TRAINING FOR POWER AND SPEED: EFFECTS OF INCREASING OR DECREASING JUMP SQUAT VELOCITY IN ELITE YOUNG SOCCER PLAYERS

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ABSTRACT

Loturco, I, Nakamura, FY, Kobal, R, Gil, S, Cal Abad, CC, Cuniyochi, R, Pereira, LA, and Roschel, H. Training for power and speed: Effects of increasing or decreasing jump squat velocity in elite young soccer players. *J Strength Cond Res* 29(10): 2771–2779, 2015—The aim of this study was to test the effects of 2 different velocity-oriented power training regimens by either increasing or decreasing the jump squat velocity during jump training sessions applied 3 times a week for 6 weeks in soccer players. Twenty-four elite under-20 soccer players were randomly assigned to an increased bar velocity group (IVG) or a reduced bar velocity group (RVG). Athletes had their countermovement jump heights, mean propulsive velocities (MPVs) in jump squat, leg press maximum dynamic strength (1 repetition maximum [RM]), 20-m sprint times, and zig-zag change of direction (COD) abilities assessed before and after the intervention. Performance in all tests improved after training in both groups. However, greater gains in 1RM and MPV using 50–90% of body mass (BM) were noted for the RVG. The IVG demonstrated greater improvements in speed at 5, 10, and 20 m and MPV with no additional external load and with 40% BM. Both groups improved similarly in countermovement jumps and COD. To conclude, both velocity-oriented power training regimens were effective in eliciting neuromechanical adaptations, leading to better strength/power/speed performances, and the choice as to the most suitable method should be tailored according to players' needs/deficiencies.

KEY WORDS: negative loads, elite athletes, optimal loads, sprint, acceleration

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INTRODUCTION

Muscle power ability is widely recognized as a crucial element of successful performance in a broad range of different team and individual sports (5,20,28,45). In this regard, different methods of strength/power training (e.g., loaded jump squats) have proved successful at increasing muscle power performance in sport-related motor tasks in both trained (e.g., high-level athletes) and nontrained (e.g., physically active) individuals (12,30,35).

Nonetheless, an issue often revisited in the literature concerns the effects of manipulating training intensity and velocity throughout a given training period on strength/power performance. Despite the well-established paradigm that increased muscle power is best induced by training explosively with the optimum power load (i.e., the load that elicits maximal power output) (3,36,43,46), one may argue that it challenges the concept of specificity in power training adaptations, as most sport-specific motor tasks are performed under unloaded conditions (i.e., using athlete's body mass [BM]). In this regard, despite previous positive results (12,30,46), traditional training practice that advocates increased training intensities using external resistances, such as those frequently necessary to achieve optimum power training load (30–60% 1RM) (16,18,34), may not promote an optimal stimulus for developing speed-power qualities.

In support of this notion, it has been proposed that overloading the velocity component of power using negative loads (i.e., "reducing" the subject's body weight by mechanical assistance) in jump training could be beneficial in power development (31,42). In fact, Sheppard et al. (42) demonstrated that assisted jump training (10 kg of unloading assistance) was superior to conventional unassisted jump training in improving countermovement jump and spike jump performance in elite volleyball players. In accordance, Markovic et al. (31) showed that negative (−30% BM) rather than positive loading (+30% BM) could be more effective in improving jumping performance, as demonstrated by increased countermovement jump height and concentric phase peak velocity. However, notwithstanding the interesting results from both studies, it is important to notice that neither investigation actually controlled the movement velocity. Instead, investigators increased or decreased exercise external load, which is clearly expected to induce changes in movement velocity, although to an unknown extent. Furthermore, movement velocity may have been differently affected between subjects, thus limiting the conclusions because of the likely lack of uniformity in this important mechanical parameter of training. Argus et al. (2), however, reported comparable increases in jump height performance after either assisted or resisted jump training. The authors reported that by unloading the subjects' BM by 20% less with the aid of elastic bands, peak velocity was increased by only a small amount (~3.7% on average) when compared with free jumping, which may, at least partially, explain the results. Further investigation into the effects of unloaded jump training with not only greater magnitude of velocity manipulation but also more robust control of exercise velocity is warranted.

Therefore, the purpose of this study was to compare the effects of 2 power-oriented training regimens, using either standardized increased (unloaded condition) or decreased (loaded condition) bar velocity, on jumping and sprinting performance and on lower limb power and strength in highly trained athletes.

