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Effects of Pre-Season Short-Term Daily Undulating Periodized Training on Muscle Strength and Sprint Performance of Under-20 Soccer Players

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Abstract

The aim of this study was to evaluate the effects of daily undulating training periodization designed for maximal lower limb muscle strength and sprint performance in under-20 soccer players. Twenty-four male athletes (age = 19.1 ± 1.2 yr; mass = 71.1 ± 6.8 kg; height = 178.0 ± 0.1 cm) participated in four weeks of a daily undulating periodized (DUP) training soccer program. During the pre- and post-training periods the subjects performed a one repetition maximum (1 RM) half back squat test and a 15-meter sprint. Significant training-induced changes were observed in sprint times (pre = 2.38 ± 0.01 s; post = 2.31 ± 0.02 s) and 1 RM tests (pre = 107.0 ± 2.0 kg; post = 128.0 ± 2.2 kg). These results indicate that a DUP program is efficient in promoting positive neuromuscular adaptations in soccer players, even with a short-term preseason training period.

Keywords: periodization, soccer, sprint, muscle strength

Introduction

Soccer is characterized as having an intermittent sport modality in which biomotor determinant actions are performed at a high intensity and short duration requiring high levels of strength, velocity, and power. Parameters for this type of performance are dependent on an efficient anaerobic system for the realization of explosive muscle actions (Hoff, 2005; Bangsbo et al., 2006).

Among the systems used to improve physical conditioning of athletes, resistance training is seen as an effective method for improving the neuromuscular system and promoting increases in performance during the competitive seasons in elite athletes (Chelly et al., 2009; Chelly et al., 2010; Nunes et al., 2011; Hermassi et al., 2011). The magnitude of adaptive responses in the continuous process of training depends on the manipulation of acute variables including: intensity, volume, muscle action, choice and order of exercises, rest intervals between sets and exercises, movement velocity, and weekly frequency (Kraemer and Ratamess, 2004).

Due to the high adaptive capacity of the neuromuscular system, training programs require constant changes in training load to promote a continuous adaptive response. In this sense, periodization or planned variations in training stimuli are processes frequently conducted by teams from several modalities to reach specific training goals and peak performance (Stone et al., 1999; Gramble, 2006).

Among the methods used, undulating periodization proposed by Poliquin (1998) aims to generate variations in training programs with greater frequency compared to traditional/linear periodization. The model adapted by Rhea, Ball, Phillips and Burkett (2002) was based on alterations between intensity and volume occurring daily for each training session; this type of training has been termed, daily undulating periodization (DUP).

Few studies have attempted to investigate the effects of DUP on physical performance in various athletic sports modalities. Brazilian soccer is characterized by a short pre-season and a long competitive phase with a high frequency of matches. In our point of view, DUP could be used by strength and conditioning coaches because of the short period available to physically prepare the athletes. Thus, the purpose of this study was to investigate the effects of four weeks of DUP training on neuromuscular variables (speed and strength) in male soccer players.

Methodology

Subjects

Twenty-four under-20 male athletes (age = 19.1 ± 1.2 yr; body mass = 71.1 ± 6.8 kg; height = 178.0 ± 0.1 cm) volunteered to participate in this study. All the participants were members of men´s soccer teams competing in Brazilian national-level competitions (with a minimum of four years of specific training). The criteria for the inclusion and exclusion of the participants in this study were: (a) experience with the modality for at least two years; (b) experience with resistance training and 1 RM tests for at least one year; (c) participate in all training sessions and games; (d) must not have suffered any type of injury that could interfere in the study; and (e) must not have been away from training for over one month prior to the beginning of the study. All athletes completed a questionnaire to assess their health status and provided pre- and informed-consent forms after being informed of the research methods. For athletes under age of 18 years, parental or guardian informed-consent forms were submitted prior to the study. This study was approved by the local Research Ethics Committee (protocol 80/12).

Experimental Approach

To investigate the influence of DUP training during the pre-season for an under-20 soccer team, neuromuscular assessments were performed before and after four weeks of physical training, using a within-subject design. All athletes were familiar with the test protocols, which were performed with a minimum of 24-hour rest intervals. The tests performed included: (a) a maximum muscle strength test (1 RM) for the half back squat exercise and (b) a 15-meter sprint. Prior to testing, subjects performed a standard warm-up that consisted of jogging for three minutes at a comfortable speed. One day prior to the evaluation, training loads (mainly volume) on the athletes were reduced. All athletes were verbally encouraged and motivated to make maximum efforts during the tests, which were performed between 16:00 and 17:30 hours. Additionally, subjects were instructed to drink water and refrain from ingesting caffeine during the test day.

Training Periodization

The soccer team performed DUP training to develop the following: (a) maximum strength, (b) anaerobic endurance, (c) power, and (d) strength endurance. The training program was performed five times per week (Monday through Friday), for a total of 20 training sessions. All the training sessions began with standardized warm-up exercises for ~10 minutes that included running drills and stretching exercises. The DUP training protocol incorporated four separate types of training. The protocols used for this experiment is shown below.

