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Effects of 1 vs. 2 sessions per week of equal-volume sprint training on explosive, high-intensity and endurance-intensive performances in young soccer players

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ABSTRACT: The study aimed to evaluate the effects of 1 vs. 2 sessions per week of equal-volume sprint training on explosive, high-intensity and endurance-intensive performances among young soccer players. Thirty-six young male soccer players were randomly divided into 2 experimental groups that performed either a single weekly sprint training session (ST1, n = 18, age: 17.2 ± 0.8 years) or two weekly sprint training sessions (ST2, n = 18; age: 17.1 ± 0.9 years) of equal weekly and total volume, in addition to their regular soccer training regimen. Linear sprinting (10 m, 20 m, 30 m, and flying 10 m), T-test agility, countermovement jump (CMJ) and maximal oxygen consumption were assessed one week before (T1), in the middle (T2) and immediately after the 10 weeks of training (T3). A large magnitude and statistically significant main effect for time was found in all the assessed variables after both training interventions (all $p < 0.001$; ES ≥ 0.80). No main effect was observed between the 2 groups at any time in linear sprinting, T-test or CMJ test ($p > 0.05$; ES < 0.20). A significant interaction effect ($F = 4.05$; $p = 0.04$, ES = 0.21) was found for maximal oxygen consumption with ST2 inducing better performance than ST1 ($p = 0.001$; ES = 1.11). Our findings suggested that the two sprint training frequencies were effective in enhancing explosive, high-intensity and endurance-intensive performances. However, it is recommended for coaches and fitness coaches to use a biweekly sprint training modality as it was found to be more effective in improving endurance-intensive performance.

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INTRODUCTION

Soccer is the most popular sport worldwide [1]. It has been reported that during soccer matches, players are required to perform multiple actions demanding muscles strength, power, speed, agility and endurance-intensive fitness components [2, 3, 4], suggesting therefore that physical conditioning for soccer players is a complex process [5]. Moreover, studies investigating the time structure of soccer matches reported that players covered about 9–12 km during a 90-min game, with high-intensity running or sprinting representing only 8–12% of the game [6, 7, 8]. In this context, it has been reported that each player performed 17 to 81 sprints, with each action lasting 2 to 4 seconds, covering then a distance shorter than 20 m [6, 8, 9]. Likewise, peak sprint velocity during matches was found to be around 31 to 32 km.h^{-1}, most often performed without a ball [7]. For more details, it was found that 45% of the scored goals were preceded by straight sprints while 16% are preceded by a jump and only 6% by a change of direction [10]. Furthermore, straight line sprints, agility skills and repeated sprint ability (RSA) can distinguish the level of practice [11] as professional players were found to cover a greater distance during sprint actions throughout a game compared to amateur athletes [7, 12]. These findings suggest that training should put emphasis on developing these high-speed actions and be a component of soccer players' fitness training [13].

In order to enhance specific soccer performance, different training protocols have been conducted and were reported to be effective in improving specific sprint ability [14, 15, 16]. In fact, training programmes based on sprint [16], resisted sprinting [15], assisted sprinting [15], speed, agility and quickness (SAQ) drills [14], repeated sprinting [17], plyometrics [18], strength [4], and complex and contrast training [19] have been shown to improve sprint ability for both youth and adults soccer players. Specifically, previous studies have revealed that speed training was effective in improving explosive performance [20], and fibre hypertrophy with beneficial neural adaptations [21] added to an improvement in the ability to store elastic energy in leg extensors [22].

In this regard, several contributing factors (e.g., specificity, individualization) have been reported by different researchers to be paramount for the development of speed in soccer [11]. For that reason, sprint training programmes should be gradually progressive, in terms of intensity and the number of sprint repetitions [11]. Furthermore, due to its anaerobic nature, speed training targets the neuromuscular system, and therefore intensities and recovery periods must be calibrated with precision [23]. During the in-season period, professional soccer players are required to play 1 to 3 official matches per week, and consequently have limited time available for athletic training. Therefore, it is important that coaches optimize the in-season sprint training frequency so that athletic performance can be maintained and acute training-related fatigue avoided. Usually, sprint training for soccer is conducted specifically once per week, eliciting positive effects on specific soccer fitness-related performance among young elite soccer players [17]. However, the optimal number of training sessions per week remains undefined [11]. To the current knowledge of the authors, no studies have investigated the efficacy of different sprint training frequencies at the same training volume on the soccer players' physical fitness. For that reason, the purpose of this study was to evaluate the effects of 1 vs. 2 sessions per week of equal-volume sprint training on explosive (linear sprint speed and vertical jumping), high-intensity (agility T-test) and endurance-intensive (maximal oxygen consumption) performances in young soccer players.