METHODS

Experimental Approach to the Problem

To test the efficacy of 2 different velocity-oriented power training regimens, this research compared the effects of either increasing (unloaded condition) or reducing (loaded condition) the jump squat velocity during jump training on strength, power, and speed in young elite soccer players. Athletes were tested at the beginning (PRE) and at the end (POST) of a 6-week preseason training period for their countermovement jump height, mean propulsive velocity (MPV) in the jump squat exercise, leg press maximum dynamic strength (1 repetition maximum [RM]), 20-m sprint test, and zig-zag change of direction (COD) speed. The increase or decrease in movement velocity during training was based on an individual reference value. Initially, the mean propulsive bar velocity was assessed during jump squat without any additional external load to the Smith machine. This was determined as the "velocity of reference" for the determination of the training protocols. Thereafter, 20% increments or decrements in velocity were provided to each experimental group during training by loading or unloading the bar.

Subjects

Twenty-four young (under-20) male soccer players who had been engaged in a regular soccer training program for at least 6 years volunteered for this research. All the participants had previous experience in resistance training and could perform jump squats proficiently. In addition to the intervention, all the players were engaged in a standardized physical and technical-tactical training composed of 2 weekly sessions of ball-specific drills (amounting to 120 minutes), 2 weekly sessions of small-sided games (amounting to 90 minutes), and 1 weekly simulated match (amounting to 80 minutes). The study protocol took place before the Brazilian Sub-20 (under 20 years) Soccer Elite Championship, during the preseason training period. Before the study, athletes were asked to sign an informed consent form, which was approved by the Institutional Review Board for the Use of Human Subjects. All subjects under 18 years of age had written informed consent from a guardian to participate in the study.

Figure 1. Illustration of the elastic band system attached to the Smith machine bar used to increase bar velocity.

Training Protocols

After the pretests, athletes were randomly assigned to 1 of the 2 groups: (a) increased bar velocity group (IVG) ($n = 12$; age: 18.7 ± 0.5 years; height: 177 ± 5.2 cm; BM: 70.8 ± 6.1 kg) or (b) reduced bar velocity group (RVG) ($n = 12$; age: 18.4 ± 0.6 years; height: 175 ± 7.3 cm; BM: 69.4 ± 5.9 kg). The experimental training protocols consisted of 6 sets of 6 repetitions of the jump squat exercise, with a 3-minute rest interval between sets, performed under 2 conditions: (a) 20% increase in bar velocity as compared with the velocity of reference (IVG training) and (b) 20%

