Different Loading Schemes in Power Training During the Preseason Promote Similar Performance Improvements in Brazilian Elite Soccer Players

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Abstract

Loturco, I., Ugrinowitsch, C., Tricoli, V., Pivetti, B., and Roschel, H. Different loading schemes in power training during the preseason promote similar performance improvements in Brazilian elite soccer players. J Strength Cond Res 27(7): 1791–1797, 2013—The present study investigated the effects of 2 different power training loading schemes in Brazilian elite soccer players. Thirty-two players participated in the study. Maximum dynamic strength (1RM) was evaluated before (B), at midpoint (i.e., after 3 weeks; T1), and after 6 weeks (T2) of a preseason strength/power training. Muscle power, jumping, and sprinting performance were evaluated at B and T2. Players were randomly allocated to 1 of 2 training groups: velocity-based (VEL: n = 16; age, 19.18 ± 0.72 years; height, 173 ± 6 cm; body mass, 72.7 ± 5.8 kg) or intensity-based (INT: n = 16; age, 19.11 ± 0.7 years; height, 172 ± 4.5 cm; body mass, 71.8 ± 4.8 kg). After the individual determination of the optimal power load, both groups completed a 3-week tradition strength training period. Afterwards, the VEL group performed 3 weeks of power-oriented training with increasing velocity and decreasing intensity (from 60 to 30% 1RM) throughout the training period, whereas the INT group increased the training intensity (from 30 to 60% 1RM) and thus decreased movement velocity throughout the power-oriented training period. Both groups used loads within ±15% (ranging from 30 to 60% 1RM) of the measured optimal power load (i.e., 45.2 ± 3.0% 1RM). Similar 1RM gains were observed in both groups at T1 (VEL: 9.2%; INT: 11.0%) and T2 (VEL: 19.8%; INT: 22.1%). The 2 groups also presented significant improvements (within-group comparisons) in all of the variables. However, no between-group differences were detected. Mean power in the back squat (VEL: 18.5%; INT: 20.4%) and mean propulsive power in the jump squat (VEL: 29.1%; INT: 31.0%) were similarly improved at T2. The 10-m sprint (VEL: −4.3%; INT: −1.6%), jump squat (VEL: 7.1%; INT: 4.5%), and countermovement jump (VEL: 6.7%; INT: 6.9%) were also improved in both groups at T2. Curiously, the 30-m sprint time (VEL: −0.8%; INT: −0.1%) did not significantly improve for both groups. In summary, our data suggest that male professional soccer players can achieve improvements in strength- and power-related abilities as a result of 6 weeks of power-oriented training during the preseason. Furthermore, similar performance improvements are observed when training intensity manipulation occurs around only a small range within the optimal power training load.

Keywords: sprint performance, jump height, mean propulsive power, optimal load, power training

Introduction

It is well established that muscular strength and power play a significant role in soccer performance (3,4,10,17,20,27). A top-class player performs 150–250 high-intensity and explosive activities during a soccer game (1). Kicking, jumping, sprinting, accelerating, and changing direction are important tasks within a soccer match. Thus, strength and power have become decisive for professional soccer players (24). In this regard, the use of resistance exercises at the optimal power training load (i.e., the load that elicits the maximal power production in a specific movement, 30–60% 1RM) (9) constitutes an important training tool because it has been shown to successfully increase power ability in sport-specific movements in both physically active and well-trained individuals (6–8,19,22).

Despite these previous findings, considerable controversy exists regarding the manipulation of the training intensity around the optimal load throughout a training period. In this concern, the manipulation of both the intensity and velocity of the training loads have been long thought to significantly affect the force-velocity relationship and thus power...
The classical concept of training periodization assumes that overall training volume should decrease with a concomitant increase in training intensity over time (23). However, one may speculate that, despite the previous suggestion that strength and power gains can be achieved with maximal will lifting (32), this paradigm may actually defy the specificity of power training adaptations because increasing training intensities would impair movement velocity and thus compromise power ability in sport-specific tasks. In fact, it has been proposed that the transfer of training to performance may be maximized if training loads allow for similar movement velocities when compared with those of the intended sport (9,11,18,19).

Therefore, it is plausible to assume that a velocity-based loading scheme using loads within the optimal power training load range (i.e., increasing velocity and thus decreasing the relative intensity [% 1RM] over time) throughout a given training period may be advantageous over a traditionally employed intensity-based training program, in which the relative intensity increases over time, thus hampering velocity production.

The present study investigated the effects of 2 different power training loading schemes in Brazilian elite soccer players. We hypothesized that a loading scheme that favored increased movement velocity over time would greatly increase power in low–external load tasks such as sprinting and jumping when compared with a traditional loading scheme (i.e., increased intensity over time).

