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Effects of Plyometric Training on the Performance of 5-km Road Runners

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Abstract – The aim of the present study was to compare the performance changes in amateur road runners submitted to two different types of plyometric protocols. Twenty-four male individuals were randomly divided into three groups: running training associated with plyometric with squat jump (PSG; n: 8; age: 38±5 years; BMI: 25,81±3.29 kg/m2); running training associated with plyometric with drop jump (PDG; n: 8; age: 39±4years; BMI: 26.14±1.91 kg/m2); and control group (GC; n: 8; age: 35±3 years; BMI: 25.31±1.09 kg/m2), that just performed the running training. The distances were the same for all groups and the speeds were calculated by the VO2PRO pace load method. The running performance was measured by the 5 km running test. The ANOVA revealed significantly higher (p<0.05) time differences between the PSG (140.50 s) and the PDG (170.63 s) when compared with the CG (4.75 s) after the intervention. Despite the intervention groups with the plyometric did not reveal significant differences between them, the PDG was the most efficient when compared with PSG (effect size: 1.0 and 0.62, respectively). It was concluded that the plyometric training can optimize the 5 km running performance, being the drop jump protocol the most efficient.

Key words: Running, Plyometric Exercise, Power of Lower Limbs, Speed.

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INTRODUCTION

The sports, in a general way, use an alternation in contraction and relaxation process of muscle fiber,the stretch-shortening cycle (SSC). The plyometric is an important SSC activator (Baker, 1996; Tsatalas et al.,2010), allowing to optimize the functional and skill movements patterns in sports achievement (Davies et al., 2015). The plyometric is not a new method and has been popularly used in eastern European since 1960, by the Soviet coach Yuri Verkhoshanski (Esteves et al., 2012).

The plyometric training uses the SSC through the stretching movement (eccentric contraction) of the agonist's muscles, quickly followed by a shortening movement (concentric contraction) of those muscles (Allerheiligen & Rogers, 1995; Chu & Plummer, 1984). Hence, it uses the contraction cycles defined in a one way order (eccentric, isometric and concentric) objectifying to optimize the neuromuscular system reaction from the capacity to store elastic energy during the eccentric phase and transfer it to the movement concentric phase (Guedes Neto et al., 2005).

The use of this technique to optimize the performance in several sports modalities is quite widespread in the scientific community (Adams et al., 1992; McBride et al., 2002). However, it is not much discussed in the literature which type of jump is the most efficient to optimize the sports performance in certain modalities, as the road running, for instance. The road running is one of the most practiced physical activities in the world, presenting a considerable increase in the number of adepts in the last four decades (Castro et al., 2018; Hespanhol Junior et al., 2012).

Around the 1990s, the running has gained a boost in Brazil. Since then, it has been consolidating as a sports modality and urban cultural practice with an increase in the number of events and in the number of participants (Morales et al., 2013). Therefore, the aim of this study was to compare the performance alterations in amateur road runners that was submitted to two different types of plyometric protocols.

MATERIAL & METHODS

Participants

The present research is an experimental study. Twenty-four male runners were randomly divided, by simple draw, into one of these groups: 1) PSG – Running training associated with plyometric training with the squat jump; 2) PDG – Running training associated with plyometric training with the drop jump; 3) CG – Control group, which just performed the running training. There were eight members in each group.

As inclusion criteria, the participants should be an amateur runner for at least six months and should have participated in at least a 10 km race running during this period of road running practice. We excluded from the study individuals who presented any type of injury or pain that could interfere with the intervention and those who missed any data collection or any of the intervention days of the experimental protocols.

All individuals were invited to voluntarily participate in the research and signed a consent form for the participation in research.

Experimental design

The experiment was divided into four distinct stages:

1st – Common training period: all volunteers, regardless of group, has run three times a week for four weeks, totalizing 12 sessions, with different distances in each weekly training (5, 8 and 12 km) and the speeds were calculated based on the *pace* of the first session of the week using the VO2PRO pace load method (Machado,2013).

2nd – Pre-intervention test: 5 km running test, where were obtained the best time for the running distance. It was realized in the 13th training session.

3rd – Plyometric training intervention period: the volunteers of the PSG and the PDG performed, from the 14th training session, the plyometric training protocol proposed twice a week, during eight weeks, always on Wednesdays and Fridays, before the running training.

4th – Post-intervention: 5 km post-intervention test with plyometric training, realized in the 37th training session.

Running training protocol

The running training protocol was the same for all groups, with three running sessions per week always performed on Mondays, Wednesdays, and Fridays during all the experiment period, totalizing 12 weeks.

