Effects of Different Plyometric Training Frequencies on Measures of Athletic Performance in Prepuberal Male Soccer Players

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Abstract

Bouguezzi, R, Chaabene, H, Negra, Y, Ramirez-Campillo, R, Jlalia, Z, Mkaouer, B, and Hachana, Y. Effects of different plyometric training frequencies on measures of athletic performance in prepuberal male soccer players. *J Strength Cond Res* 34(6): 1609–1617, 2020—This study aimed to compare the effects of 1 vs. 2 sessions of equal-weekly volume plyometric training (PT) across 8 weeks on measures of athletic performance (i.e., sprint time, change of direction [CoD], jumping ability, and muscle strength) in prepuberal male soccer players. Thirty participants were randomly assigned either to 1 session PT group (1SPT [$n = 15$]) or 2 sessions PT group (2SPT [$n = 15$]). Plyometric training was integrated into their regular soccer training routine. Pretraining and posttraining tests for the assessment of sprint time (e.g., 5, 10, 20, and 30-m), CoD (e.g., T-test and modified Illinois change of direction test [MICODT]), jumping ability (e.g., standing long jump [SLJ], countermovement jump [CMJ], and squat jump [SJ]), muscle strength (reactive strength index [RSI]), and kicking distance were conducted. Results showed a main effect of time for 5-m sprint-time performance ($F_{(1,56)} = 4.00$, effect size [ES] = 0.53 [medium], $p = 0.05$), T-test ($F_{(1,56)} = 23.19$, ES = 1.28 [large], $p < 0.001$), MICODT ($F_{(1,56)} = 5.72$, ES = 0.94 [large], $p = 0.02$), SLJ ($F_{(1,56)} = 16.63$, ES = 1.09 [large], $p < 0.001$), CMJ ($F_{(1,56)} = 15.43$, ES = 1.04 [large], $p < 0.001$), SJ ($F_{(1,56)} = 20.27$, ES = 1.20 [large], $p < 0.001$), RSI ($F_{(1,56)} = 26.26$, ES = 1.36 [large], $p < 0.001$), and kicking distance ($F_{(1,56)} = 47.19$, ES = 1.83 [large], $p < 0.001$). There were no training group × time interactions in all the measured outcomes. In conclusion, when an equated moderate volume of jumps is performed, higher PT frequency across 8 weeks has no extra effects on prepuberal male soccer players' measures of athletic performance. The present findings may help optimizing PT interventions dedicated to prepuberal male soccer players.

Key Words youth, football, training load, stretch-shortening cycle, physical fitness

Introduction

Unloaded plyometrics is a form of sports enhancement training that has been extensively used in youth soccer (29,32,42). Typically, plyometric drills involve quick and powerful jumping or hopping multijoint movements. These movements use the stretch-shortening cycle in which muscles experience a rapid stretching action (i.e., eccentric phase) followed by an immediate shortening action (i.e., concentric phase) (11). The previous stretching action has been demonstrated to improve the performance of the final concentric phase compared with a unique concentric contraction (9).

The beneficial effects of plyometric training (PT) in youth soccer players' measures of athletic performance had been previously reported (2,26,28,33). These benefits range across muscular power development (e.g., jumping ability), sprinting (e.g., straight speed), and change of direction (CoD) ability (2,22,29) that are considered key athletic performance components in youth soccer (20,38). The adaptations that take place after PT in young soccer athletes are primarily of neuronal nature (i.e., at the level of the central and peripheral nervous systems) (19).

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However, optimal PT design for improving high-intensity actions still needs to be sufficiently addressed. Particularly, previous studies have mainly focused on PT intensity (e.g., drop jumps at increasing height) (8,31,39,40) and volume (e.g., different foot contacts number) (4,30,42), whereas instructions related to the benefits of manipulating PT session frequency remain unclear especially in prepuberal soccer players.