**METHODS**

**Experimental Approach to the Problem**

To test if a velocity-based approach in power training is superior to the classical one (i.e., intensity-based), the present study evaluated the effects of 2 different power training loading schemes on the power development of Brazilian elite soccer players during their preseason training period. Subjects’ maximum dynamic strength (1RM) was evaluated before (B), at midpoint (i.e., after 3 weeks; T1), and after 6 weeks of a preseason strength/power training (T2). Muscle power, jumping, and sprinting performance were evaluated at B and T2. Before the beginning of the training protocol, the individual’s optimal power load (i.e., the load that elicits the maximal power production) (9) in the jump squat exercise was also determined. The optimal power load in the jump squat was used as a reference load during the power training period. Afterward, subjects were randomly allocated to 1 of 2 training groups: velocity-based (VEL) or intensity-based (INT). As it has been suggested that training status (e.g., strength level) may play a role in power ability (5,26,31), all of the subjects completed a 3-week strength-oriented training period using the back squat exercise (50–60% 1RM) to minimize such effect. In this regard, it is important to note that although the players had previous experience in strength training, a 30-day off-season period preceded the study. Then, a 3-week power-oriented training period took place. Power training consisted of jump squats with either increasing velocity (VEL) or increasing intensity (INT) every 2 training sessions. During the power-oriented training period, both groups used loads within ±15% (ranging from 30 to 60% 1RM) of the measured optimal power load for the jump squat exercise (i.e., 45.2 ± 3.0% 1RM). The experimental protocol took place during the players’ preseason (6-week period) for the state championship. Figure 1 depicts the sequence of events over the experimental period.

**Subjects**

Thirty-two professional soccer players regularly competing in both the state and the national championships were randomly allocated to 1 of the 2 groups: a velocity-based group (VEL: \( n = 16 \); age, 19.18 ± 0.72 years; height, 173 ± 6 cm; body mass, 72.7 ± 5.8 kg) and an intensity-based group (INT: \( n = 16 \); age, 19.11 ± 0.7 years; height, 172 ± 4.5 cm; body mass, 71.8 ± 4.6 kg). Players have been engaged in regular soccer training for at least 10 years and have been competing in a professional level for at least 18 months. Subjects were informed of the experimental risks and signed an informed consent form before the investigation. The investigation was approved by an institutional review board for use of human subjects.

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**Figure 1.** Timeline of the study design over the 6-week period. 1RM = 1 repetition maximum; MP = mean power (watts); MPP = mean propulsive power (watts); V-10 = 10-m sprint time; V-30 = 30-m sprint time; JS = jump squat height; CMJ = countermovement jump height.
Maximum Dynamic Strength Test (Squat 1RM)
The back squat 1RM test (within-group coefficient of variability (CV) <5%) was performed using a Smith machine (Cybex International, Inc., Medway, MA, USA). Subjects ran for 5 minutes on a treadmill (Movement Technology; Brudden, São Paulo, Brazil) at 9 km·h⁻¹, followed by 5 minutes of lower-limb light stretching exercises. Afterward, they performed 2 squat warm-up sets. In the first set, subjects performed 8 repetitions with 50% of the estimated 1RM, and in the second set they performed 3 repetitions with 70% of the estimated 1RM (1RM estimation was based on their previous year preseason 1RM testing values). A 3-minute resting interval was allowed between sets. Three minutes after the warm-up, participants had up to 5 attempts to obtain the 1RM load (e.g., maximum weight that could be lifted once using proper technique), with a 3-minute interval between attempts (2). Strong verbal encouragement was given throughout the test.

Mean Power in the Squat Exercise
All of the subjects were instructed to perform 2 sets of 3 repetitions of the parallel back squat exercise with maximal speed at 60% of the 1RM load in the Smith machine. A linear transducer (T-Force Dynamic Measurement System; Ergotech Consulting S.L., Murcia, Spain) was attached to the Smith machine bar. Bar position data were sampled at a frequency of 1,000 Hz and recorded onto a computer. Finite differentiation technique was used to estimate the bar velocity and acceleration. The mean power (MP) on each repetition of the back squat exercise was obtained by multiplying the average force by the average speed, over the entire concentric phase (MP) and positive acceleration region of the concentric phase (MPP) (within-group CV <10%). The duration and amplitude of the concentric phase were determined by taking the lowest and the highest position instants of the Smith machine’s bar on each repetition. The duration of the propulsive phase of the concentric phase of each repetition was defined as the time interval in which the acceleration of the Smith machine’s bar was positive (25).