Maximum strength training was performed every Monday and consisted of 3 sets of 3 RM for all resistance exercises (half back squat, power clean, barbell bench press, and seated row). Rest intervals between sets were 3–5 minutes.

Anaerobic endurance training was performed every Tuesday and Friday and consisted of eight sets of 2-minute small-sided games with three players per team. The games were performed on a natural-grass soccer pitch (30 m wide and 30 m in length) and goalkeepers were added. There was a maximum of two ball touches per player and when this occurred, players were immediately replaced; this was to maintain the game intensity. Rest intervals between sets were four minutes.

Power training was performed every Wednesday and consisted of four sets of eight continuous jumps over 40-cm high obstacles (spaced at intervals of 80 cm) and a sprint over five meters. These plyometric exercises were performed on a natural-grass soccer pitch and the subjects were instructed to jump with maximal height and minimal ground contact time. Rest intervals between sets were 2–3 minutes.

Endurance strength training was performed every Thursday and consisted of three sets of 15 RM for all resistance exercises (half back squat, power clean, barbell bench press, and seated row). Rest intervals between sets were one minute.

Maximum Muscle Strength (1 RM)

The determination of maximal muscle strength in the half back squat exercise (Smith machine) was measure with a 1 RM test following procedures described by Brow and Weir (2001). Briefly, the subjects performed a warm-up of 2–3 sets of 5–10 repetitions at ~40% to 60% of their estimated 1 RM before the protocol. During the exercise performance, subjects were required to execute the squat until a 90° knee angle was reached. The test was performed with a maximum of five attempts with rest intervals of 3–5 minutes between each attempt.

Maximum Sprint Performance

The determination of 15-meter sprint times was performed on a natural-grass soccer field and the athletes wore standard training clothing and soccer boots. The athletes were positioned behind the start line (0.5 m) and were instructed to perform the sprint with maximal effort, after a start signal. The time to complete 15 meters was assessed using two photocells (CEFISE® Standard photocells, Brazil). Each athlete performed two attempts and the best result was recorded.

Statistical Analysis

Data normality was assessed by the Shapiro-Wilk test. The data showed normal distribution so the comparisons of means (before and after) were performed by a paired Student´s t-test. All data were expressed as mean ± standard error of the mean (SEM). A study-power analysis suggested that a minimum of 14 subjects analyzed and a 5% significance level would yield at least 90% power for detecting differences for the variable of a 1 RM test for the half back squat exercise. The level of significance was set at 5%.

Results

Figure 1 shows the data of the sprint test. A significant difference was observed ($P = 0.0008$) between the pre- (2.38 ± 0.01 s) and post- (2.31 ± 0.02 s) training program. Additionally, values for the back squat 1 RM test increased significantly between pre- and post-training ($P = 0.0001$), with the following loads: 107.0 ± 2.0 kg and 128.0 ± 2.2 kg, respectively (Figure 2).

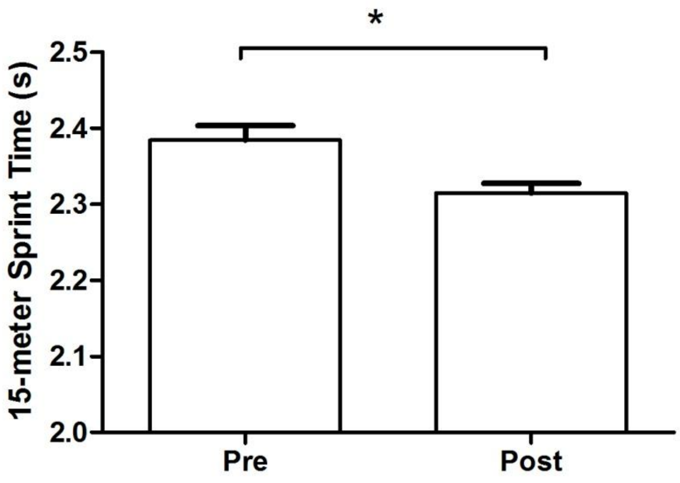

Figure 1. Changes in 15-meter sprint test performance pre- and post-periodized training program. Data are expressed as mean ± SEM (n = 24).

* Significant difference between conditions.