Typically, frequency refers to the number of training sessions performed in a given period (i.e., a week) (37). Ramirez-Campillo et al. (30) studied the effect of PT volume and training surface over 7 weeks, 2 sessions per week on measures of athletic performance (i.e., sprinting, jumping ability, and maximal strength) in male high-school adolescent students (~17 years). The authors reported that measures of athletic performance enhancement were related with the volume and training surface of PT. Recently, Chaabene and Negra (4) examined the effect of low (up to 120 foot contacts per session) vs. high (up to 220 foot contacts per session) PT volume on measures of athletic performance in prepuberal male soccer players (U-13) over 8 weeks and revealed similar performance improvement in sprint time, CoD, and jumping ability between the 2 programs. de Villarreal et al. (7) studied different PT frequencies in conjunction with various PT volume and intensity on measures of athletic performance in active physical education students (21–26 years) over 7 weeks. They showed that both moderate (i.e., 840 jumps, 2 sessions per week) and low (i.e., 420 jumps, 1 session per week) PT frequency induced greater gains in jumping and sprinting performance compared with high (i.e., 1,680 jumps, 4 sessions per week) PT frequency. To the best of our knowledge, the effect of PT frequency (controlling for total volume) have been analyzed only by Yanci et al. (43), comparing the effect of 1 vs. 2 PT sessions of equal-weekly volume on measures of athletic performance in futsal players aged 22.5 ± 5 years. The main findings of this study demonstrated that both PT frequencies were similarly effective in enhancing 15-m sprint time, CoD, and horizontal jump performances. Notably, authors demonstrated that 1 PT session per week significantly increased repeated sprint ability performance, whereas 2 PT sessions did not. Yanci et al. (43) concluded that 1 PT session per week may be more appropriate for improving measures of athletic performance in futsal players.

To date, no research has assessed the effects of manipulating PT frequency on measures of athletic performance in prepuberal male soccer players. Such a study would be of great on-field importance for coaches and strength and conditioning professionals who look for the proper handling of PT variables to achieve meaningful and safe performance adaptation. Thus, the aim of the current study was to compare the effects of 8 weeks, 1 session vs. 2 sessions of equal-weekly volume PT, on measures of athletic performance (i.e., sprint-time, CoD, jumping ability, and muscle strength) in prepuberal male soccer players. Based on previous findings (43), we hypothesized that 1 session PT group achieves comparable training-induced performance enhancements compared with 2 sessions PT group on measures of athletic performance in prepuberal male soccer players.

Methods

Experimental Approach to the Problem

Two weeks before baseline testing, 2 familiarization sessions were held to get subjects acquainted with the tests. Pretraining and posttraining, tests for the assessment of sprint time (i.e., 5-, 10-, 20-, and 30-m), CoD (i.e., T-test and modified Illinois change of direction test [MICODT]), jumping ability (i.e., standing long jump [SLJ], countermovement jump [CMJ], and squat jump [SJ]), muscle strength (reactive strength index [RSI]), and kicking distance were conducted. All tests were scheduled at least 48 hours after the most recent training session or competition and under the same experimental conditions. Participants were instructed to use the same athletic shoes and clothes during the pretesting and posttesting. All tests were conducted outdoor on an artificial pitch turf.

Subjects

To compare the effects of a short-term (i.e., 8 weeks) equal-volume PT program with 1 vs. 2 training sessions per week on measures of athletic performance in prepuberal male soccer players, 30 participants from the same football club academy, with no regular strength or PT experience, voluntarily participated in this study. They were randomly assigned either to 1 session PT group (1SPT [$n = 15$]; 11.32 ± 0.27 years; 145.33 ± 3.56 cm; 39.0 ± 6.08 kg; maturity offset = −3.09 ± 0.36 years) or 2 sessions PT group (2SPT [$n = 15$]; 12.27 ± 0.33 years; 145.18 ± 5.67 cm; 35.44 ± 4.77 kg; maturity offset = −2.90 ± 0.34 years). Participants had 4.0 ± 0.5 years of regular soccer training, with 3–4 (i.e., 4.5–6 hours per week) training sessions per week. Players who missed more than 20% of the total training sessions and/or more than 2 consecutive sessions were omitted from the study (27,28). During the last 6 months before the beginning of the study as well as during the course of the training intervention, none of the players presented any kind of medical problems or history of bone, joint, and muscle injury that could affect their participation in the study. The level of maturation was determined at the start and after 8 weeks of training on the basis of the predicted age at peak height velocity (25). Study procedures were approved by the ethics institutional review board of the Higher Institute of Sport and Physical Education of Ksar Said, Tunisia, in accordance with the Declaration of Helsinki. Verbal and written informed consent was obtained from legal representatives and participants after the experimental protocol and its potential risks and benefits were explained. Participants were free to withdraw from the study at any time without providing reasons.