We hypothesized that two sprint training sessions per week would be more effective than one session per week to improve physical fitness in young soccer players.

MATERIALS AND METHODS

Participants

A priori power analysis was calculated with G*Power (Version 3.1.9.4, University of Kiel, Kiel, Germany) using the f test family (repeated measures, within-between interaction), with 2 experimental conditions (one sprint training session [ST1] versus two sprint training sessions [ST2]) and 3 times of measurement (pre, middle and post). The analysis revealed that a total sample size of N = 28 would be sufficient to find significant and medium-sized effects of condition (effect size f = 0.25, $\alpha = 0.05$) with an actual power of 82%. Thus, thirty-six young male soccer players volunteered to participate in the study. They were randomly divided into 2 experimental groups: a group that performed one weekly sprint training session (ST1 [n = 18], age: 17.2 ± 0.8 years, height: 173.3 ± 7.1 cm, body mass: 68.2 ± 11.5 kg, body mass index: 22.7 ± 3.2 kg/m^2); or a group that performed two weekly sprint training sessions (ST2 [n = 18], age: 17.1 ± 0.9 years, height: 175 ± 6.5 cm, body mass: 64.9 ± 7.1 kg, body mass index: 21.2 ± 2.0 kg/m^2). Written consent was obtained from the participants and their parents after being thoroughly informed about the purpose and potential risks of participating in the study. During the intervention period, the participants were requested to refrain from performing any strenuous exercises 48 hours before the beginning of the experimentation. All participants were screened and were safe from injuries prior to preliminary testing. They had been involved in competitive soccer for at least 6 years, were training 5 times per week (1.5 hours per session) and were competing regularly at a junior regional level. Goalkeepers were not included in this study due to the potential differences in their morphological characteristics and motor ability [24]. The study was fully approved by a local research ethics committee and the protocol was conducted according to the Declaration of Helsinki [25].

Experimental design

This study adopted a repeated measures design with a randomized allocation to training intervention. Subjects were divided into 2 training groups that performed either a single weekly sprint training session (GST1) or two weekly sprint training sessions (GST2) of equal weekly and total volume, in addition to their regular soccer training regimen. As the independent variable was "training type", no control group was used. The study was conducted during the soccer in-season period (the year 2018). Overall, it lasted 12 weeks and consisted of 1 week of pre-testing (T1), 10 weeks of specific training with an intermediate test (T2) performed at the beginning of the 6th week of the training period, and 1 week of post-testing (T3). Physical performance tests included linear sprinting [10, 20 and 30 m sprint with standing start (S10, S20 and S30, respectively), and flying 10 m (FS10)], agility T-test (TT), countermovement jump (CMJ) and the 20-m multi-stage shuttle run test [26].

The testing schedule included 4 similar sets of tests performed 1 week before the initiation of the study, the week before and the week after the 10-week training period, and the 6th week of the training period. The first set was conducted with the aim of getting the subjects familiarized with the testing procedures. In addition, test results of sets 1 and 2 were also used for assessing the test-retest reliability of the measures. All tests were administered on 2 non-consecutive days separated by 72 hours. On the first test day, after the anthropometric assessment, sprinting, agility and jumping tests were performed. On the second day, the 20-m multistage shuttle run test was assessed. All tests were performed on a synthetic soccer pitch under similar environmental conditions (temperature: 17–22°C, humidity: 67 ± 2%) and at the same time of the day.

Before the tests, participants completed standardized warm-up sessions of 15 min consisting of 10 min of jogging, and dynamic stretching, followed then by 2 sets of 3 exercise sprints (5 m, 10 m and 15 m). All subjects performed each test with at least 1 min of rest between all trials to ensure sufficient recovery [27].

Exercise and measurements

Anthropometric measurements. Anthropometric variables of height (cm) and body mass (kg) were measured 2 times for each subject, and the mean of each measure set was calculated. Stature and body mass measurements were made on a digital scale (OHAUS, Florhman Park, NJ) with an accuracy of 0.1 cm and 0.1 kg, respectively.

TABLE 1. The 10-week training programmes completed by the 2 experimental groups.

