EFFECTS OF SHORT-TERM STRENGTH AND JUMPING EXERCISES DISTRIBUTION ON SOCCER PLAYER'S PHYSICAL FITNESS

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Abstract:

The aim of this study was to examine the effects of a short-term (six weeks) preseason strength and jumping exercises distribution program on amateur adult soccer player's indicators of physical fitness. Twenty male athletes (age 20.1±1.6 years) were randomly divided into two groups that completed a volume-equated training program differing only in exercises distribution: a group that completed three weeks of strength followed by three weeks of plyometric training (TT; n=10) and a group that completed six weeks of combined strength and plyometric drills (S+P; n=10). Athletes completed a triple hop test with the dominant (HOPd) and non-dominant leg (HOPnd), a 15 meters sprint, a change of direction speed (CODS) test (i.e. T test), and a 6×30 meters repeated sprint with change of direction for the best ($RSCOD_b$) and mean velocity ($RSCOD_m$), and the percentage of decrement (%Dec) in sprint time. Moreover, athletes performed a squat test for maximal power. Both strength and jumping training programs were performed two times per week, equated for exercises, frequency, volume, and intensity per session. The TT group completed the strength training volume during the first three weeks, and the plyometric training volume in the last three weeks, while the S+P combined strength and plyometric training during the six weeks. A 2 (group) × 2 (time: pre, post) ANOVA with repeated measures was used for statistical analysis. Analyses revealed significant improvements for the TT and S+P (HOPd: ES=0.91, 10.28 and 16.69%, respectively; HOPnd: ES=0.86, 11.49 and 14.71%, respectively; $RSCOD_b$: ES=0.84, 9.23 and 8.34%, respectively; $RSCOD_m$: ES=0.89, 8.56 and 7.51%, respectively). In the post-test there were no significant differences between the groups in any variable analyzed. In conclusion, both training approaches were equally effective at improving jumping and repeated sprinting ability. However, only after the S+P training approach a significant improvement in CODS was observed, with more substantial changes in maximal sprinting speed.

Key words: *football, complex training, stretch-shortening cycle, repeated sprint ability, explosive training, jump training*

Introduction

Soccer is probably the most popular sport in the world. Regarding physical fitness, soccer competition demands several repeated high-intensity actions such as jumps, dribbling, kicking, change of directions, and sprints (Stolen, Chamari, Castagna, & Wisloff, 2005). Therefore, aside from endurance (Helgerud, Engen, Wisloff, & Hoff, 2001), athletes need to improve their muscle power through the use of appropriate training methods (Loturco, Pereira, et al., 2015; Ramirez-Campillo, Meylan, et al., 2014; Wong, Chamari, & Wisloff, 2010). However, there still exists considerable debate regarding how to train for better performance (Aguiar, Botelho, Lago, Macas, & Sampaio, 2012).

Power training should incorporate both strength and speed-plyometric components (Izquierdo, Hakkinen, Gonzalez-Badillo, Ibanez, & Gorostiaga, 2002; Marques, et al., 2015). Previous studies have argued that when jumping exercises are introduced into the training schedule, an initial strength training base should be introduced first (James, et al., 2018). However, others have combined these two types of drills during training sessions throughout the program for team sports players (Freitas, Martinez-Rodriguez, Calleja-Gonzalez, & Alcaraz, 2017), and some have specifically recruited male soccer players (Brito, Vasconcellos, Oliveira, Krustrup, & Rebelo, 2014; Kobal, et al., 2017). The latter approach may offer adaptation advantages compared with the former (Kobal, et al., 2017; Rodriguez-Rosell et al., 2016).