Procedures

This study was conducted during the first phase of the in-season period, from October to November. The warm-up program for all tests included 5 minutes of submaximal running with CoD, 20 vertical and 10 submaximal horizontal jumps, dynamic stretching exercises, and 5 minutes of a sprint-specific warm-up. It is worth noting that the same warm-up program was used in pretest and posttest. Tests were separated by 5–10 minutes of rest. Athletes participated in a familiarization trial and 3 test trials, with 3 minutes of rest in between except in jumping tests, in which a rest of 1 minute was adopted between jumps. The best of the 3 test trials was analyzed.

Sprint Test. Sprint time was recorded at 5-, 10-, 20-, and 30-m intervals using an electronic timing system (Microgate SARL, Bolzano, Italy). Participants started in a standing start 0.3-m before the first infrared photoelectric gate, which was placed 0.75-m above the ground to ensure that it captured trunk movement rather than false signals from limb motion. In total, 5 single-beam photoelectric gates were used.

Change of Direction Test: T-Test. The test was conducted as previously outlined (4). The time needed to complete the test was used as a performance outcome and it was assessed using an electronic timing system (Microgate SARL).

Modified Illinois Change of Direction Test. The performance outcome of the MICODT was collected using an electronic timing system (Microgate SRL, Bolzano, Italy) according to the procedure detailed by Hachana et al. (12). The MICODT involves placing 4 markers to indicate an area that is 5-m long and 5-m wide. In the center of the area, 3 markers were placed 2.5-m apart. Participants started in a prone position with the chin touching the surface of the starting line. Athletes accelerated for 5 m, turned around, and returned back to the starting line, and swerved in and out of 3 markers, completing 5-m sprints to finish the MICODT speed course. Participants were instructed not to cut over the markers but to run around them. If a participant failed to follow these instructions, the trial was terminated and restarted after a 3-minute recovery period.

Standing Long Jump

The starting position required subjects to stand with their feet at shoulders' width behind a line marked on the ground and their arms in neutral position. On the command ready, set, go, participants executed a countermovement with their legs and arms and jumped at maximal effort in the horizontal direction. Participants had to land with both feet at the same time and were not allowed to fall forward or backward. The horizontal distance between the starting line and the heel of the rear foot was recorded using tape measure to the nearest 1 cm.

Countermovement Jump and Squat Jump

During the SJ, participants started from a stationary semi-squatted position (knee angle of 90°) and performed a vertical jump at maximal effort. For the CMJ, participants started from an upright standing position, completed a fast downward movement by flexing the knees and hips, which were immediately followed by a rapid leg extension resulting in a vertical jump. Throughout the execution of both tests, participants maintained their arms akimbo. The performance was recorded using an Optojump photoelectric system (Microgate, SRL).

Reactive Strength Index

During RSI, participants performed 5 repeated bilateral maximal vertical hops using an Optojump photoelectric system (Microgate, SRL). They were instructed to maximize jump height and minimize ground contact time. The first jump was excluded and the 4 remaining ones were averaged for the calculation of RSI using the following formula:

$$\text{RSI} = \text{Jump height (mm)}/\text{Ground contact time (ms)}$$

The reliability of RSI in youth aged 13.5 $\pm$ 0.5 years has been established elsewhere (17).

Kicking Distance Test

The test was conducted as previously outlined by Ramirez-Campillo et al. (31). Participants kicked a new size 5 soccer ball (Nike Seitiro, FIFA certified) on a soccer field for maximal distance. Two markers were placed on the ground side by side to locate the kick line. After a run up of 2 strides, participants executed a maximal kick with their dominant leg. The maximal distance attained by the ball was measured using a metric tape. An evaluator was placed near to the region where the ball lands to accurately locate the point of contact and measure the distance of the kick at the nearest 0.2 m. The wind velocity was $<20\ \text{km}\cdot\text{h}^{-1}$ during all the measurement sessions (Tunisian Meteorological Service, Tunis, Tunisia).