		ST1 (n = 18)		ST2 (n = 18)	
		Exercises/R	RPE	Exercises/R	RPE
Week 1	Session 1	4 × 5m LS/30sec 4 × 5m DD/30sec 4 × 10m DD/1min 4 × 20m LS/2min 2 × 40m LS/3min	4.0	2 × 5m LS/30sec 2 × 5m DD/30sec 2 × 10m DD/1min 2 × 20m LS/2min 1 × 40m LS	4.2
	Session 2	-	-	Same work as session 1	4.3
Week 2	Session 1	6 × 5m LS/30sec 6 × 5m DD/30sec 6 × 10m DD/1min 6 × 20m LS/2min	4.4	3 × 5m LS/30sec 3 × 5m DD/30sec 3 × 10m DD/1min 3 × 20m LS/2min	4.7
	Session 2	-	-	Same work as session 1	4.6
Week 3	Session 1	6 × 10m LS/30sec 6 × 10m DD/1min 4 × 20m LS/2min 2 × 40m LS/3min	4.7	3 × 10m LS/30sec 3 × 10m DD/1min 2 × 20m LS/2min 1 × 40m LS	4.9
	Session 2	-	-	Same work as session 1	5.2
Week 4	Session 1	6 × 5m LS/30sec 6 × 5m DD/30sec 6 × 10m DD/1min 2 × 20m LS/2min 2 × 20m DD/2min 2 × 40m LS/3min	5.1	3 × 5m LS/30sec 3 × 5m DD/30sec 3 × 10m DD/1min 1 × 20m LS/2min 1 × 20m DD/2min 1 × 40m LS	4.8
	Session 2	-	-	Same work as session 1	5.1
Week 5	Session 1	6 × 5m LS/30sec 6 × 5m DD/30sec 6 × 10m DD/1min 6 × 20m LS/2min 4 × 40m LS/3min	5.4	3 × 5m LS/30sec 3 × 5m DD/30sec 3 × 10m DD/1min 3 × 20m LS/2min 2 × 40m LS/3min	5.4
	Session 2	-	-	Same work as session 1	5.7
Week 6	Session 1	6 × 5m LS/30sec 6 × 5m DD/30sec 6 × 10m DD/1min 6 × 20m LS/2min 6 × 40m LS/3min	6.6	3 × 5m LS/30sec 3 × 5m DD/30sec 3 × 10m DD/1min 3 × 20m LS/2min 3 × 40m LS/3min	6.8
	Session 2	-	-	Same work as session 1	6.5
Week 7	Session 1	6 × 5m LS/30sec 6 × 5m DD/30sec 6 × 10m DD/1min 4 × 20m LS/2min 4 × 20m DD/2min	6.9	3 × 5m LS/30sec 3 × 5m DD/30sec 3 × 10m DD/1min 2 × 20m LS/2min 2 × 20m DD/2min	6.6
	Session 2	-	-	Same work as session 1	6.6
Week 8	Session 1	6 × 5m LS/30sec 3 × 10m LS/1min 6 × 10m DD/1min 6 × 20m LS/2min	5.9	3 × 5m LS/30sec 3 × 10m LS/1min 3 × 10m DD/1min 3 × 20m LS/2min	5.7
	Session 2	-	-	Same work as session 1	5.6
Week 9	Session 1	6 × 5m LS/30sec 6 × 5m DD/30sec 4 × 10m DD/1min 2 × 20m LS/2min 2 × 30m LS/2.30min	5.2	3 × 5m LS/30sec 3 × 5m DD/30sec 2 × 10m DD/1min 1 × 20m LS/2min 1 × 30m LS/2.30min	5.2
	Session 2	-	-	Same work as session 1	4.9
Week 10	Session 1	6 × 10m LS/1min 6 × 10m DD/1min 4 × 30m LS/2.30min	4.3	3 × 10m LS/1min 3 × 10m DD/1min 2 × 30m LS/2.30min	4.4
	Session 2	-	-	Same work as session 1	4.3

Note: ST1 = group with one sprint training session; ST2 = group with two sprint training sessions; R = recovery; LS = linear sprint; DD = diagonal drill; RPE = rating of perceived exertion.

Linear sprint testing. Participants performed two 30 m and two flying 10 m tests. For the 30 m test, time for 10, 20, and 30 m was assessed using an electronic timing system (Globus, Microgate). The photocells were placed at 0.2 m height at the starting position, with a marker for the front foot placed 0.5 m behind this position, and at 1 m height at 10 m, 20 m and 30 m. To assess flying 10 m time, two pairs of photocells were set up 10 m apart, with the participant having a flying start to ensure that sprint speed was measured independently of the acceleration phase. Flying 10 m time was defined as the section time between the 5 m and 15 m marks in a 15 m sprint test. The subjects were instructed to run at maximum speed until the stop line and the best performance was retained. The intra-class correlation coefficient (ICC2.1) and the standard error of measurement (SEM) for the test-retest trial were 0.85 and 1.86% for S10; 0.86 and 1.71% for S20; 0.85 and 2.25% for S30; 0.81 and 1.2% for FS10, respectively.