The combination of loaded and unloaded drills within the same training session may increase neuromuscular responses and thus explosive performance (Ronnestad, Kvamme, Sunde, & Raastad, 2008), in some cases inducing the post-activation potentiation phenomenon (i.e. increased strength/power production after the performance of a maximal, or near maximal, muscle contraction) (Seitz & Haff, 2016). This sequence is thought to optimize performance during the unloaded drills after the execution of heavily loaded ones (Kilduff, et al., 2007), possible due to increased phosphorylation of myosin regulatory light chains, increased recruitment of higher order motor units, and acute changes in pennation angle (Tillin & Bishop, 2009). In male young soccer athletes, aged 18.9 years, eight weeks of combined maximal (i.e. 60-80% 1RM) and explosive strength training helped to maintain sprinting speed that otherwise was reduced (-7%) in soccer players who completed plyometric training (unloaded drills) before resistance training (load drills) (Kobal, et al., 2017). Similarly, compared to a control condition, combined maximal (i.e. 50-90% 1RM) and explosive strength training improved jumping and endurance performance (11-18%) in amateur players aged 22.5 years (Faude, Roth, Di Giovine, Zahner, & Donath, 2013). However, the mentioned studies were conducted during the competitive period, with fewer studies conducted in the preseason with soccer players (Freitas, et al., 2017). To our knowledge, only one short-term (i.e. six weeks) preseason study has combined resistance training with plyometric and speed exercises in prepubertal young soccer players, and found significant improvements in maximal dynamic strength, jumping and sprinting performance (Rodriguez-Rosell, et al., 2016). However, whether a short-term six weeks preseason combined maximal and explosive strength training can improve adult player's performance deserve further consideration. Therefore, the aim of this study was to examine the effects of a short-term (six weeks) preseason strength and jumping exercises program distribution on amateur adult soccer player's indicators of physical fitness. Our hypothesis was that both training approaches would be effective at improving soccer player's physical fitness, although the combined training approach would induce greater improvements.

Methods

Participants and experimental design

To compare the effects of a short-term preseason combining strength and plyometric training programs of equal volume but of different temporal distribution (strength and plyometric drills) on male soccer player's physical fitness, athletes were randomly divided into a group that completed six weeks of combined strength and plyometric drills (within each training session) and a group that completed three weeks of strength followed by three weeks of plyometric drills. Before and after the intervention athletes performed a set of athletic performance tests: a triple hop with the dominant (HOPd) and non-dominant (HOPnd) leg, 15 meters sprint, repeated sprint with change of direction (RSCOD), change of direction speed (CODS), and a progressive explosive squat test. Within- and between-group differences were explored to verify the effectiveness of the different temporal training distributions.

National-level male soccer players (age 20.1±1.6 years; height 178.6±5.6 cm; body mass 70.6±4.8 kg), competing for the same club and submitted to the same soccer-specific training load, participated in this study during the preseason. Athletes completed between four to six 120 minutes training sessions per week during the investigation period. A typical training week included technical-tactical drills, specific soccer conditioning (e.g. small-sided games), and injury prevention exercises for 60, 30 and 10% of the weekly training time, respectively. Moreover, athletes played six friendly matches during the preseason, with a mean of playing time per athlete of 70.4±10.4 minutes.

To be included, athletes had i) to complete ≥90% of the training intervention, ii) to be cleared from a physician to complete maximal-intensity exercise, iii) to be free from injuries in the four months preceding this study, and iv) to be an outfield player (i.e. goalkeepers were excluded). After pre-intervention measurements, athletes were divided by simple randomization (Suresh, 2011) into a group that completed three weeks of strength followed by three weeks of plyometric training (TT; n=10) and a group that completed six weeks of combined strength and plyometric drills within each neuromuscular training session (S+P; n=10). After a thorough explanation given to athletes regarding the aims, potential benefits and risks associated with their participation in the study, a signed informed consent form was obtained. The technical department of the soccer club approved the study. This study protocol with human participants was also approved by the ethical review board of the responsible institutional department. The study design followed the norms established in the Declaration of Helsinki.