Plyometric Training Interventions

Both 1SPT and 2SPT completed an 8-week in-season PT intervention with 1 or 2 training sessions per week, respectively. The total PT volume per week (i.e., foot contacts) was the same for both groups. Plyometric training drills were integrated into their regular 80–90-minute soccer training routines. The second PT session for the 2SPT group was completed 72 hours after the first one. A standardized 8–12-minute warm-up preceded each PT session including low-intensity running, coordination exercises, dynamic movements (i.e., lunges and skips), sprints, and dynamic stretching for the lower limb muscles. The PT session lasted between 7 and 19 minutes for the 1SPT group and between 4 and 9 minutes for the 2SPT group. The PT drills were completed before the remaining soccer training time (e.g., technical and tactical drills). At the beginning of each training week, the first training session was performed at least 48 hours after the soccer match that was scheduled for the weekend. The PT protocol is detailed in Table 1. Each PT session included vertical (i.e., CMJs) and horizontal (i.e., 2-footed ankles hop forward and double leg zig-zag) jumps performed at a maximal intensity (i.e., maximal height and forward distance with a minimal contact time for vertical and horizontal jumping, respectively). Both groups performed continuous jumps (i.e., cyclical) using arm swing. During the first 4 weeks, all vertical and horizontal jumping were executed bilaterally, whereas during the last 4 weeks, horizontal jumping, particularly, was performed bilaterally and unilaterally. A 90-second rest was provided between each set and PT exercise. Training sessions were supervised by a qualified instructor certified by the Tunisian soccer association.

Statistical Analyses

Data are presented as mean values and *SD*s. Data were tested for normal distribution using the Shapiro-Wilk's test. The independent t test was applied to determine baseline between-group differences. To establish the effect of the interventions on the dependent variables, a 2 (group: 1SPT and 2SPT) × 2 (time: pre, post) analysis of variance with repeated measures was determined for each parameter. When group × time interactions reached the level of significance (i.e., significant F value), group-specific post hoc tests (i.e., paired t tests) were used. It is noteworthy that because of the numerous comparisons included in the current study, there is a risk of making type I error. Nevertheless, adjusting p-value to overcome type I error has been shown to increase the likelihood of making type II error (10). Therefore, we preferred not going for a p-value adjustment, whenever possible, due to the above-mentioned reason. To determine the magnitude of the training effect, effect sizes (ES) were determined by converting partial eta-squared to Cohen's d. According to Cohen (6), ES can be classified as small (≤0.49), medium (0.50–0.79), and large (≥0.80). Test-retest reliability was assessed using the intraclass correlation coefficients (ICCs) (6). The alpha level of significance was set at $p \leq 0.05$. All data analyses were performed using SPSS 20.0 (SPSS, Inc., Chicago, IL, USA).

Results

All subjects received treatment as allocated. Four and 5 subjects from the 2SPT and 1SPT group, respectively, dropped out because they left the youth soccer training center for personal reasons. In addition, 3 other participants were removed from the statistical analysis because they missed more than 20% of the total PT sessions. Therefore, 30 participants completed the training program with an adherence rate of 95%. None reported any training- or test-related injuries. All measures of athletic performance at preintervention and postintervention are displayed in Table 2. At baseline, no significant between-group differences were

Table 1. Characteristics of the plyometric training programs.*

		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
2SPT	Volume (sets × reps) per session	3 × (8–9)	3 × 10	3 × (11–12)	3 × (13–14)	6 × (7–8)	6 × (8–9)	6 × (8–10)	6 × 10
	Contact number per session	25	30	35	40	45	50	55	60
1SPT	Volume (sets × reps) per session	6 × (8–9)	6 × 10	6 × (11–12)	8 × 10	9 × 10	10 × 10	11 × 10	12 × 10
	Contact number per session	50	60	70	80	90	100	110	120

*2SPT and 1SPT: 2 sessions and 1 session plyometric training groups, respectively.