Agility testing. The T-test was used to determine speed with directional changes such as forward sprinting, left and right shuffling, and backpedalling. Moreover, any subject who crossed one foot in front of the other, failed to touch the base of the cone, and/or failed to face forward throughout had to repeat the test [28]. Subjects performed two trials separated by at least one minute of rest. Time of the fastest trial was recorded. ICC2.1 and SEM for test-retest trial were 0.79 and 4.68%, respectively.

Jump testing. Athletes performed the countermovement jump test as described by Haj- Sassi et al. [29]. Subjects were instructed to keep their hands on their hips to prevent the influence of arm movements. They began from an upright standing position, performed a very fast preliminary down-ward eccentric action followed immediately by a powerful upward motion. The subjects were instructed to jump as high as possible, and verbal encouragement was provided to each subject before each trial. Each athlete performed 3 trials separated by at least one minute of rest and the best result was recorded. The height of each jump (cm) was assessed with an infrared jump system (Optojump; Microgate, Bolzano, Italy). ICC2.1 and SEM for the test-retest trial were 0.78 and 9.2%, respectively.

Endurance-intensive assessment. The 20 m multistage shuttle run test [26] consisted of running with continuously increasing velocity back and forth between two lines separated by 20 m until voluntary exhaustion. Athletes started with an initial speed of 8 km/h, which increased by 0.5 km/h every minute. The required running velocity in each sequence was controlled by a pre-recorded acoustic signal. The Leger prediction equation was used for the indirect calculation of maximum oxygen uptake (VO_2max):

VO_2max (ml/min/kg) = maximal aerobic speed (km/h) × 3.5 [30].

ICC2.1 and SEM for test-retest trial were 0.75 and 11.73%, respectively.

Training interventions

The sprint training programme was designed by the investigators, consisting of adding one or two sessions a week, throughout 10 weeks, to the regular soccer training programme for ST1 and ST2, respectively. The training protocol consisted of linear sprints and change of direction speed exercises performed at all-out mode [31]. During each session, players performed sprint training after 12 min of standardized warm-up (consisting of jogging and dynamic stretching followed by some sprint repetitions). At equal volume sprint training, ST1 performed the whole training session in one day (Wednesday), while the ST2 completed the total amount of work on two different days (Wednesday and Friday) (Table 1). Rating of perceived exertion score (RPE, Borg's CR-10 scale) was collected after each training session to assess the subjective intensity of the training sessions [32].

Statistical Analysis

Data analyses were performed using SPSS version 20 for Windows (IBM Corp, Armonk, N.Y., USA). Values are presented as means ± SD. The normality of data sets was checked using the Kolmogorov-Smirnov test. Relative reliability of each variable was assessed using an intraclass correlation coefficient (ICC2.1). Absolute reliability of each outcome measure was expressed as the standard error of measurement (SEM), calculated as: $\mathrm{SEM} = \mathrm{SD} \times \sqrt{1 - \mathrm{ICC}}$ [33]. Compound symmetry was tested using the Mauchly test. Two-way analysis of variance (2-conditions group: [ST1 or ST2] × time of measurement: [T1, T2 and T3]) with repeated measures was used to determine the differences between experimental conditions. When a difference was found, a Bonferroni post hoc test was used to determine significant differences between groups' means, correcting for the multiple comparisons. To determine the magnitude of the training effect, effect sizes (ES) were determined by converting partial eta-squared to Cohen's d [34]. The magnitude of effect size were classified as trivial (< 0.20), small (0.20–0.49), medium (0.50–0.79), and large (0.80 and greater) [34]. Moreover, upper and lower 95% confidence intervals (95% CI) were calculated for corresponding variation. An independent samples t-test was applied to compare the RPE scores between the two groups. Statistical significance was set at $p < 0.05$.

RESULTS

RPE scores collected at each training session during the whole training period were not different between the two group conditions. Absolute values and qualitative outcomes resulting from the within and between-group analyses are displayed in Tables 2 and 3.