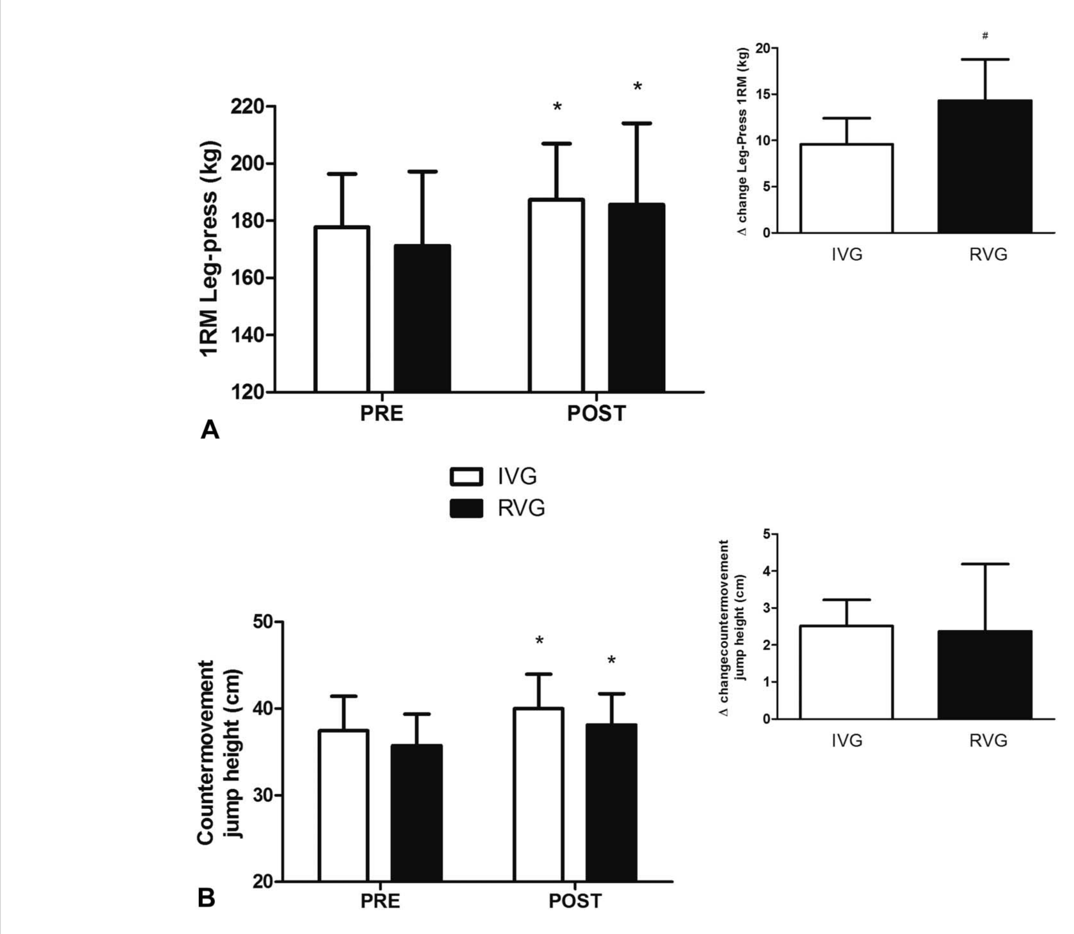

Figure 2. A) Absolute and delta change scores for maximum dynamic strength (1RM) in leg press in both groups; (B) absolute and delta change scores for countermovement jump height in both groups. IVG = increased bar velocity group; RVG = reduced bar velocity group; PRE = before the training period; POST = after the training period; 1RM = 1 repetition maximum; *$p \le 0.05$ when compared with PRE values (within-group comparisons); #$p \le 0.05$ for between-group comparison.

reduction in bar velocity as compared with the velocity of reference (RVG training). An elastic band system capable of pulling the Smith machine bar was used to increase the bar velocity (Figure 1). The system was composed of 1–8 elastic bands connected to the Smith machine bar, which allowed the subjects to reach higher bar velocities. For IVG, the number of bands was progressively increased until the subject reached a mean propulsive bar velocity 20% higher than the velocity of reference (average IVG velocity was $1.63 \pm 0.11\ \text{m}\cdot\text{s}^{-1}$). For RVG, the reduction (20%) in mean propulsive bar velocity was obtained by adding external loads to the Smith machine. An average of 41.4 ± 9.5 kg was used to load the bar in the RVG group, and the average velocity for RVG was $1.08 \pm 0.07\ \text{m}\cdot\text{s}^{-1}$. A linear encoder (T-Force; Dynamic Measurement System, Ergotech Consulting S.L., Murcia, Spain) was used to determine bar velocity in all the experimental conditions and to monitor velocity throughout all training sessions. To maintain a constant difference of ±20% between the "velocity of reference" and the actual training velocity throughout the entire experimental period, reassessments of the "velocity of reference" were performed every 2 weeks.

Countermovement Jump Test

Before performing the countermovement jump tests, subjects completed a 15-min warm-up including general (i.e., running at a moderate pace for 5 minutes followed by 5 minutes of lower limb active stretching) and specific exercises (i.e., submaximum attempts at countermovement jumps). The athletes were required to maintain their hands on the hips during jumps and freely determine the amplitude of the countermovement to avoid changes in jumping coordination pattern (28). A total of 6 attempts (with 15 seconds between attempts) were performed on a contact platform (Smart Jump; Fusion, Brisbane, Australia), and jump height was calculated using the