The sample size was determined according to changes in vertical jump performance in a group of soccer players subjected to a control (Δ=0.5 cm; SD=1.1) or a short-term plyometric training protocol (Δ=2.6 cm; SD=1.6) (Ramirez-Campillo, Burgos, et al., 2015) comparable with that applied in this study. Eight participants per group would yield a power of 95% and α=0.01.

Testing procedures

Athletes participated in two familiarization sessions, including familiarization with one repetition maximum (1RM) determination, one week before baseline testing in the venue where test and training drills took place. Measurements were always completed at the same time of day (18:00 to 20:00 h), with athletes using same garments, after 48-72 h of rest from the last training session, competitive match, or previous measurement session. Although not controlled, the players were asked to attend the sessions in an adequate fed and hydrated state and to avoid consumption of caffeinated drinks in the hours preceding measurements. The measurements were performed during the first and eighth weeks of the preseason, corresponding to the weeks immediately before and after the study intervention, respectively. All measurements were always administered in the same order and by the same investigators, who were blinded to the training group of the participants. Athletes were assessed over a two-day period. On the first day, body mass and height (SECA® – 700; precision of 0.05 kg and 0.1 cm, respectively), HOPd, HOPnd, 15 meters sprint, and RSCOD tests were completed. On the second day, the CODS and a progressive explosive squat test were carried out. To reduce the risk of fatigue, athletes rested 15 minutes between the tests. Before testing, athletes were guided by a strength and conditioning coach to complete 15 minutes of warm-up, including jogging, dynamic and static stretching, joint movements, low-intensity jumps, and 10-30 meters sprints. In order to motivate athletes to achieve maximal effort during testing, each testing session replaced a regular soccer training session. To assess reliability, thresholds of ≥0.80 for the intraclass correlation coefficient were set (Hopkins, 2000). As in previous studies (Ramirez-Campillo, et al., 2018), the reliability of assessments was over the established threshold. Of note, the reliability for the maximal repeated sprint with change of direction and for the maximal progressive squat test for maximal power were not assessed. Due to their exhaustive nature, these tests were applied only once.

Triple hop test. According to a previously validated protocol (Rosch, et al., 2000), athletes performed HOPd and HOPnd. Briefly, athletes performed three consecutive maximal jumps forward as far as possible on the testing leg and landed on it after the final jump, maintaining the position for a brief moment. Arm movement was allowed during the test. Two valid maximal attempts were allowed per leg, with two minutes of rest between them. The maximal distance achieved was selected for analysis.

15 meters sprint test. Athletes completed a linear 15 meters sprint as fast as possible, starting 0.5 meters behind the timing gates (Witty, Microgate®, Italy). Participants voluntarily initiated the sprint, with two valid maximal attempts, and two minutes of rest between them. The fastest time was selected for analysis.

Repeated sprint with change of direction. The test comprised six bouts of two 15 meters sprints with 180º change of direction and 30-s of passive recovery between the bouts (Buchheit, et al., 2008). Prior to the test, participants executed a preliminary single shuttle-sprint of the same total distance (15+15 meters) which was used as the criterion score. Subjects rested five minutes before actually starting the test. If performance in the first sprint was worse than the criterion score (i.e. an increase of 2.5% in time), the test was finished and this participant was required to rest for five minutes before re-starting the test. Participants commenced each sprint from a standing start position with their front foot placed 0.5 meters behind the starting/finishing timing gate (Witty, Microgate®, Italy). A visual electronic system (WittySEM, Microgate®, Italy) controlled the rest time between the bouts. From the total time ($RSCOD_t$), the best ($RSCOD_b$), the mean ($RSCOD_m$), and the percentage of decrement (%Dec) in sprint time were retained for subsequent analysis. The %Dec was calculated using the formula: $\%Dec=[(RSCOD_t \div RSCOD_b \cdot \text{number of bouts}) \cdot 100] - 100$ (Spencer, Bishop, Dawson, & Goodman, 2005). Standard verbal encouragement was provided during each sprint (i.e. *Go, go, go*...).