Monday session – 5 km distance and maximum speed for this distance.

Wednesday session – 8 km distance and speed of 85% of the pace load obtained in the Monday session.

Friday session – 12 km distance and speed of 75% of the pace load obtained in the Monday session.

Pace load calculation

The pace load was calculated after the first running training of the week. The route total time, in

minutes and seconds, was converted to seconds and divided by the running distance to obtain the value in seconds per kilometers (s/km).With time expressed in seconds, the value was multiplied by 100 and divided by the percentage value that we wanted to find, according to the following formulas:

Pace load 85% (s/km) = pace (seconds) * 100 / 85

Pace load 75% (s/km) = pace (seconds) * 100 / 75

Plyometric training protocol

The plyometric training sessions were performed twice a week in the PSG and PDG, for 8 weeks, totalizing 16 sessions, always performed on Wednesday and Friday sessions, before the running training. The plyometric training protocol was divided into two different stages: first stage, warm-up, which was common to both groups; and the second stage, in which a specific jump type was used per group. The 30 seconds of stimulation and 30 seconds recovery time load, as well as the number of series in the proposed protocol, has followed the recommendations of Machado et al. (2017) for prescription of high-intensity interval training using the body weight.

The warming protocol was composed by 2 series of 30 seconds of stimulation with 30 seconds of recovery with multi-directions jumps and interval up to 5 seconds between each jump in each series. In sequence, the volunteers started the specific jumps protocols.

The plyometric training protocol for the PSG was composed by 6 series of squat jump with 30 seconds of stimulation and 30 seconds recovery, with interval up to 2 seconds between each jump in each series (45 cm box height).

The plyometric training protocol for the PDG was composed by 6 series of drop jump with 30 seconds of stimulation and 30 seconds recovery, with interval up to 2 seconds between each jump in each series (45 cm box height).

Statistical analysis

For the characterization of the sample group, the mean and standard deviation measures were used for the variables age, body mass, height, and body mass index (BMI). The ANOVA with repeated measures followed by Tukey post hoc was used to analyze the intragroup and intergroup variations. The ANOVA one way, followed by Tukey post hoc, was used to compare the difference in average time (W) of the 5 km running test results pre and post-intervention between groups. The study admitted the value of $p<0.05$ to statistical significance. Additionally, the effect size was calculated by G of Hedges to analyze the results magnitude of this study. All analyzes of this study were performed using the IBM SPSS Statistics version 21.0 statistical package for Windows.

RESULTS

Table 1 shows the characteristics of the sample, separated by group, for each variable.

Table 1. Sample characterization

Variables	PSG	PDG	CG
Age	38±5	39 ± 4	35 ± 3
BodyMass(kg)	81.38 ± 12.01	83.88 ± 8.29	78.63 ± 3.96
Height(cm)	1.77 ± 0.04	1.79 ± 0.04	1.76 ± 0.02
BMI(Kg/m^2)	25.81 ± 3.29	26.14 ± 1.91	25.31 ± 1.09

BMI: Body mass index; PSG: Running and plyometric training with squat jump group; PDG: Running and plyometric training with drop jump group; CG: control group.

To identify the performance evolution in each group, it was used the time difference (W) variable, in seconds, that represents the difference between time in 5 km before the intervention protocol and after the intervention (table 2). From the time results analysis of the 5 km test, it was observed that PSG and PDG presented the lowest times ($p = 0.003$; $p < 0.001$, respectively) in the post-test when compared to CG. There were no significant differences from pre to post-test in the study groups. The intragroup time difference (W) variable did not present significant difference between intervention groups (PSG and PDG). However, when comparing these groups (PSG and PDG) with CG, there was a significant difference in this variable ($p = 0.044$; $p = 0.021$, respectively). It demonstrates that the inclusion of a plyometric training proposal was considerably significant for the runners' evolution.

Table 2. Comparative analysis of the 5 km test times between groups

Group	Pre-test	Post-test	Δ
PSG(s)	1495.50±227.98	1355.00±134.67 *	140.50 *
PDG(s)	1470.25±169.24	1299.63±191.47 *	170.63 *
CG(s)	1701.00±130.09	1696.25±139.35	4.75

PSG: Running associated to plyometric training with squat jump group; PDG: Running associated to plyometric training with drop jump group; CG: Control group; 5: intragroup time difference; * p < 0.05, PSG and PDG vs. CG.