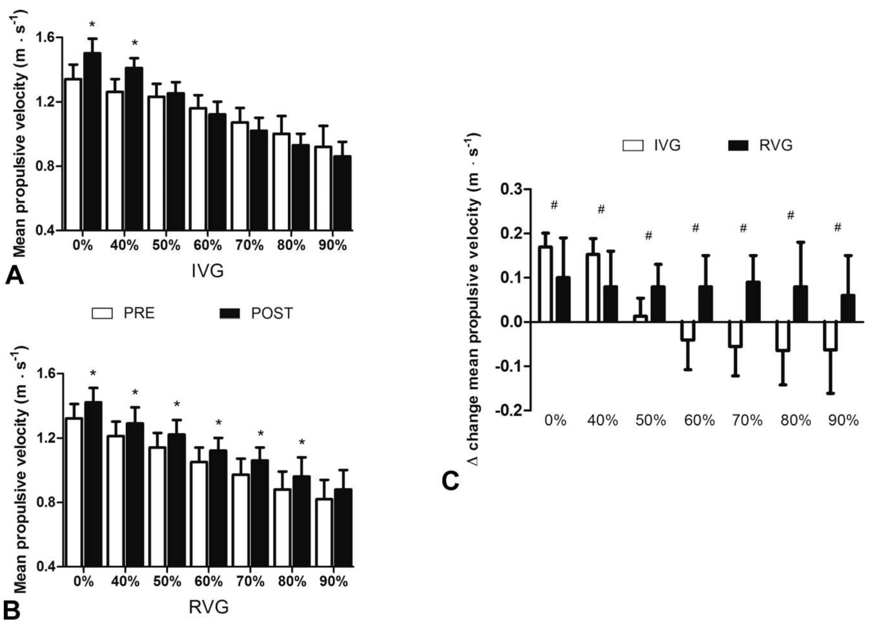

Figure 3. Mean propulsive velocity in the unloaded (0%) and loaded (40–90% BM) jump squat PRE and POST in the IVG (A) and in the RVG (B). $*p \leq 0.05$ when compared with PRE values (within-groups comparisons). C) Delta change scores in mean propulsive velocity for the IVG and RVG groups in the unloaded (0%) and loaded (40–90% BM) jump squat. $\#p \leq 0.05$ for between-group comparisons. IVG = increased bar velocity group; RVG = reduced bar velocity group; PRE = before the training period; POST = after the training period.

formula by Bosco et al. (4). The highest attempt was considered for data analysis purpose.

Mean Propulsive Velocity

Mean propulsive velocity was assessed during jump squats on a Smith machine (Technogym Equipment, Cesena, Italy). Participants were instructed to perform 3 repetitions (30 seconds apart) at maximal velocity in each condition. First, participants performed jump squats without any additional external load to the equipment. This condition was considered for the determination of the "velocity of reference," and it was denominated 0% BM as no load had been added to the machine. After this, the athletes executed the same exercise in loaded conditions (i.e., 40, 50, 60, 70, 80, and 90% BM). Jump squats were performed with knee flexion allowing the thigh to be parallel to the ground, and upon a command, subjects were requested to jump as fast and as high as possible without their shoulders losing contact with the bar. A 5-minute interval was allowed between loads. To determine MPV for each load relative to BM, a linear encoder (T-Force, Dynamic Measurement System, Ergotech Consulting S.L.) was connected to the Smith machine bar. The bar position data were sampled at 1,000 Hz using a computer. Finite differentiation technique was used to calculate bar velocity and acceleration. For further analysis, we considered the MPV obtained during the jump squat repetition executed at the highest velocity (at each relative load).

Maximum Dynamic Strength Test (1RM)

Maximum dynamic strength was assessed using the 1RM leg press test. Before the actual test, 2 familiarization sessions were conducted. During testing, a 5-minute warm-up was performed on a treadmill at 9 km·h^{-1} followed by 5 minutes of lower limb active stretching exercises. Then, subjects executed 2 warm-up sets, as follows: (a) athletes performed 5 repetitions at 50% of the estimated 1RM followed by (b) 3 repetitions at 70% of the estimated 1RM. A 3-minute rest interval was provided between all sets. After 3 minutes, athletes started the test and were allowed up to 5 attempts to achieve their 1RM (i.e., maximum weight that could be lifted once using the proper technique) (6). The measurements were performed on a Plyo Press machine (PlyoPress; Athletic Republic, Park City, UT, USA), and the participants started the concentric movement from 90° knee flexion. Strong verbal encouragement was provided during the attempts.

20-m Sprint Speed Test

Subjects started from a standing position 0.3 m behind the starting line. Four pairs of photocells (Smart Speed; Fusion Equipment) were positioned at 0, 5, 10, and 20 m along the course. They sprinted twice, with a 5-minute rest interval between attempts. The fastest sprint was used for further analysis.