Change of direction speed (CODS). The CODS T test was applied following previous recommendations (Sassi, et al., 2009). Athletes performed two valid maximal trials, with two minutes of recovery between the trials. The best performance result was used for analyses. A timing gate (Witty, Microgate®, Italy), located at the start/finish line (same line for this test), was used to record time, while athletes initiated the test 0.5 meters behind the gate. The total distance covered was 20 meters for each trial.

Progressive squat test for maximal power. Following previously validated protocols (Sanchez-

Sanchez, et al., 2018), athletes completed a maximal progressive explosive half-squat test using a bar in a Smith machine (MultipowerPeroga®, Murcia, Spain). In the initial vertical-bipedal position, the bar was at shoulder-level, the feet were at shoulder-width distance, and the knees and hips were in full extension. Adhesive marks were added to the floor and the barbell to assure consistency in hand and feet position during testing. From the initial position, athletes performed an eccentric movement using a 90° knee angle (goniometer-determined) with a controlled speed (0.5-0.65 m/s) (Pareja-Blanco, Rodriguez-Rosell, Sanchez-Medina, Gorostiaga, & Gonzalez-Badillo, 2014) and then a concentric leg extension as fast as possible (without jumping). The initial load was 30% of 1RM for one set of four consecutive repetitions, then one set at 45 and 60%. Then, the load was increased to 70, 80, and 100% of 1RM for three, two and one repetition, respectively. Four minutes of rest were allowed between the sets. A linear encoder was used to obtain data every millisecond operating at 1000 Hz (SmartCoach-PowerEncoder®, Europe AB. Stockholm, Sweden). The software SmartCoach® (v.3.1.3.09) was used to translate data into power records. Athletes were motivated to perform at maximal concentric effort speed and were provided with feedback after each set repetition. The maximal value of power was retained for analyses (Loturco, Pereira, et al., 2015).

Training program

The training programs were performed during six weeks, two sessions per week, 20-25 minutes per session, as a replacement of some technical-tactical soccer drills. All the training drills were performed on an artificial grass surface, and were programmed based on previous experience with the team and from previous studies (Wong, et al., 2010). After 15 minutes of warm-up similar to that described in previous paragraphs, athletes completed their respective training programs, using the same exercises, volume, and intensity (Table 1).

However, the TT completed the full strength training volume during the first three weeks and the plyometric training volume in the last three weeks, while the S+P combined strength and plyometric training during each neuromuscular training session throughout the six weeks of the preseason. In order to equate for total volume at the end of the six weeks of training, the S+P used a reduced volume (i.e. 50%) per session compared to the TT during the six weeks. For the strength drills, athletes used an intensity equivalent to 6RM and controlled movement velocity (not maximal velocity), while for the plyometric (unloaded) drills athletes were encouraged to achieve minimum contact time with the ground and maximal height or distance in each repetition, using a rapid stretch-shortening cycle (Andrade, et al., 2020; Ramirez-Campillo, Vergara-Pedreros, et al., 2016). For the strength drills, the load used was progressively increased to allow subjects to achieve a consistent value of ~6RM during the six weeks of training. All sessions were supervised by two strength and conditioning coaches and technical staff members, maintaining a coach:trainee ratio of 1:4. The rest between sets of strength and plyometric drills was 60 seconds (American College of Sports Medicine, 2009; Ramirez-Campillo, Andrade, et al., 2014; Seitz & Haff, 2016)

Statistical analysis

All values are reported as M ± SD. Normality and homoscedasticity assumptions made for all data were checked using the Shapiro-Wilk and Levene tests, respectively. Measures of dependent variables were analyzed in 2 (Groups) × 2 (Time: pre, post) ANOVA with repeated measures on time. *Post-hoc* tests with Bonferroni-adjusted α were conducted to identify comparisons that were statistically