Although the intervention groups with plyometric (PSG and PDG) did not present significant difference between them, the mean values of evolution were numerically higher in approximately 30 seconds. It means thatPDG was the most efficient in performance when compared with PSG, which can be visualized by the effect size values (Figure 1).

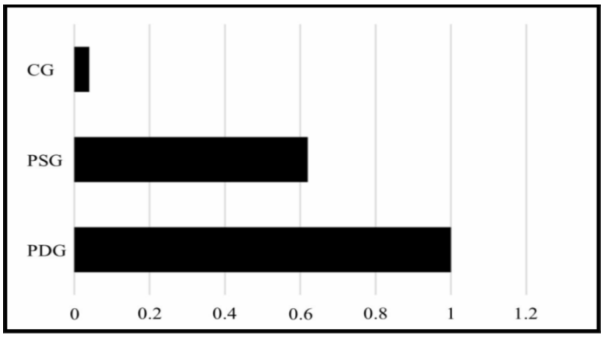

Fig. 1. Effect size for PSG (0.62), PDG (1.00) and CG (0.04) groups

Therefore, the PSG presented a moderate impact on the performance evolution of the runners; however, the PDG presented a high impact on performance after the intervention. Nevertheless, the CG had a non-significant impact on the runners' performance.

DISCUSSION

The main findings of this study are related to the performance improvement in the 5 km distance of runners submitted to a plyometric training protocol. However, the advantage after doing the protocol with drop jump was clear. These results of significant improvement on the performance with plyometric training are compatible with studies in runners presented in the literature (Ebben, 2001; Marcello et al., 2017), in which there was performance improvement after doing the plyometric training protocol.

The plyometric training has been applied in different sports modalities (Lombardi et al., 2011; Durigan et al., 2013; Dias et al., 2016) with favorable results (Young, 2006) and contradictory in their efficiency (Adams et al., 1992). The improvement in performance has been associated with running, strength, speed and power economy (Guglielmo et al., 2005). Furthermore, it is known that plyometric training is an efficient method to improve speed, strength, and power for optimizing intra and intermuscular coordination during the movement (Guedes Neto et al., 2005).

In a systematic review, Alcaraz-Ibañez and Rodriguez-Pérez (2018) analyzed the endurance training effect on trained runners performance, suggesting that strength training, including plyometric, optimizes performance in runners of 1,500 to 10,000 meters, with sessions just twice a week and a minimum interval of 48 hours, ranging from 6 to 12 weeks. However, the study does not present the effectiveness of jumping types during the training, which generates some debate in the scientific community and between coaches.

In the present study, it is possible to consider that the jumping type of PDG has presented a fast transition to the concentric phase in comparison with PSG, allowing to increase not only the capacity of explosive strength but also decrease of the foot contact with the ground, which may have been transferred to the running. It was observed that the performance was influenced not only by strength but also by the better contact response with the ground that the drop jump can provide. Cormie, McCaulley, and McBride (2007) observed that the explosive strength seems not to be associated with the best economy of running movement, what would make the runners have better performance. That finding is compatible with the results of this study, in which the group that had the best performance was what, besides explosive strength, also optimized the contact time of the foot with the ground in function of reactivity caused by drop jump.

The study of Cormie et al. (2007) has used a sample with 26 volunteers, divided into three groups, and compared the response of strength training, strength training plus plyometric (squat jump) and control group, during 12 weeks. It was observed that the power work from jumping has improved the strength-speed relation, indicating that there was a higher strength transfer than the other groups. The same could have happened with the runners of this study, that also presented improve in performance post plyometric training with squat jump, but during an intervention period of 8 weeks.

In another study, the researchers (Markovic, Vuk & Jaric, 2011) have compared the jumping performance from countermovement jump (CMJ) training with negative and positive activation during 7 weeks.

The authors concluded that the CMJ activated in a negative form had better performance when compared with CMJ activated in a positive form, which leads us to understand that the transition from eccentric contraction to concentric boosts the athletic performance.

The main limitations of this study are the use of only male individuals in the sample group and the small size of the sample. Both characteristics may limit the external validation of results, which must be cautiously interpreted. However, this study established a homogeneous composition of the sample group to preserve an ecological validity. Moreover, the methodological procedures adopted have a pronounced practical applicability in physical training and/or rehabilitation.

CONCLUSIONS

Based on the findings of the present study, it is possible to conclude that the protocol with the drop jump movement was the most efficient for the performance development, specifically for the road runners. It isrecommended that future studies investigate the processes to which the drop jump was significantly higher than the squat jump for the running performance and whether it will occur in other cyclic sports such as swimming, cycling, and rowing.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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