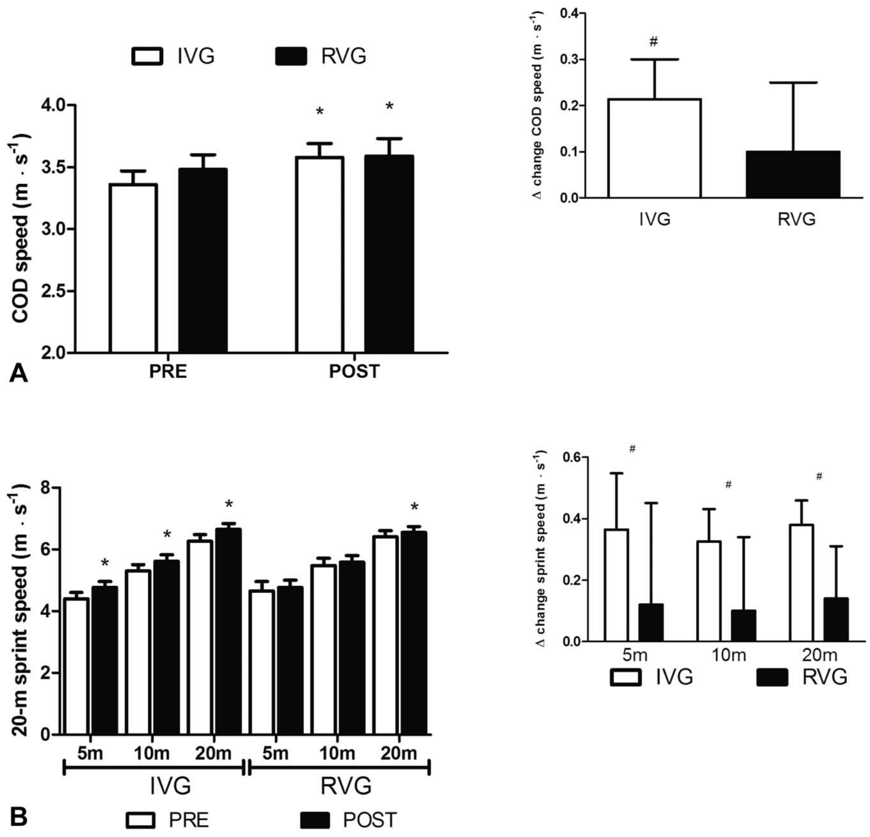

Figure 4. A) Absolute and delta change scores for maximum zig-zag COD speed performance in both groups. $*p \leq 0.05$ for within-group comparisons (PRE vs. POST); $\#p = 0.07$ for between-group comparisons. B) Absolute and delta change scores for 20-m sprint speed performance in both groups. $*p \leq 0.05$ when compared with PRE values (within-group comparisons); $\#p \leq 0.05$ for between-group comparisons. COD = change of direction; IVG = increased bar velocity group; RVG = reduced bar velocity group; PRE = before the training period; POST = after the training period.

Zig-Zag Change of Direction Speed Test

The COD speed test course consisted of four 5-m sections marked with cones set at 100° angles. Starting from a standing position with the front foot 0.3 m behind the first pair of photocells, the athletes were required to run, changing direction as fast as possible, until crossing the second pair of photocells (27,41). Two maximal attempts, with a 5-minute rest interval between them, were allowed. The best time was retained for further analysis.

Statistical Analyses

Data normality was assessed through visual inspection and the Shapiro-Wilk test. A mixed-model for repeated measures was conducted for countermovement jumps, MPV, 20-m sprint, and COD speed assuming group (IVG and RVG) and time (PRE and POST) as fixed factors and subjects as a random factor. In case of significant F values, a Tukey's adjustment was used for multiple comparison purposes. Significance level was set at $p \leq 0.05$. Unpaired T-tests were used to assess possible between-group differences in pre- to post-test changes in scores (delta change analysis). Effect sizes (ES) for all the dependent variables were calculated according to the previously described method (10). Intraclass correlation coefficients (ICCs) were used to indicate the relationship within vertical jumping in loaded (jump squats) and unloaded conditions (countermovement jumps) for MPV and jump heights. The ICC was 0.94 for the MPV and 0.96 for the jump height.

RESULTS

Maximum Dynamic Strength (1RM)

Leg press 1RM was similar between the 2 groups at PRE ($p = 0.90$). No group × time interaction was observed ($p = 0.99$). Both IVG (5.4%, ES = 0.52, $p < 0.0001$, within-group comparison) and RVG (8.3%, ES = 0.55, $p < 0.0001$, within-group comparison) improved their 1RM from pre- to post-test. Delta change analysis indicated that RVG induced greater 1RM gains than IVG ($p = 0.005$) (Figure 2A).