Trivial magnitude and non-statistically significant differences were observed between conditions in S10 ($F_{1,17} = 0.68$; $p = 0.42$, ES = 0) and FS10 ($F_{1,17} = 0.37$; $p = 0.55$, ES = 0) across the three times of measurement. However, a main effect for time was identified in which S10 performance ($F_{2,34} = 58.68$; $p < 0.0001$, ES = 1.77) and FS10 performance ($F_{1.35,23.01} = 60.36$; $p < 0.0001$, ES = 1.79) improved from pre- to post-test across both conditions (Table 2). A significant interaction was observed between condition and time (S10: $F_{2,34} = 5.47$; $p = 0.009$, ES = 0.49, and FS10: $F_{2,34} = 4.40$; $p = 0.02$, ES = 0.42).

TABLE 2. Linear sprinting measures of the 2 experimental groups before (T1), in the middle (T2) and after the training interventions (T3).

Variable	Group	T1	T2	T3	ES	95% CI
S10 (s)	ST1	1.89 ± 0.06	1.84 ± 0.06‡	1.83 ± 0.05†¥	T1 vs T2: 0.83 T2 vs T3: 0.18	T1 vs T2: 0.03–0.07 T2 vs T3: 0.00–0.03
	ST2	1.91 ± 0.06	1.87 ± 0.07‡	1.82 ± 0.07†¥	T1 vs T2: 0.61 T2 vs T3: 0.71	T1 vs T2: 0.02–0.07 T2 vs T3: 0.03–0.07
	Overall	1.90 ± 0.06	1.85 ± 0.07‡	1.83 ± 0.06†¥	T1 vs T2: 0.77 T2 vs T3: 0.31	T1 vs T2: 0.03–0.06 T2 vs T3: 0.02–0.05
S20 (s)	ST1	3.35 ± 0.07	3.31 ± 0.07‡	3.29 ± 0.07 †¥	T1 vs T2: 0.57 T2 vs T3: 0.29	T1 vs T2: 0.02–0.06 T2 vs T3: 0.01–0.03
	ST2	3.35 ± 0.09	3.30 ± 0.09‡	3.28 ± 0.11 †¥	T1 vs T2: 0.56 T2 vs T3: 0.40	T1 vs T2: 0.02–0.08 T2 vs T3: 0.01–0.08
	Overall	3.35 ± 0.08	3.30 ± 0.08‡	3.28 ± 0.10 †¥	T1 vs T2: 0.56 T2 vs T3: 0.40	T1 vs T2: 0.02–0.08 T2 vs T3: 0.01–0.08
S30 (s)	ST1	5.04 ± 0.17	4.94 ± 0.16‡	4.86 ± 0.18 †¥	T1 vs T2: 0.61 T2 vs T3: 0.47	T1 vs T2: 0.05–0.21 T2 vs T3: 0.01–0.09
	ST2	5.04 ± 0.24	4.95 ± 0.25‡	4.85 ± 0.23 †¥	T1 vs T2: 0.37 T2 vs T3: 0.42	T1 vs T2: 0.04–0.16 T2 vs T3: 0.05–0.22
	Overall	5.04 ± 0.21	4.94 ± 0.21‡	4.86 ± 0.21†¥	T1 vs T2: 0.48 T2 vs T3: 0.38	T1 vs T2: 0.05–0.15 T2 vs T3: 0.05–0.12
FS10 (s)	ST1	1.39 ± 0.03	1.36 ± 0.03‡	1.34 ± 0.04†¥	T1 vs T2: 1.00 T2 vs T3: 0.57	T1 vs T2: 0.01–0.03 T2 vs T3: 0.02–0.04
	ST2	1.38 ± 0.04	1.35 ± 0.04‡	1.33 ± 0.04†	T1 vs T2: 0.75 T2 vs T3: 0.50	T1 vs T2: 0.03–0.05 T2 vs T3: -0.004–0.03
	Overall	1.38 ± 0.03	1.36 ± 0.04‡	1.34 ± 0.04†¥	T1 vs T2: 0.57 T2 vs T3: 0.50	T1 vs T2: 0.02–0.04 T2 vs T3: 0.01–0.03

Note: Values are given as mean ± SD; ST1 = group with one sprint training session; ST2 = group with two sprint training sessions; S10 = 10 m linear sprint; S20 = 20 m linear sprint; S30 = 30 m linear sprint; FS10 = Flying 10 m linear sprint; ES = effect size; 95% CI = 95% confidence interval. † A significant difference when comparing T1 and T3; ‡ A significant difference when comparing T1 and T2; ¥ A significant difference when comparing T2 and T3. The statistical significance level was set at $p \leq 0.05$.

