocity in back squat (p>0.05).

DISCUSSION

In connection to the primary objective of the research, the result of the student-t-test showed a significant increase in blood levels of MB-CK and Total-CK 24 hours after the application of the experimental and control condition (p<0.05). However, only the experimental condition showed an increase in the 30-m sprints performance after the pre-activation with I-SVR (p<0.05). As previously mentioned, there is evidence that the appropriate application of training loads significantly increases the levels in muscular strength⁴). Nevertheless, as in this study, other researchers have also shown an increase in the stress and muscular biomarkers post-effort^{14, 15}), together with a muscular strength increase.

Additionally, a study carried out by Doma et al. showed an increase in late muscular pain and an increase in biomarkers, specifically CK post-strength training¹⁴). At the same time, Kyröläinen et al. show evidence of an increase in Cortisol levels post-combined strength and endurance training¹). Also, Peñailillo et al. assessed the subjective perception post-competition,

Table 1. Changes in performance with and without pre-activation of I-SVR on back squat

Variables	Base line	Set 1	Set 2	Set 3	Partial Eta-Squared ES
	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD	
30-m sprint with I-SVR (ms)*	4,733.6 $\pm$ 220.1	4,458.1 $\pm$ 176.7	4,498.2 $\pm$ 196.8	4,454.6 $\pm$ 103.1	0.529
30-m sprint without I-SVR (ms)	4,733.6 $\pm$ 220.1	4,581.8 $\pm$ 205.8	4,524.1 $\pm$ 246.9	4,756.4 $\pm$ 431.2	0.281
[La] with I-SVR (mmol/L)***	1.42 $\pm$ 0.2	6.08 $\pm$ 1.8	8.83 $\pm$ 1.9	10.35 $\pm$ 1.9	0.928
[La] without I-SVR (mmol/L)***	1.78 $\pm$ 0.7	5.12 $\pm$ 1.0	7.04 $\pm$ 1.9	7.86 $\pm$ 2.5	0.896
Squat velocity with I-SVR (m·s ⁻¹)	0.692 $\pm$ 0.03	0.692 $\pm$ 0.05	0.672 $\pm$ 0.06	0.696 $\pm$ 0.04	0.118

I-SVR: Intra-Set Variable Resistance; ms: millisecond; [La]: Lactate Concentrations; mmol/L: millimoles per Liter; m·s⁻¹: meters per second; SD: standard deviation; ES: effect size. *p<0.05, ***p<0.001.

Table 2. Changes in blood biomarkers of muscle damage with and without pre-activation of I-SVR on back squat

Variables	24 h after	Base line	Δ	Confidence interval	Cohen's d-test ES
	mean $\pm$ SD	mean $\pm$ SD			
MB-CK with I-SVR (U/L)*	24.7 $\pm$ 8.3	17.2 $\pm$ 3.3	7.5 U/L	14.7–0.26 U/L	1.30
MB-CK without I-SVR (U/L)*	22.5 $\pm$ 3.0	17.2 $\pm$ 3.3	5.3 U/L	0.47–10.1 U/L	1.70
Total-CK with I-SVR (U/L)*	575.5 $\pm$ 384.0	151.0 $\pm$ 39.3	424.5 U/L	22.4–826.5 U/L	2.01
Total-CK without I-SVR (U/L)*	572.8 $\pm$ 254.7	151.0 $\pm$ 39.3	421.8 U/L	124.6–719.0 U/L	2.87

I-SVR: Intra-Set Variable Resistance; MB-CK: metabolic Creatine Kinase; Total-CK: total Creatine Kinase; U/L: units per liter; SD: standard deviation; ES: effect size; *p<0.05.

concluding that female athletes have a higher perception faced with the same effort as male athletes¹¹). The preceding information, together with other research, has allowed us to determine that the pause time for and/or between the same exercises varies between male and female¹⁶). Also, regardless of the methods used to assess BBMD, both CK and Cortisol should be measured before, during, and after the application of training loads, since studies indicate that, especially in the female, periods more extended than seven days might be required to generate a complete recovery¹⁵).

In conclusion, pre-activation with I-SVR is an efficient methodology to increase muscular strength levels in female athletes. However, and in order not to increase significantly the BBMD levels, it is suggested to apply these stimuli with rest periods longer than 24 hours between sessions when using pre-activation of I-SVR to obtain PAP.

Conflict of interest

None.

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