Countermovement Jump Height

The IVG and RVG baseline values for countermovement jump height were comparable ($p = 0.68$). No between-group differences were observed at POST ($p = 0.63$), indicating that both training methods were equally effective in increasing jumping ability. Significant within-group differences were detected in both groups (IVG: 5.4%, ES = 0.52, $p < 0.0001$; RVG: 8.3%, ES = 0.55, $p < 0.0001$). Delta change analysis showed no between-group differences for countermovement jump height ($p = 0.80$) (Figure 2B).

Mean Propulsive Velocity

Mean propulsive velocity was assessed with different external loads (Figures 3A, B). The analysis of the data regarding MPV with no additional external load (condition used for the determination of the velocity of reference) revealed that both groups were similar at PRE ($p = 0.97$) with no significant difference between them at POST ($p = 0.13$). Both training methods induced significant within-group changes (PRE to POST) in MPV (IVG: 12.6%, ES = 1.96, $p < 0.0001$; RVG: 7.5%, ES = 1.06, $p = 0.0003$). Importantly, delta change analysis showed that IVG had a greater improvement in MPV than RVG at 0% BM ($p = 0.03$) (Figure 3C). A similar result was found for MPV at 40% BM (Figure 3C). Groups were similar at PRE ($p = 0.47$), and both training methods significantly improved this parameter (IVG: 12.1%, ES = 1.96, $p < 0.0001$; RVG: 6.7%, ES = 0.90, $p = 0.001$). Additionally, delta change analysis revealed a greater improvement for IVG when compared with RVG ($p = 0.012$).

Results for MPV at 50, 60, 70, 80, and 90% BM showed a similar pattern between them. Groups were comparable at PRE, and no group × time interaction effect was observed at any intensity (all $p > 0.05$). However, the loaded training mode (RVG) was able to induce positive changes in MPV from PRE to POST at all the above-mentioned intensities (all $p \leq 0.05$, within-group comparisons), whereas the IVG group showed no significant change in the same parameters (all $p > 0.05$, within-group comparisons) (Figures 3A, B). Delta change analysis revealed that RVG had significantly greater improvements than IVG at all of the intensities assessed (all $p \leq 0.05$) (Figure 3C).

Zig-Zag Change of Direction Speed

Groups were similar at baseline ($p = 0.11$), and no group × time interaction was detected ($p = 0.99$). Both training regimens improved COD speed (IVG: 6.3%, ES = 1.87, $p < 0.0001$; RVG: 2.9%, ES = 0.85, $p = 0.03$; within-group comparisons). Delta change analysis indicated an important trend toward significance for greater improvements in COD speed for IVG when compared with RVG ($p = 0.07$) (Figure 4A).

20-m Sprint Speed

Sprint speed was assessed at 5, 10, and 20 m. Groups were similar at baseline at all distances evaluated (all $p > 0.05$), and no group × time interactions were observed (all $p > 0.05$). The IVG group showed significant pre-to post-test improvement at all distances (5 m: 8.2%, ES = 1.76, $p = 0.0005$; 10 m: 6.1%, ES = 1.57, $p < 0.0001$; 20 m: 6.0%, ES = 1.77, $p < 0.0001$, within-group comparisons), whereas RVG had significant improvement only at 20 m (5 m: 2.5%, ES = 0.39, $p = 0.45$; 10 m: 1.9%, ES = 0.43, $p = 0.21$; 20 m: 2.2%, ES = 0.69; $p = 0.005$, within-group comparisons). Delta change analysis showed that IVG had greater improvements in sprint speed at all distances evaluated when compared with RVG (all $p \leq 0.05$) (Figure 4B).

DISCUSSION

This is the first study that has investigated the effects of 2 different velocity-oriented power training regimens (i.e., increased bar velocity [IVG] vs. reduced bar velocity [RVG]) on the strength, power, and speed abilities of elite young soccer players during a preseason conditioning program composed of 6 weeks. The main finding of this study was that increasing (IVG), rather than decreasing (RVG), movement velocity during jump squat training was more effective in inducing speed performance-related changes in a group of junior elite soccer players over a 6-week preseason training period. However, strength and power adaptations followed a load-specific pattern, with RVG demonstrating greater increases in 1RM and MPV at loaded conditions (from 50 to 90% BM).