Table 2. Changes on proxies of athletic performance variables from pretraining to posttraining for each group.*

	2SPT			1SPT			ANOVA p (ES)		
	Pretest	Posttest	Δ (%), 95% CI	Pretest	Posttest	Δ (%), 95% CI	Time	Group	Group × time
T_5 (s)	1.22 ± 0.07	1.16 ± 0.07	−4.77 (−7.20 to −2.33)	1.22 ± 0.09	1.19 ± 0.10	−2.13 (−5.57 to 1.31)	0.05 (0.53)	0.48 (0.19)	0.46 (0.20)
T_{10} (s)	2.11 ± 0.08	2.06 ± 0.09	−2.13 (−3.87 to −0.39)	2.12 ± 0.15	2.09 ± 0.16	−1.10 (−3.27 to 1.07)	0.28 (0.29)	0.47 (0.19)	0.73 (0.08)
T_{20} (s)	3.72 ± 0.15	3.73 ± 0.15	0.30 (−1.25 to 1.85)	3.78 ± 0.30	3.72 ± 0.30	−1.49 (−3.12 to 0.13)	0.69 (0.10)	0.65 (0.12)	0.58 (0.14)
T_{30} (s)	5.32 ± 0.20	5.37 ± 0.22	0.92 (−0.73 to 2.59)	5.42 ± 0.44	5.36 ± 0.41	−1.03 (−2.18 to 0.10)	0.94 (0)	0.59 (0.14)	0.53 (0.16)
T-test (s)	12.17 ± 0.98	11.02 ± 0.45	−9.10 (−11.72 to −6.47)	12.11 ± 0.83	11.31 ± 0.76	−6.46 (−8.68 to −4.24)	0.000 (1.28)	0.57 (0.15)	0.38 (0.22)
MICODT (s)	11.82 ± 0.91	11.49 ± 0.48	−2.54 (−5.11 to 0.01)	12.04 ± 0.68	11.50 ± 0.68	−4.42 (−6.32 to −2.52)	0.02 (0.94)	0.54 (0.16)	0.57 (0.15)
SLJ (cm)	157.13 ± 10.70	170.07 ± 10.70	8.46 (4.59 to 12.33)	164.93 ± 21.22	181.87 ± 11.18	11.55 (4.85 to 18.24)	0.000 (1.09)	0.01 (0.71)	0.58 (0.14)
CMJ (cm)	20.39 ± 3.88	24.15 ± 3.50	20.04 (12.84 to 27.24)	19.72 ± 3.69	24.22 ± 5.03	23.41 (13.15 to 33.68)	0.000 (1.04)	0.77 (0.06)	0.72 (0.08)
SJ (cm)	18.22 ± 4.21	22.65 ± 3.17	27.62 (17.39 to 37.84)	18.40 ± 3.36	23.22 ± 4.92	25.82 (20.04 to 31.61)	0.000 (1.20)	0.71 (0.08)	0.84 (0.06)
RSI ($mm\cdot ms^{1}$)	0.79 ± 0.21	1.10 ± 0.27	43.96 (23.11 to 64.81)	0.72 ± 0.29	1.15 ± 0.33	70.40 (42.09 to 98.71)	0.000 (1.36)	0.87 (0)	0.40 (0.22)
Kicking distance (m)	19.19 ± 3.92	25.89 ± 3.78	37.31 (27.36 to 47.26)	16.89 ± 2.83	22.62 ± 3.39	36.21 (24.21 to 48.21)	0.000 (1.83)	0.003 (0.82)	0.59 (0.14)

*ANOVA = analysis of variance; 2SPT = 2 sessions plyometric training group; 1SPT = 1 session plyometric training group; ES = effect size; Δ = pretraining to posttraining change; CI = confidence interval; T_5, T_{10}, T_{20}, and T_{30} = 5-, 10-, 20-, and 30-m sprint time, respectively; MICODT = modified Illinois change of direction test; SLJ = standing long jump; CMJ = countermovement jump; SJ = squat jump; RSI = reactive strength index.

observed with respect to their maturity offset indicating that the maturation level of participants was prepuberal. Similarly, no between-group differences were noticed at baseline regarding all the measures of athletic performance undertaken (Table 2).