Jump Squat and Countermovement Jump
The jump squat was performed from an initial static position at 90° knee angle. Subjects were instructed to maintain their hands start from a static squat position (i.e., ~90° of knee flexion) and jump as high as possible without losing contact with the bar. For the optimal power load determination, subjects were tested in a progressive overload fashion (starting with 0% 1RM in 10% 1RM increments) until the maximum power was achieved. A 3-minute rest was given between each lift. The trial with the greatest power output was accepted for further analysis. For the pre- and posttest evaluation, jump squat tests were conducted using 45% 1RM. The mean propulsive power (MPP) on each repetition of the jump squat exercise was obtained by multiplying the average force by the average speed, over the entire concentric phase (MP) and positive acceleration region of the concentric phase (MPP) (within-group CV <10%). The duration and amplitude of the concentric phase were determined by taking the lowest and the highest position instants of the Smith machine’s bar on each repetition. The duration of the propulsive phase of the concentric phase of each repetition was defined as the time interval in which the acceleration of the Smith machine’s bar was positive (25).

Mean Power and Mean Propulsive Power in the Jump Squat Exercise
This test was performed following the same basic procedures described for the previous test. Subjects were instructed to
on their waist and freely determine the amplitude of counter-movement jump (CMJ) to avoid changes in jumping coordination (31). Additionally, an experienced researcher conducted all of the tests and visually checked for countermovement occurrence during the jump squat to ensure reproducibility. The subjects performed 5 jumps with a 15-second interval between attempts (within-group CV <10%). Jumps were executed on a contact platform (Win Laborat, Buenos Aires, Argentina). The best and the worst jumps were discarded, and the average of the remaining jumps was used for data analysis.

Ten-m and 30-m Sprint Test
Three pairs of photocells were used to mark the starting point (i.e., 0 m), 10-m, and 30-m distances (within-group CV <10%). Subjects accelerated as much as possible for 5 m before crossing the starting point. They performed 2 attempts, and the best one was considered for further analysis.

Training Protocols
The strength-oriented training period (first 3 weeks) was composed of regular back squat exercises. The strength-oriented training period followed standard load progression, with loads ranging from 50 to 80% 1RM (16). The power-oriented training period (following 3 weeks) comprised jump squat exercises. All of the exercise sets were interspersed by a 2-minute interval. Total training load was equated across the training groups. During the power training period, the VEL group increased the exercise velocity and decreased the

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**Figure 4.** Mean power (MP; in watts) in the squat exercise using 60% 1RM (A), mean propulsive power (MPP; in watts) in the jump squat using 45% 1RM (B), 10-m (C) and 30-m (D) sprint time (seconds), jump squat height (centimeters) (E), and countermovement jump height (centimeters) (F). *p < 0.05 when compared with B (intragroup comparison).
exercise intensity within ±15% of the measured optimal power load (i.e., 45.2 ± 3.0% 1RM), going from 60% 1RM during the first week to 45% 1RM during the second week and ending the training period with a lighter load (i.e., 30% 1RM) and greater movement velocity. The INT group increased exercise intensity within the established range of the measured optimal power load (i.e., from 30 to 45 to 60% 1RM, during weeks 1, 2, and 3, respectively), thus decreasing exercise velocity. Players from both groups were instructed to move the load as fast as possible and to jump as high as possible during the entire power-oriented training period. All of the training sessions were supervised by an experienced strength and conditioning training coach. The entire preseason training period (6 weeks) involved not only the strength/power training (twice a week) but also training for general development of soccer-specific technical-tactical skills (4 times a week). Importantly, the soccer-specific technical-tactical training was the same for both groups. Figure 2 depicts the details of the strength/power training protocol for each group over the 6-week preseason training period.

Statistical Analyses
Data normality was assessed through visual inspection and the Shapiro-Wilk test. All of the variables presented a normal distribution. Mixed models assuming group (VEL and INT) and time (B and T2) as fixed factors and subjects as a random factor were used for MP, MPP, jump squat, CMJ, and 10-m and 30-m sprint speed analyses. An additional level for time was considered when analyzing the 1RM data (B, T1, and T2). In case of significant F values, a Tukey adjustment was used for multiple comparison purposes. Significance level was set at \( p \leq 0.05 \). An initial analysis revealed no between-group differences for any of the variables at B.

RESULTS
The strength-oriented training period was effective in increasing maximum dynamic strength. At T1, both groups displayed comparable gains in 1RM (VEL: 9.2%; INT: 11.0%). Similar strength gains were also observed between VEL and INT when compared at T2 (VEL: 19.8%; INT: 22.1%) (Figure 3).

Both groups similarly improved MP in the back squat exercise at 60% 1RM (VEL: 18.5%; INT: 20.4%) and MPP in the jump squat exercise at 45% 1RM at the end of the training period (VEL: 29.1%; INT: 31.0%; Figures 4A, B). Accordingly, the 10-m sprinting was similarly improved after T2 (VEL: −4.3%; INT: −1.6%; Figure 4C). The jumping performance increments for both the jump squat and the CMJ were also comparable across groups (VEL: 7.1%; INT: 4.5% and VEL: 6.7%; INT: 6.9%, respectively; Figures 4E, F). Curiously, the only variable that did not present a significant improvement for neither group was the 30-m sprint time (VEL: −0.8%; INT: −0.1%; Figure 4D).