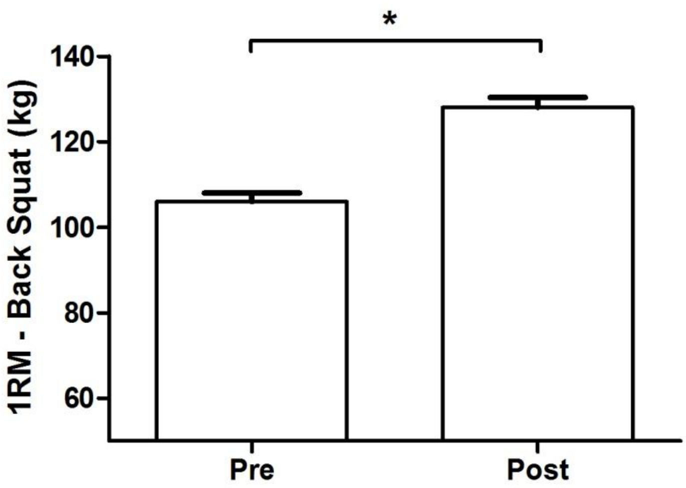

Figure 2. Changes in 1 RM test for back squat exercises pre- and post-periodized training program. Data are expressed as mean ± SEM (n = 24).

* Significant difference between conditions.

Discussion

The purpose of this study was to investigate the influence of DUP training on: (a) maximum lower limb muscle strength and (b) 15-meter sprint time. The major finding of this study was that the periodization training resulted in significant improvements in both maximal squat strength and 15-meter sprint performance, in national-level under-20 male soccer players.

Studies conducted to evaluate the influence of DUP in resistance training programs showed greater increases in muscle strength than linear or classical periodization (Rhea et al., 2002; Prestes et al., 2009). These data demonstrate that performing daily program alterations can be more effective than linear periodization. On the other hand, these data were not reproducible in team sports scenarios since other training methodologies, beyond resistance training, are performed and required for soccer players.

In our study, DUP was used to perform daily changes in various training methodologies (resistance training, plyometric, and small-sided games). Our results show that the daily training periodization proposed for the under-20 soccer team was efficient at inducing neuromuscular adaptations.

To our knowledge, only two studies have investigated the effects of DUP training on neuromuscular performance in soccer athletes. Pacobahyba et al., (2012) evaluated a 12-week pre-season DUP resistance training program. Their results indicate that the periodization proposed was not effective for increasing muscle strength (1 RM test) for the bench press and squat exercises. The authors suggested that, due to the high level of training in athletes, a periodization of 12 weeks was not sufficient to cause an increase in muscle strength. Alternatively, Souza et al., (2010) observed that 12 weeks of linear and DUP resistance training induced significant changes for vertical and horizontal jump performances in young soccer players.

Certainly, the difference between the manipulation of periodization training programs, the evaluation's protocols, and levels of trainability contributed to the differences among previous studies. Conversely, in the DUP training employed for the present study, we observed that a short-term pre-season training period (4 weeks) was sufficient to induce significant improvements in maximal squat strength and to increase sprint performance over 15 meters, in high-level under-20 athletes. These data have practical implications since, in many countries, the pre-season in soccer is relatively short. Therefore, the enhancement of neuromuscular performance during short-term physical training was effective with our DUP proposal.

Modern soccer players are required to perform at higher speeds and strength levels to achieve determinant muscle actions. The ability to produce maximal speed in a single effort may have a critical impact on a team's performance in decisive matches (Hoff, 2005). The improvement in short sprint performance observed in our study is likely related to an increase in lower limb muscle strength. These are physical aspects that depend greatly on muscular strength and power (mainly concentric) during the acceleration phase (Bret et al., 2002). Additionally, the ground reaction force (eccentric and concentric muscle actions) is another aspect associated with neuromuscular and maximal short sprint performance (Weyand et al., 2000).

In this context, studies have demonstrated a positive correlation between back squat muscle strength and sprint performance of 5 meters (Chelly et al., 2010), 10 meters, and 30 meters

(Wisløff et al., 2004) in soccer players. McBride et al. (2009) also reported an association between a 5-yard sprint performance and a 1 RM back squat.

Based on the acceleration phase and ground reaction force, the increase in half back squat strength performance, which uses a large amount of muscle mass, contributed to improved short sprint performances. These findings are corroborated with previous research that observed that increases in back squat strength were associated with better sprint performance after seven (Ronnestad et al., 2008) and eight weeks (Chelly et al., 2009) of resistance training in soccer players.

A limitation of this study is that only DUP training was performed. Thus, it was not possible to compare our training protocol with another periodization model (i.e., linear or block) or a control group. However, the inclusion of a control group consisting of athletes not required to practice soccer for an entire season was impossible and unethical, as the withholding of training would be detrimental to the players' development. In a practical point of view, it is very difficult to perform research with competitive soccer teams that are involved in important national competitions. However, our results provide a general index of neuromuscular performance, and future studies might provide additional information about the effects of different periodization models on short term pre-season neuromuscular adaptations.

Conclusion

In conclusion, the present study indicates that a DUP training program for soccer players is efficient in promoting positive neuromuscular adaptations in soccer players, even with a short period of intervention. Therefore, our data suggests that DUP may be considered appropriate for soccer teams who have short duration pre-season.

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