Tests Reliability

The ICCs for test-retest trials were high for all measures of athletic performance undertaken. Results ranged between 0.88 and 0.92 for all the sprint intervals, 0.91 and 0.90 for the T-test and the MICODT, respectively, 0.92, 0.91, and 0.93 for the SLJ, SJ, and CMJ, respectively, and 0.94 for the kicking distance test.

Sprint Time

A main effect of time for 5 m was observed ($F_{(1,56)} = 4.00$, ES = 0.53 [medium], $p = 0.05$), but not for 10-, 20-, and 30-m sprints ($F_{(1,56)} = 1.19$, 0.15, 0.004, ES = 0–0.29 [small], $p > 0.05$, respectively). Training group × time interaction failed to reach the significance level for all sprint intervals ($F_{(1,56)} =$ 0.11–0.54, ES = 0.08–0.20 [small], $p > 0.05$) (Table 2).

Change of Direction Tests

For the T-test, results indicated a main effect of time ($F_{(1,56)} = 23.19$, ES = 1.28 [large], $p < 0.001$) with no training group × time interaction ($F_{(1,56)} = 0.76$, ES = 0.22 [small], $p > 0.05$). Regarding MICODT, similar results were observed with a main effect of time ($F_{(1,56)} = 5.72$, ES = 0.94 [large], $p = 0.02$) and no training group × time interaction ($F_{(1,56)} = 0.31$, ES = 0.15 [small], $p > 0.05$) (Table 2).

Jumping Ability

For SLJ, a main effect of time was demonstrated ($F_{(1,56)} = 16.63$, ES = 1.09 [large], $p < 0.001$), with no training group × time interaction ($F_{(1,56)} = 0.29$, ES = 0.14 [small], $p > 0.05$). Similarly, a main effect of time was observed for both CMJ and SJ ($F_{(1,56)} = 15.43, 20.27$, ES = 1.04 [large], 1.20, $p < 0.001$, respectively), with no training group × time interaction for both tests ($F_{(1,56)} = 0.12, 0.03$, ES = 0.08, 0.06 [small], $p > 0.05$, respectively, for CMJ and SJ) (Table 2).

Reactive Strength Index

For RSI performance, results showed a main effect of time ($F_{(1,56)} = 26.26$, ES = 1.36 [large], $p < 0.001$). Nevertheless, no training group × time interaction was observed ($F_{(1,56)} = 0.70$, ES = 0.22 [small], $p > 0.05$).

Kicking Distance

In the kicking distance test, a main effect of time ($F_{(1,56)} = 47.19$, ES = 1.83 [large], $p < 0.001$) was observed with no training group × time interaction ($F_{(1,56)} = 0.29$, ES = 0.14 [small], $p > 0.05$) (Table 2).

Discussion

This study aimed to compare the effects of 1 vs. 2 sessions per week of equal-volume PT on measures of athletic performance in prepuberal male soccer players across 8 weeks of training. In agreement with our hypothesis, findings showed that (1) both training interventions are equally effective and safe (i.e., no injury occurred) and (2) no significant between-group differences were established from pretest to posttest in all measures of athletic performance undertaken. Therefore, higher training exposure in terms of PT session frequency has no advantage on prepuberal male soccer players' measures of athletic performance when an equated moderate volume of jumps is completed in a short-term period (i.e., 8 weeks).