Despite the similar pre- to post-test improvement in 1RM observed between the 2 groups, RVG showed a greater net change in lower limb maximum strength. Although previous studies have shown that training with either light or heavy loads is capable of significantly–and similarly–improving 1RM (19,34), which may be, at least partially, explained by the fact that subjects, including those in this study, had the intention to move the bar as rapidly as possible; our results showed a load-specific response. In fact, RVG produced specific gains at the initial phase of the force-velocity curve (high-force/low-velocity zone) (17,24,33), substantially increasing the ability to apply a great amount of force at lower velocities. In this regard, it has been previously demonstrated that higher external loads are more effective in inducing neuromuscular adaptations favoring maximum strength ability (17,24,33). Nonetheless, it is important to note that, overall, our data support the concept that training even at very low loads (i.e., IVG) is feasible when aiming to increase 1RM.

Both the IVG and RVG groups were equally effective in inducing increases in vertical jumping height. The absence of between-group differences may be associated with 2 factors: (a) the significant improvements in MPV demonstrated by IVG and RVG when using very light and/or light loads (i.e., 0 and 40% BM) and (b) the significant increases in maximum strength reported by both training regimens at POST. Although IVG showed greater increases in MPV than RVG at unloaded conditions and at loads close to BM (0 and 40% BM; Figure 3C), RVG presented greater changes in maximum strength ability (Figure 2A). It has been widely reported that improvements in either of these 2 force-velocity zones (represented by different ranges of external loads) are directly related to enhancements in vertical jumping ability (18,29,47). It seems reasonable to assume that the advantage of each training regimen on producing these distinct and particular/specific adaptations balanced the gains in countermovement jump performance attained by the subjects.

The average speed over longer distances (20 m) was significantly increased in both groups; however, IVG had greater net improvements in this variable. Moreover, only IVG had significant increases in speed at 5 and 10 m. Although increases in maximum strength have been related to improvements in acceleration rates achieved over very short distances, RVG did not show significant improvements at 5- and 10-m speed, despite the significant increase in 1RM in this group. In this regard, it is plausible to suggest that other neuromechanical factors could affect speed over multiple distances. Namely, as force is the product of mass and acceleration (38), it is likely that the manipulation of the traditional strength training paradigm (i.e., increasing acceleration/decreasing mass instead of increasing mass/decreasing acceleration) induces more specific adaptations in acceleration ability over a wide range of distances. Possibly, jump squat performed at higher velocities may elicit more specific neural adaptations (e.g., motoneurons excitability and nerve conduction velocity) (40) with greater transference to acceleration performance in short sprints than exercises performed at lower velocities. Therefore, performing the exercise at velocities that resemble muscular activity while sprinting seems to be a key factor in this case.

The performance in the zig-zag COD speed test depends directly on the maximum acceleration rate achieved by the athletes over a very short distance (23,37). Accordingly, IVG presented not only a significant pre- to post-test increase in COD performance but also a greater net improvement than RVG. Curiously, despite the absence of improvements in 5- and 10-m sprint speed, RVG also performed better in COD test at POST. This is in line with the relationship between COD speed and athletes' acceleration capacity (23,37). However, such association still needs clarification, as RVG improved COD performance without increasing maximum acceleration rate over very short distances. Performance in COD speed tests probably involves more physical/neuromuscular components than acceleration ability alone (7,9,49). As exemplified by the countermovement jump, the improvement in this given test can be attained by a combination of different changes in functional and physiological determining factors.

Mean propulsive velocity is a valid indicator of athletic performance, as its calculation is independent of the magnitude of the athletes' BM. As a linear encoder determines power production from a velocity/time curve generated by a "loaded bar" (11), during the jump squats, a substantial portion of the actual load is overlooked (i.e., subject's body weight) and the resulting power is often underestimated (14). Furthermore, the possibility of assessing bar velocity using fixed percentages of the individuals' BM as a reference avoids misinterpretation of the power-related measurements, which may be accentuated by seasonal variations in the athletes' weight (21). Essentially, changes in MPV using the same percentage of BM imply higher relative power outputs, regardless of the absolute amount of muscle power produced. Under this mechanical principle, MPV is considered as an important indicator of the actual capacity of applying force to a given mass by accelerating it as fast as possible. Our data demonstrate that both IVG and RVG were able to increase MPV at unloaded and very light-loaded conditions (0 and 40% BM). However, IVG had significantly greater net gains at both conditions when compared with RVG. Importantly, when increasing the magnitude of the lifted load (i.e., 50, 60, 70, 80, and 90% BM), only RVG showed significant gains in MPV, suggesting that the parametric relationship between force and velocity (i.e., the higher the load, the lower the velocity) plays a central role in modulating the strength-power training adaptations. Indeed, several studies have argued that heavy-load training methods generally result in greater improvements in the high-force/low-velocity portion of the force-velocity curve, whereas light-load training regimens induce higher adaptations toward the high-velocity/low-force end of the curve (1,13,22,25,26,44,48). Considering these findings, it appears that, besides loading intensity, the mechanical manipulation of the vectorial variable of the force equation (i.e., acceleration) is able to cause specific athletic adaptations, especially at loads close to body weight.