DISCUSSION
We hypothesized that a loading scheme favoring increased movement velocity over time would greatly increase sprinting and jumping performance when compared with a traditional loading scheme (i.e., increased intensity and decreased velocity over time) within a 6-week training period. The findings reported in this study do not support our hypothesis because distinct power-oriented training schemes produced similar performance improvements. Furthermore, the results of this study suggest that different variations of the loading schemes around the optimal load for power training may constitute similarly effective stimuli to improve performance and muscle power production ability.

The training schemes used in this study (i.e., VEL and INT) targeted at developing the power abilities in the different components of the power equation. For instance, the heavier loads (60% 1RM) used within the power-oriented training period would favor increases toward the high-intensity end of the force × velocity curve, whereas the lighter intensities (30% 1RM) would provide improvements toward the high-velocity end of the curve. As a distinct temporal organization of the lighter and heavier loads was provided between VEL and INT, we expected that it would differently affect the low-external load tests (i.e., sprinting and jumping).

It has been previously demonstrated that distinct power training loads (i.e., between 30 and 100% of the maximal isometric force) promote similar increases in maximal power and velocity in the elbow flexion (28,29). However, both studies used single-joint movements. Conversely, the study by McBride et al. (19) demonstrated that ballistic training using different intensities (i.e., 30 and 80% 1RM) produced load-specific adaptations. Only the low-intensity group displayed a significant increase in peak power in the low-intensity (30% 1RM) jump squat, whereas the high-intensity group improved the 50 and 80% 1RM jump squat peak power.

One may argue that the loads employed in the latter study were considerably different than the ones used in the present study. That may actually have been the case. However, because several studies have suggested that the use of the optimal load for power training (i.e., the load that elicits the maximal power production in a specific movement) (9) may constitute an effective stimulus for power development, we opted for varying loads within a spectrum around the optimal load and keeping a more feasible approach to realistic training scenarios. Nonetheless, it is tempting to speculate that if a broader range of loads were used, a different outcome could have been found. Supporting this concept, others have also found that when testing loads that were not dramatically different (i.e., −50 vs. 80% 1RM), comparable results were found between groups in sport-specific tasks across an intermediate- to high-velocity spectrum (12).

Furthermore, it is possible to speculate that the lack of differences between the experimental groups in the post-training tests may be related to the rather short training...
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period adopted (6-week preseason training period). Although we agree with such argument, it is imperative to highlight the fact that the pre-season in professional soccer in Brazil consistently ranges from 4 to 6 weeks. Additionally, other studies have shown performance improvements in similar time frame preseason periods (15,30,33). Alternatively, we could have designed a 6-week instead of a 3-week power-oriented training. However, because athletes were previously in an off-season period, and given the previous suggestions that training status (e.g., strength level) may play a role in power ability (5,26,31), we opted for a 3-week basic strength training period. Moreover, it has been advocated that combining the development of both the components of the power equation (i.e., strength and velocity) may reflect in better power development across a training period (14,21,28), further corroborating our strategy. Finally, unfortunately, it is unfeasible to conceive that coaches and professional players will be available for a year-round experimental study, which could interfere with their training program. Instead, the cooperation with the Brazilian professional soccer team in this study constitutes a unique opportunity to gather knowledge regarding strength training effects on soccer players’ performance during their actual preseason training.

Nonetheless, caution should be exercised when considering the practical application of our findings. Even though the subjects of this study were elite Brazilian soccer players, it is possible that these athletes are sensitive to a more dramatically different distribution of the training loads across the training period. In summary, our data suggest that trained individuals have similar performance improvements when training load manipulation occurs just around the optimal load for power training.

PRACTICAL APPLICATIONS

Soccer competitive seasons are becoming longer and, consequently, less time is devoted for preseason preparation. The current study indicates that male professional soccer players can achieve improvements in strength- and power-related abilities as a result of 6 weeks of power-oriented training during the pre-season. There were no differences in performance between treatment groups, indicating that both forms of training load manipulation (i.e., velocity- or intensity-oriented) were equally effective. Thus, our results highlight the possibility of using both strategies to improve the power-related components of soccer. In addition, we suggest that coaches involved in power training for team sports such as soccer should be concerned about the selection of the most appropriate training load range rather than with loading schemes variations. According to our results, we suggest that using loads within a small range around the individual’s peak power output (e.g., from 30 to 60% of the 1RM, assuming a measured optimal power training load of 45% 1RM) leads to improvements in power-related performance during the preseason training period in elite soccer players.

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