For S20 and S30, no statistical interactions ($F_{2,34} = 2.29$; $p = 0.12$, ES = 0.26, and $F_{1.37,23.38} = 0.40$; $p = 0.67$, ES = 0, respectively) or main effect for conditions were observed between conditions at any time ($F_{1,17} = 0.15$; $p = 0.70$, ES = 0, and $F_{1,17} = 0.001$; $p = 0.98$, ES = 0, respectively). In contrast, a large magnitude and statistically significant main effect for time was observed in which S20 and S30 performances improved from pre- to post-test across both conditions ($F_{2,34} = 42.87$; $p < 0.0001$, ES = 1.50, and $F_{1.38,23.41} = 48.55$; $p < 0.0001$, ES = 1.60, respectively) (Table 2).

Trivial magnitude and non-statistically significant differences were observed between conditions in TT ($F_{1,17} = 1.70$; $p = 0.21$, ES = 0.19) and CMJ ($F_{1,17} = 0.07$; $p = 0.79$, ES = 0) across the three times of measurement. However, a main effect for time was identified in which TT performance ($F_{1.41,23.99} = 104.27$; $p < 0.0001$, ES = 2.36) and CMJ performance ($F_{2,34} = 47.11$; $p < 0.0001$, ES = 1.58) improved from pre- to post-test across both conditions (Table 3). A significant interaction was observed between condition and time (TT: $F_{1.28,21.69} = 6.94$; $p = 0.01$, ES = 0.57, and CMJ: $F_{1.29,21.99} = 4.53$; $p = 0.03$, ES = 0.44).

For VO_2max, there was a main effect for condition ($F_{1,68} = 7.72$; $p = 0.007$, ES = 0.31) with GST2 elicited higher VO_2max in comparison to GST1. Moreover, there was a main effect for time ($F_{1,68} = 69.44$; $p < 0.0001$, ES = 0.99) in which VO_2max performance improved from pre- to post-test. A significant interaction was observed between condition and time ($F_{1,68} = 4.05$; $p = 0.04$, ES = 0.21) in which VO_2max performance improved from pre- to post-test for both conditions (95% CI = 1.78 to 4.64 and 3.82 to 6.68; ES = 1.43 and 2.56; all $p < 0.0001$; for ST1 and ST2, respectively) and ST2 showed higher post-test performance than ST1 (95% CI = 0.99 to 6.86; ES = 1.11; $p = 0.001$) (Table 3).

TABLE 3. Agility, jump and endurance-intensive measures of the 2 experimental groups before (T1), at the middle (T2) and after the training interventions (T3).

Variable	Group	T1	T2	T3	ES	95% CI
TT (s)	GST1	9.99 ± 0.37	9.86 ± 0.30‡	9.75 ± 0.29†¥	T1 vs T2: 0.39 T2 vs T3: 0.71	T1 vs T2: 0.05–0.22 T2 vs T3: 0.05–0.17
	GST2	10.30 ± 0.48	9.96 ± 0.38‡	9.87 ± 0.23†¥	T1 vs T2: 0.37 T2 vs T3: 0.29	T1 vs T2: 0.23–0.45 T2 vs T3: 0.02–0.17
	Overall	10.15 ± 0.45	9.91 ± 0.34‡	9.81 ± 0.32†¥	T1 vs T2: 0.60 T2 vs T3: 0.30	T1 vs T2: 0.17–0.30 T2 vs T3: 0.06–0.14
CMJ (cm)	GST1	29.6 ± 2.5	31.8 ± 2.7‡	33.3 ± 3.3†¥	T1 vs T2: 0.85 T2 vs T3: 0.29	T1 vs T2: 1.16–3.26 T2 vs T3: 0.02–2.91
	GST2	30.3 ± 3.5	31.4 ± 3.5‡	32.1 ± 3.2†¥	T1 vs T2: 0.31 T2 vs T3: 0.21	T1 vs T2: 0.61–1.52 T2 vs T3: 0.21–1.13
	Overall	30.0 ± 3.0	31.6 ± 3.1‡	32.7 ± 3.3†¥	T1 vs T2: 0.53 T2 vs T3: 0.34	T1 vs T2: 1.05–2.23 T2 vs T3: 0.38–1.75
VO_2max ($ml \cdot min^{-1} \cdot kg^{-1}$)	GST1	44.5 ± 2.2	-	49.8 ± 1.9†§	T1 vs T3: 2.56	T1 vs T2: 3.82–6.68
	GST2	44.1 ± 2.0	-	47.4 ± 2.4†	T1 vs T3: 1.43	T1 vs T3: 1.78–4.64
	Overall	44.3 ± 2.1	-	48.6 ± 2.5†	T1 vs T3: 1.84	T1 vs T3: 3.22–5.24