It is important to note that, unlike previous studies (19,32,34), we manipulated movement velocity by artificially increasing maximum acceleration rate (for the IVG condition) rather than decreasing external load (in comparison with heavy-loaded groups). Therefore, even the "decelerated group" (RVG) trained at a substantially high velocity, which partially explains their positive results in power/speed–specific motor tasks (e.g., zig-zag COD speed, 20-m sprint, and countermovement jump height). Other authors have already examined the effects of jump training with negative (−30% BM) versus positive loading (+30% BM) on vertical jumping ability (31). Contrary to our results, the "negative method" was found to be more effective than "positive jump training" in improving countermovement jump performance. Despite the similarities between the 2 studies, we opted to control bar velocity rather than manipulating external load (based on a %BM) to reduce the discrepancies among the maximum movement velocities attained by the subjects with different body weights. An important limitation of the methods based on external load manipulation is that, even with an equal percentage of "body weight reduction," heavier subjects might achieve lower velocities than lighter subjects when moving a given load, hindering the interpretation of the velocity-specific adaptations. Conversely, by controlling training intensities in a velocity-based approach, all the subjects may actually execute the exercises at a similar accelerated/decelerated percentage (e.g., 20% faster or 20% slower). This approach is particularly interesting as it allows subjects to reach movement velocities that would otherwise be unattainable without "mechanical assistance" (for the accelerated groups). As a final point, it is likely that this "artificial acceleration" may provide a number of changes/adaptations in the neuromuscular system, thus modifying kinematic/dynamic patterns of some motor tasks, especially those performed at high velocities. Other studies should investigate the neuromuscular adaptations related to exercise velocity manipulation and their effects on sport-related motor tasks.

This study is limited by the absence of a control group (athletes maintaining their normal training routine without adding explosive exercises). Even in the absence of a control group, this is the first study to report significant improvements in loaded and unloaded jumping, agility, maximal strength, and sprinting ability over multiple distances in response to 2 different velocity-manipulated jump squat training regimens. The significant changes in neuromuscular performance are not a common finding in studies with similar cohorts of elite soccer players. Most studies report maintenance or only slight improvements in performance in power/speed tests during the preseason/season (8,15,39). For this reason, it is plausible to suggest that the improvements observed in this study could be related to the addition of both velocity-oriented power training regimens to the "traditional" soccer training. In this regard, future studies controlling for the effects of normal training regimens on strength/power/speed are required to ascertain the net effects of additional power training exercises.

PRACTICAL APPLICATIONS

Technical and strength and conditioning coaches are constantly seeking effective training regimens in team sports to elicit neuromechanical adaptations that are relevant to competitive performance. However, the congested fixture and technical and tactical training schedules–commonly observed among field and court sports–preclude the desired exposure to physical training aiming to induce improvements in neuromuscular abilities (exemplified by maximal and explosive strength and sprinting). In this regard, the outcomes of this study suggest that increasing bar velocity during jump squat exercises (with the aid of a system composed of elastic bands attached to a Smith machine) favors adaptations in the high-velocity/low-force end of the force-velocity curve. In practical terms, this training mode benefits performance in (a) jump squats undertaken with a load close to BM and (b) short sprinting ability when compared with training with reduced bar velocity. However, decreasing bar velocity (by adding weights to the bar during the jump squat exercise) favors adaptations in the low-velocity/high-force end of the curve, as demonstrated by greater improvements in MPV between 50 and 90% BM in jump squat and in 1RM performance, when compared with the increased bar velocity training method. Finally, both training strategies were demonstrated to be equally effective in improving countermovement jump and COD ability, suggesting that either one may be used to these ends. However, in athletes with deficiencies in sprinting ability, the increased bar velocity strategy may be preferable. Conversely, the decreased bar velocity method is preferred if the target is optimizing maximal strength and performance in loaded explosive movements (e.g., jumping or sprinting against external sources of resistance–tackling). In athletes with a well-balanced strength/power/speed relationship, a combination of positive and negative training methods may be applied to induce further adaptations at both ends of the force-velocity curve.

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