The beneficial effect of PT on sprint-time performance in youth male soccer players has been well established (ES = 0.50–0.95) irrespective of the period of the season (i.e., preseason and/or in-season) (2,4,29). In view of the high frequency of short-intensity and high-intensity sprints during the soccer match, improving the quality of acceleration is paramount to increase soccer's chances of winning challenges (e.g., winning ball possession and stand out from opponents) in a real game situation (3,41). Findings of this study demonstrated that both interventions were only moderately effective in improving acceleration (i.e., 5-m sprint-time) performance after 8 weeks of training (Table 2). Previous research mainly attributed this observation to the improvement in ground contact time during acceleration after PT (23,36). Specifically, Rimmer and Sleivert (36) studied the effects of 8-week PT program vs. sprint training program in healthy male participants (24 ± 4 years) and revealed that PT had the greatest effects on sprinting during the initial acceleration phase (i.e., 0–10-m) compared with the other sprinting phases (i.e., 10–20-, 20–30-, and 30–40-m). Authors attributed these observations to the fact that sprinting performance improvements occur at the velocity of muscle action that most closely approximates that of muscle action during PT exercises used in training, which means mainly during acceleration. In addition, because of the similarity of ground contact time between acceleration and PT exercises (22,44), the greatest training-related transfer from plyometrics to sprinting may most probably occur during the initial acceleration phase (36). It is worth noting that there are no studies dealing with the effect of manipulating PT session frequency in prepuberal male soccer players. For instance, Ramirez-Campillo et al. (34) demonstrated that only the progressive volume-based PT increased sprint-time performance compared with constant volume-based one in youth male soccer players (11–15 years). de Villarreal et al. (7) revealed that either low (i.e., 420 jumps, 1 session per week), moderate (i.e., 840 jumps, 2 sessions per week), or high (i.e., 1,680 jumps, 4 sessions per week) PT frequency similarly improved 20-m sprint-time performance in active physical education students (21–26 years). Accordingly, from time-efficiency and risk of injuries occurrence perspectives, low and moderate PT frequencies are more appropriate than high PT frequency in improving sprinting performance in physical education students (7). Likewise, Yanci et al. (43) revealed similar performance improvement (ES = −0.64 to −1.0) after either 1 or 2 sessions per week of equal-volume PT on 15-m sprint-time performance in senior futsal players. It is worth noting that findings of the current study showed a lack of improvement in 10-, 20-, and 30-m sprint-time performance in both groups after 8 weeks of training. This means that the current training stimulus was insufficient toward enhancing this fitness quality. Particularly, a previous study (32) revealed that PT incorporating horizontal stimulus may increase expectations to gain adaptations in the horizontal nature measures of athletic performance such as sprinting. Therefore, regarding our findings, one possible explanation for the lack of performance improvement in 10-, 20-, and 30-m sprint times may be the lack of horizontal stimulus (i.e., low horizontal jump volume), which remains below the minimum threshold required to trigger significant sprint-time increases (32). In addition, the lack of measurement accuracy derived by the single-beam timing system used in this study may be another reason that may, partially, explain the lack of performance enhancement during these sprinting intervals (14,15).

Change of direction ability is a paramount performance determinant in soccer (1). In agreement with our hypothesis, findings of this study indicated that either 1SPT or 2SPT induced large magnitude of adaptation in CoD ability (i.e., T-test and MICODT) after 8 weeks of training (Table 2). These findings partially contrast with those of Yanci et al. (43), where improvement in the 505 CoD test was large (ES = −5.5) after 2SPT compared with a moderate one (ES = −0.67) after 1SPT in senior futsal athletes. The greater CoD improvements in the study of Yanci et al. (43) may be attributed to the use of specific CoD drills during training interventions. The comparable CoD performance improvements between both groups in the current study may be due to the fact that both PT programs included horizontal and vertical jump exercises without any specific CoD drills. Therefore, the lack of training specificity may justify the lack of any additional effects of 2SPT over 1SPT (43,45). In the same context, Young et al. (45) examined the effects of 6 weeks of sprint vs. agility training in healthy and physically active men (24 ± 5.7 years) and revealed that the agility training group showed significant enhancements in agility performance without inducing any significant effect on linear sprint performance. However, the current results are in accordance with previous findings that proved the effectiveness of PT in improving CoD performance in prepuberal male soccer players (ES = 0.54–1.52) (4,29). On the whole, it seems that changing PT frequency (i.e., the number of training session per week) does not yield any additional CoD performance improvement in prepuberal male soccer players after 8 weeks of training when a moderate volume of PT is applied. As a result, these findings may suggest that PT frequency is not a worthwhile training load parameter for stimulating CoD enhancement in prepuberal male soccer players. Overall, improvements in CoD performance may be mainly attributed to neuromuscular adaptations that occurred before PT training. These adaptations are essentially in form of increased firing frequencies and enhancement of patterns that enable athletes to rapidly switch between deceleration and acceleration motions (5,13).