Note: Values are given as mean ± SD; ST1 = group with one sprint training session; ST2 = group with two sprint training sessions; TT = T-test; CMJ = countermovement jump; VO_2max = Maximal oxygen consumption; ES = effect size; 95% CI = 95% confidence interval. † A significant difference when comparing T1 and T3; ‡ A significant difference when comparing T1 and T2; ¥ A significant difference when comparing T2 and T3. § Significantly different from GST1 at T3; the statistical significance level was set at $p \leq 0.05$.

DISCUSSION

To the current author's knowledge, this is the first study to evaluate the volume-equated effects of 1 vs. 2 sessions of sprint training per week on explosive, high-intensity and endurance-intensive performances in young soccer players. The results indicated both training regimens as being effective in improving the assessed physical performances after 10 weeks. No difference was observed between the 2 groups at any time in linear sprinting, agility or CMJ test, whereas endurance-intensive performance improved more after the biweekly sprint training modality, which does not confirm our hypothesis.

For linear sprint speed performances, the present study showed that both training regimens induced the same improvements across the whole training period with the speed performance improving by 0.18 and 0.19 seconds for ST1 and ST2, respectively, during the 30 m sprint test. By comparison, previous studies have reported that sprinting performances (i.e., 10, 20 and 30 m) increased significantly after different modalities of sprint training [19, 35, 36]. Specifically, Kotzaminidis et al. [35] reported that 9 weeks of combined resistance and speed training induced significant improvements (≈ 0.15 s) during the 30 m sprint test in soccer players. Also, 1 and 2 sessions/week training groups improved 10 and 20 m sprint test performances, with the time being reduced by 4 and 1.7% in ST1 and 5.9 and 2.7% in ST2, respectively. Similarly, Gil et al. [36] reported that 6 weeks of resisted sprint training were effective to improve sprint performance in 10 and 20 m tests with the performance time reduced by 5 and 3%, respectively. The results of the present study suggest that the sprint training programme is useful to improve sprint performances over distances between 10 and 30 m, which reinforces the idea that the usual sprint training modality is the approach to be recommended to increase sprint performance for either short distances or when improvements are demanded to be achieved for short periods of time [37].

However, there were no significant differences between ST1 and ST2 in linear sprint speed. In this regard, Alves et al. [19] reported that 1 vs. 2-weekly complex and contrast training (CCT) induced the same performances in 5 and 15 m sprint tests in young elite Portuguese soccer players. Likewise, Cavaco et al. [38] did not report significant differences in 15 m speed performance after 6 weeks of 1-weekly or 2-weekly complex training (CXT), which was explained by the lack of coordination during puberty stages as height and muscular development increase fast and negatively affect motor coordination [38].

Furthermore, for agility performance, ST1 and ST2 induced 4.1 and 2.4% improvements in the T-test, respectively. These findings are in accordance with the results of Gil et al. [36], who reported a significant reduction of 6.2% in Zig-Zag test performance. By contrast, Alves et al. [19] and Cavaco et al. [38] reported that the agility performance remained unchanged after complex training intervention. According to these authors, training programmes designed to improve agility should be specific and independent from speed training programmes [19, 38]. Since agility movements are more dependent on motor control factors than maximal strength or muscular power [39], agility performance improvement for both groups in the present study may be related to the nature of speed training where players performed change of direction drills throughout the whole training period, which may have positively affected the agility performance by improving motor control and coordination. Nonetheless, no significant difference was found between the two groups in the present study for agility performance, suggesting that agility performance enhancement was not dependant on training sessions' frequency when athletes were performing with the same training load.

For jump height performance, CMJ performances increased significantly for ST1 and ST2 with 1.8 and 3.7 cm, respectively. Dawson et al. [40] and Markovic et al. [41] reported that repeated sprint training was able to increase jumping height in physically active subjects after 6- and 10-week interventions, respectively. The improvement of CMJ performance during the present study may possibly be explained by the fast and efficient utilization of elastic energy in the stretch-shortening cycle as well as increased strength and power of knee extensor muscles, strongly engaged in the actions during fast running [41]. Moreover, CMJ performance improvement may be related to a concomitant speed performance enhancement as it was reported that CMJ performance has been related to sprint performance [42]. During the present study, although not significant, the improvement for ST2, which was twice as high as that recorded for ST1, is encouraging to investigate the effect of a longer training programme.