Table 1. The six-week preseason strength and plyometric training program*

Traditional training group (n=10)				Combined strength and plyometric training group (n=10)			
Week 1-3				Week 1-6			
	Intensity	Sets	Repetitions		Intensity	Sets	Repetitions
Back half-squat	6RM	4	6	Back half-squat	6RM	2	6
Bent-over row	6RM	4	6	Bent-over row	6RM	2	6
Forward lunge	6RM	2	6	Forward lunge	6RM	1	6
Week 4-6							
Vertical jump	Max	4	5	Vertical jump	Max	2	5
Horizontal jump	Max	4	5	Horizontal jump	Max	2	5
Unilateral vertical jump	Max	2	8	Unilateral vertical jump	Max	1	8
Unilateral horizontal jump	Max	2	8	Unilateral horizontal jump	Max	1	8

Note. *: all plyometric jump drills were performed without external load and with arm swing; RM: maximum repetition; Max: maximum speed effort.

Table 2. Effects of training interventions on dependent variables (M±SD)

	Traditional training group (n=10)			Combined strength and plyometric training group (n=10)			ANOVA p-value (ES)		
	Pre-test	Post-test	Δ	Pre-test	Post-test	Δ	Group	Time	Group x Time
HOPd (meters)	5.85±0.92	6.45±0.34	10.28	5.62±0.60	6.52±0.42	16.69	p<0.5 (0.07)	p<0.001 (0.91)	p<0.07 (0.29)
HOPnd (meters)	5.77±0.33	6.42±0.38	11.49	5.66±0.56	6.45±0.37	14.71	p<0.6 (0.05)	p<0.001 (0.86)	p<0.5 (0.05)
CODS (seconds)	5.21±0.61	4.98±0.28	3.82	5.64±0.61	5.04±0.22	9.85	p<0.03 (0.42)	p<0.01 (0.48)	p<0.2(0.15)
$RSCOD_b$ (seconds)	6.04±0.22	5.47±0.10	9.23	6.01±0.14	5.50±0.18	8.34	p<0.9 (0.01)	p<0.001 (0.84)	p<0.7 (0.02)
$RSCOD_m$ (seconds)	6.20±0.23	5.66±0.06	8.56	6.14±0.14	5.67±0.15	7.51	p<0.8 (0.01)	p<0.001 (0.89)	p<0.5 (0.04)
%Dec (%)	2.63±1.72	3.44±1.94	67.21	2.12±1.65	3.07±1.31	78.32	p<0.6 (0.04)	p<0.1 (0.24)	p<0.9 (0.01)
Sprint 15 meters (seconds)	2.33±0.39	2.29±0.40	1.62	2.34±0.06	2.29±0.08	1.99	p<0.9 (0.01)	p<0.07 (0.33)	p<0.9 (0.01)
Power (Watios)	753±123	808±222	8.45	780±185	828±205	9.35	p<0.6 (0.05)	p<0.6 (0.03)	p<0.9 (0.01)

Note. HOPd and HOPnd: triple hop test with dominant and non-dominant leg, respectively; CODS: change of direction speed; $RSCOD_b$ and RSCODm: repeated sprint with change of direction best and mean time, respectively; %Dec: percentage of decrement in sprint time in the RSCOD test; ES: effect size; Δ: percentage pre-post change.

significant. Alpha level was set at <.05. To determine the magnitude of the training effect, effect sizes (ES) were determined by converting partial eta-squared to Cohen's d. According to Hopkins, Marshall, Batterham, and Hanin (2009), ES can be classified as: ≤0.19 (trivial), 0.2-0.59 (small), 0.6-1.19 (moderate), 1.2-1.99 (large), and ≥2 (very large). Analyses were performed with the Statistical Package for the Social Sciences (SPSS v. 21.0 for Windows; SPSS Inc., Chicago, IL., USA).