Results demonstrated that both PT groups showed large performance improvements in vertical (i.e., SJ and CMJ) and horizontal (i.e., SLJ) jumping performance (Table 2). These findings corroborate previous research that reported moderate to large effect of PT on measures of jumping performance (ES = 0.73–1.30) (4,28,29). The recent meta-analysis of Moran et al. (26) confirmed that PT is highly effective (ES = 0.91) for improving jumping performance in prepuberal athletes. Although using different training volumes, de Villarreal et al. (7) reported that either low (1 PT session per week) or moderate (2 PT sessions per week) PT induced similar performance increases in jumping performance. In accordance with the findings established in sprint-time and CoD performance, it seems that increasing PT frequency does not yield any additional benefits on jumping performance in prepuberal male soccer players. In brief, outcomes of this study showed that either 1SPT or 2SPT are equally effective training interventions in improving prepuberal male soccer players' jumping performance. Factors that govern jumping improvement after PT are essentially of neuronal origin e.g., increased motor unit recruitment (i.e., intramuscular coordination) as well as better synergistic and less antagonistic muscle activation strategies (i.e., intermuscular coordination) (20).

In terms of muscle strength, our findings revealed that both groups showed large magnitude of performance improvements after 8 weeks of training in RSI outcomes (Table 2). The RSI reflects the ability of youth athletes to produce maximal strength in a minimal time. In agreement with our data, de Villarreal et al. (7) reported that either low (1 PT session per week) or moderate (2 PT sessions per week) PT induced similar performance increases in RSI. In addition, Lloyd et al. (18) observed significant training effects on RSI after 4 weeks of PT in 12-year-old boys. It has been previously demonstrated that the rate of force development (21) with the motor unit recruitment level (35) are the main factors responsible for RSI improvement. Therefore, by reference to our findings, it seems that both PT interventions (i.e., 1SPT and 2SPT) were similarly effective in stimulating these 2 factors. This means that increasing PT frequency does not induce any extra effects on RSI performance level in prepuberal male soccer players.

In regards to the kicking distance test, this soccer-specific trait was largely improved after 8 weeks of either 1SPT or 2SPT program (Table 2). This is in agreement with previous findings (24,31). This observation may be attributed to the improvement in some biomechanical parameters involved in kicking the ball (e.g., the maximum linear velocity of the toe, ankle, knee, and hip at ball contact) (16,24) due to the neuromuscular adaptations in terms of strength and power gains after PT (20).

To summarize, findings from this study demonstrated that higher training exposure in terms of PT session frequency has no additional effect on prepuberal male soccer players' measures of athletic performance when an equated short term (i.e., 8 weeks) moderate volume of jumps is accomplished. It is worth noting that sprinting performance during the current study was measured through a single-beam system. Previous studies (14,15) reported that dual-beam system provides greater measurement time accuracy compared with single-beam system. Therefore, outcomes related to sprinting performance revealed in this study should be cautiously considered. Therefore, future studies evaluating sprinting performance could use dual-beam system instead of single-beam one to get higher measurement accuracy.

Practical Applications

Performing either 1SPT or 2SPT in a short-term period induced similar athletic performance increases in prepuberal male soccer players. Consequently, from a practical application point of view, 1SPT is recommended over 2SPT for 2 reasons: (a) coaches and strength and conditioning professionals can save time in the benefits of more technical-tactical training when adopting 1SPT over 2SPT and (b) although both PT programs were safe (i.e., no training-related injuries), 1SPT is preferable over 2SPT to avoid exposing prepuberal male soccer players to an additional risk of training-related injuries (i.e., higher training load exposed on the musculoskeletal system during 2SPT). Whether manipulating PT intensity alone or in conjunction with frequency and/or volume affects prepuberal male soccer players' measures of athletic performance need to be further addressed. In addition, to what extent the current findings are applicable to puberal and postpuberal male soccer players or other type of sports require further studies.

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