Finally, for endurance-intensive performance, both groups showed significant improvement for VO_2max values after 10 weeks of sprint training (ST1 = 8.2% and ST2 = 10.8%), with a better performance recorded for ST2 in comparison to ST1. Previous studies reported the effectiveness of sprint training in enhancing VO_2max and aerobic enzyme activity [20, 40, 43]. In a study by Shalfawi et al. [43], one extra weekly session of repeated sprint training of 8 weeks induced greater Yo-Yo Intermittent Recovery level 1 test (Yo-Yo IR1) improvement. In terms of consistency between training and the testing procedure, it was reported that when training and testing procedures used the same mode of exercise, VO_2max improvement was found to be higher when other modes of exercise testing are used [44]. Specifically with the present study, VO_2max improvements can possibly be attributed to the nature of the two training programmes where movements can mimic those performed during the 20-m shuttle run test where changes of direction are widely used. Thus, the ability to change direction largely performed in the sprint training programmes may have positively affected the performance during the endurance-intensive field test.

Another finding of this study was the significantly greater improvement in VO_2max performance after the biweekly sprint training modality compared with once weekly sprint training. It was reported that the magnitude of oxygen consumption increase depends on the training programme design, which can be determined through the exercise intensity, duration, recovery and frequency of sessions [45]. In this regard, it was reported that only two sessions per week may be a sufficient training session frequency to increase VO_2max [46]. The results of the present study are consistent with those reported by Baquet et al. [46], who showed that two sessions per week over 7 weeks of short intermittent exercises (10 or 20 s) at velocity ranging from 100 to 130% of maximal aerobic speed, performed on a short track, were able to increase absolute VO_2max (9.1%) and VO_2max relative to body mass (8.2%) in prepubertal children, which reinforces the usefulness of using more than one session a week to enhance aerobic fitness in prepubertal and adolescent participants.

It seems that under volume-equated conditions, 2 sessions/week of sprint training resulted in better VO_2max improvement compared with 1 session/week. Our findings suggest that exposure to only 1 weekly sprint training session in combination with specific soccer training can be a sufficient stimulus to enhance performance in youth soccer players while guaranteeing the reduction of injury risk [11]. Thus, from a practical point of view, 1 sprint training session may be more useful for coaches when programming training content during congested periods, especially during soccer competition, which implies limited training days/sessions due to the necessity of recovering from matches and traveling [47]. Moreover, one training session allows coaches to spend more time in improving their technical-tactical abilities while preserving the same physical fitness development.

Finally, we acknowledge some limitations in the study. First, the study period lasted only 10 weeks, whereas longer periods of training may be required especially when investigating the effects of training on related muscular performances (i.e., speed, agility, power). Although this duration was sufficient to achieve significant increases in explosive, high-intensity and endurance-intensive performances in both groups, it is conceivable that explosive and high-intensity differences between groups may be achieved when a longer training programme is investigated. Also, the absence of a control group in which subjects would have completed the regular training sessions and played the official matches without participating in any of the experimental protocols limits the conclusions from this study. Moreover, larger number of subjects could have more relevant effects. Finally, the results of our investigation are specific to young soccer players from the regional level and therefore cannot necessarily be generalized to other populations including senior males and females with a high level of practice.

CONCLUSIONS

Both of the training regimens seem to be effective for soccer-related fitness improvement in youth players during the in-season period. Indeed, our results showed that the prescription of 1 or 2 weekly sprint training sessions during the in-season period contributed to improving the explosive, high-intensity and endurance-intensive performances among youth soccer players. Specifically, ST2 was more effective in conditioning endurance-intensive performance compared to ST1.

For coaches and strength and conditioning professionals, it is necessary to know the optimal weekly frequency of sprint training required to improve or maintain certain explosive actions and the aerobic fitness in young soccer players. Our data indicated that sprint training performed once a week may provide a sufficient training stimulus to increase physical fitness in youth soccer. This information may be useful for coaches in periods where the emphasis needs to be put on tactical qualities while spending as little time as possible on increasing physical performance. These measures can also help coaches and strength and conditioning professionals to develop more personalized training and rehabilitation for both children and adults. However, additional training modalities could be included (e.g., plyometric training, strength training, RSA training) if the goal is to further improve specific soccer fitness-related performance.

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Conflict of interest declaration

No potential conflict of interest was reported by the authors.

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