Results

The analyses revealed significant main effects of time for the TT and S+P (HOPd: ES=0.91, 10.28 and 16.69%, respectively; HOPnd: ES=0.86, 11.49 and 14.71%, respectively; $RSCOD_b$: ES=0.84, 9.23 and 8.34%, respectively; $RSCOD_m$: ES=0.89, 8.56 and 7.51%, respectively). No significant changes were observed for either group in %Dec, sprint 15 meters and power in the squat test (Table 2).

No group × time interaction was observed for HOPd (p=.06, ES=0.29), HOPnd (p=.46, ES=0.05), CODs (p=.19, ES=0.15), $RSCOD_b$ (p=.67, ES=0.02)), $RSCOD_m$ (p=.49, ES=0.04), %Dec (p=.89, ES=0.01), sprint 15 meters (p=.86, ES=0.01) or power in the squat test (p=.84, ES=0.01).

Discussion and conclusions

The aim of this study was to examine the effects of a short-term preseason strength and jumping exercises distribution program on amateur adult soccer player's indicators of physical fitness. Main results indicate that only the combined strength and plyometric training program (i.e. the S+P group) was effective in improving CODS performance.

Jumping ability was enhanced after both training interventions (Table 2), an expected result in soccer players, especially considering the plyometric training component incorporated into the training program of both training groups, as in previous studies with soccer athletes (Chaabene & Negra, 2017; Granacher, Prieske, Majewski, Busch, & Muehlbauer, 2015). Considering the unilateral nature of most competitive soccer actions with players implicated in predominantly unilateral weight-bearing fundamental movements, such as running, cutting, kicking, vertical and horizontal leaps, and changing running direction (McCurdy, Langford, Doscher, Wiley, & Mallard, 2005), the improvements in unilateral jumping ability in the HOP test may be of relevance for soccer players in competitive situations. In fact, a greater jumping ability have showed to be related to a better position in competitive soccer leagues (Arnason, et al., 2004), and a greater jumping ability also may reduce injury risk (Arnason, et al., 2004). Of note, both training interventions were equally effective at enhancing jumping ability, although the TT used twice the volume of jumps compared to the S+P in the three weeks preceding the post-intervention assessment. In this sense, it may have been expected a greater jump improvement in the TT compared to the S+P (Lesinski, Prieske, & Granacher, 2016).

However, this was not the case, which might be attributed to the beneficial effects of the combined training approach used by the S+P (Freitas, et al., 2017). In this sense, loaded drills executed at the beginning of the training sessions may have facilitated phosphorylation of myosin regulatory light chains and recruitment of higher order motor units during the plyometric jump drills executed later in the same session (Tillin & Bishop, 2009), increasing the efficiency of this training method.

Regarding CODS, the TT and the S+P achieved no meaningful ES improvements (Table 2). Previous authors have found CODS improvements after strength-plyometric training interventions. In young soccer players, Garcia-Pinillos, Martinez-Amat, Hita-Contreras, Martinez-Lopez, and Latorre-Roman (2014) observed significant improvements in CODS performance (i.e. 5.1%) in the Balsom test after 12 weeks of combined strength-plyometric training. However, in our study the improvement in CODS was important only in the S+P (9.85%), but not in the TT (3.82%). If greater improvements in CODS occurred in the S+P group due to a post-activation potentiation effect by the combination of strength and plyometric drills in the same training session (Ebben & Watts, 1998), using an adequate rest interval between both types of drills (Kilduff, et al., 2007), should be clarified in future studies. Moreover, the underlying mechanism of the improvement (e.g. eccentric strength) (Sheppard & Young, 2006) should also be considered for future studies.

The RSCODb and RSCODm ability improved after both training interventions. The repeated sprint ability is heavily dependent of both metabolic and neuromuscular factors (Mendez-Villanueva, Hamer, & Bishop, 2008). Neuromuscular adaptations are typically found after plyometric training (and strength training) interventions (Markovic & Mikulic, 2010). Among the neuromuscular adaptations, the ability to recruit fast-twitch motor units (Mendez-Villanueva, Hamer, & Bishop, 2007) might be particularly important after strength and plyometric training (Markovic & Mikulic, 2010). Regarding the %Dec, this may be a poor indicator of RSCOD adaptations in response to a short-term preseason strength and plyometric training program among soccer players, and we strongly discourage its use for assessment of players responsiveness to a current training approach. In this sense (although we did not assess the reliability of the test) the %Dec increased in both groups after the intervention, indicating an unrealistic greater fatigue during the RSCOD test, as our results indicate that players from both groups improved RSCODb and RSCODm ability. Therefore, the use of RSCODb and RSCODm absolute scores may be better suited to assess fatigue adaptations in soccer players after strength and plyometric training during the preseason.

Both groups have a similar behavior 15 meters sprint performance. Because vertical strength and maximal-intensity exercise are related with sprint performance (Loturco, D'Angelo, et al., 2015), the maximal-intensity vertical drills completed during the intervention might have positively affected sprint performance in the training groups. However, due to the importance of horizontal force production and application in sprint performance, the incorporation of horizontal drills during training probably played at least an equally important role in sprint performance improvement (Ramirez-Campillo, Gallardo, et al., 2015). The improvements observed after training in a unidirectional maximal-intensity movement such as the 15 meters sprint may have been mediated by rapid (i.e. ≤ six weeks) neuromuscular adaptations of the targeted muscle groups (Markovic & Mikulic, 2010). Of note, although both training groups significantly improved 15 meters sprint performance, the ES was trivial (ES=0.1) in the TT, while the S+P achieved a moderate (ES=0.71) meaningful improvement (Table 2). Whether the combination of strength and plyometric jump drills in the same training sessions induced a post-activation potentiation effect (Ebben & Watts, 1998), leading to a greater ES improvement in the S+P compared to the TT, deserves further research attention. In partial agreement with a previous six weeks study with young (i.e. ~23 year-old) soccer players (Loturco, et al., 2016), it appears that the *transference* of the effects from a strength-based phase to the explosive power training phase is not straightforward, and that maintaining a prolonged exposure to an optimal and sport-specific training strategy (combining strength and plyometric drills) can enhance more the CODS and sprint performance than more traditional periodization models.

Regarding power in the half-squat test, none of the training groups improved, contrasting with previous findings using loaded countermovement jump (Ramirez-Campillo, Gonzalez-Jurado, et al., 2016) or a squat loading test (Rodriguez-Rosell, et al., 2016). Differences between the training and assessment protocols may help to explain the apparently contrasting findings. In this sense, the strength training drills in our study emphasize a controlled-velocity during both the eccentric and concentric portions of the movements. On the other hand, the half-squat test is a concentric-explosive drill. In this sense, a reduced strength training velocity during our intervention might have limited fast-twitch fibers adaptations, limiting their ability to increase performance in an explosive drill such as the half squat test (Cronin & Sleivert, 2005). Moreover, in previous studies (Ramirez-Campillo, Gonzalez-Jurado, et al., 2016; Rodriguez-Rosell, et al., 2016), where a greater specificity occurred between the training exercises and the measurement exercise, as compared with our study, significant increases in the half squat test were found. Alternatively, instead of using heavy loads, training at the *optimum power* zone (i.e. a specific percentage range of the one-repetition maximum at which power production is maximized) (Loturco, Nakamura, et al., 2015) might have induced changes in the maximal power generated during the half squat (Loturco, et al., 2016).

Some potential limitations were identified in the current study. In this sense, future studies should aim to identify the underlying physiological and biomechanical basis of current findings. Moreover, a control group *per se* was not included in the current study, which should be addressed in future replications of the current training approach.

In conclusion, although both training approaches were equally effective at improving jumping and repeated sprinting ability, only the combination of strength and plyometric drills in every training session led to improvements in CODS after six weeks of preseason training in male soccer players and more substantial changes in maximal sprinting speed.

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