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A Combined 7-Week Strength and Power Training: Effects on Body Composition, Strength, Speed, and Agility in U14 and U16 Youth Elite Soccer Players

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Abstract: The aim of this study was to analyze the effects of a 7-week combined strength and power training program on body composition, aerobic capacity, strength, sprint, and agility in elite youth soccer players. Twenty-one players, divided into age groups (U14 and U16), participated in this study. In addition to four training sessions per week (plus matches), the two groups completed a strength training session on Match Day 4 (MD-4) and a power training session on Match Day 2 (MD-2). Before and after the intervention, various tests were conducted, including skinfold measurements, submaximal intermittent shuttle run, eccentric hamstring strength (EHS), countermovement jump (CMJ), single-leg jump (SLJ), sprint test with split times at 10 and 30 m, agility *t*-test, push-ups, and pull-ups. Our results indicate that a seven-week program of combined strength training led to significant improvements in body composition, EHS, jump performance, and pull-up tests for both groups of players ($p < 0.05$). Moreover, the U14 group also demonstrated an improvement in the agility test ($p < 0.01$). The U14 group experienced more substantial gains than the U16 group in agility and push-up performance ($p < 0.05$). The sprint performance remained unchanged for both groups ($p > 0.05$), suggesting that specific training is required to improve this quality.

Keywords: strength training; power training; youth soccer players; soccer

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1. Introduction

Soccer is the most popular and practiced sport worldwide and is characterized by players exhibiting intermittent activity, combining periods of low and high intensity [1,2]. Another characteristic of soccer is that it has become more demanding over the years. For example, Barnes et al. [3], after analyzing the external load of English Premier League matches over seven consecutive seasons (2006 to 2013), found that the distance covered at high intensity increased on average by about 30%, while high-intensity actions increased by 50%. High-intensity actions have a great influence on match performance. The literature shows that 83% of soccer goals are preceded by high-intensity actions such as straight sprinting, jumps, changes in direction, or a combination of these actions [4]. It is also widely known that strength training in soccer is used to improve the specific actions that players have to perform on the pitch [5] since increased lower limb strength is correlated with improvements in these kinds of actions [6–8]. In addition to these improvements in

performance, a suitable strength training program will help to reduce the risk of injury [9] and minimize muscle damage caused by training and matches [10]. To increase strength in professional soccer players, various methods have been proposed, including traditional resistance exercises [11–13], power training [14], plyometrics [15], complex training [16], flywheel technology [17], and sprint training and resisted sprint training [18,19].

Recently, interest in strength training at the youth level has also grown considerably, and several national associations consider it a safe way to improve the performance of young athletes when properly implemented [20,21]. Despite findings that young players from Belgian [22] and English soccer academies [23] have a better chance of playing professionally if they have greater speed and explosiveness compared to their peers, the literature on strength training in young soccer players is still incomplete. Most of the existing studies on elite young soccer players, although showing significantly positive effects in improving strength, agility, power, and speed, have focused on only a single training method [24–27] and only a few have studied the differences in adaptations related to biological age [25].

In junior soccer players, combining strength training with power training has been suggested to have a greater effect than strength training alone [28]. It has been argued that to optimize power abilities, players should undertake training activities relating to the full spectrum of the Force–Velocity curve to simultaneously enhance force production and early rate of force development (RFD), combining heavy and light loads [29]. A combination of activities over two different training days has been proposed as an effective way to improve power ability [30]. Although various studies in the literature have analyzed the effects of strength training in young athletes, to our knowledge, there are no studies with young soccer players combining the use of two resistance training sessions, split between strength (at MD-4) and power (at MD-2), and comparing the effects of this program on different age groups. This intervention is novel because it follows the fundamental principle of soccer microcycle periodization, in which the central part of the microcycle is overloaded and the training load is progressively reduced to induce a tapering phase. Given that such interventions have not been previously implemented in young players, the aim of this study was to analyze the effects of a 7-week combined strength and power training on body composition, strength, sprint, and agility in elite youth soccer players.

2. Materials and Methods

2.1. Participants

Twenty-one healthy male players (14.0 ± 0.8 years old) from two elite youth football teams at the same academy participated in this study. They were categorized according to age: Under 14 (U14) (n = 12; height 159.1 ± 11.4 cm; weight 41.7 ± 10.7 kg) and Under 16 (U16) (n = 9; height 167.4 ± 4.2 cm; weight 53.2 ± 4.3 kg). All subjects normally participated in five team training sessions (~ 7 h per week) and one official match at the weekend. To be included in the study, participants had to have taken part in at least 85% of the specific strength training sessions and 85% of the total team training sessions. Participants were required to be free of any injuries during the pre- and post-test to be eligible for inclusion in the study.

The data were acquired from daily routine monitoring and testing during the team's training, in which player activities are measured over the competitive season, so ethics committee clearance was not required [31]. Nevertheless, the study conformed to the recommendations of the Declaration of Helsinki, and the players were informed of the purpose of the study, the experimental protocol, and potential risks.

2.2. Study Design

This experimental study covered a period of 11 weeks in total. The first 2 weeks were used to familiarize the players with the specific strength exercises. After this familiarization process, a battery of tests was conducted. Players' performances were assessed by the countermovement jump (CMJ), single-leg jump (SLJ), push-ups, pull-ups, eccentric hamstring strength, 30 m linear sprint, an agility *t*-test, and a submaximal shuttle run test. Body composition was also assessed using anthropometric measurements. After that, 7 weeks of intervention weeks were completed. During this period, the players participated in two strength training sessions per week, accumulating a total of 14 strength sessions. Both sessions were conducted in the gym and lasted ≈30–40 min in each case. Each week, the first strength-oriented session was scheduled on Wednesday (4 days before the weekend match), while the power-oriented session was scheduled on Friday (2 days before the match). At the end of the training protocol, both groups of players completed a post-test.

2.3. Strength Training

The strength session was scheduled on MD-4 (see Table 1).

Table 1. An example of the organization of the different training components in a standard micro cycle.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
OFF	Video analysis Pre-activation on the pitch (10 min): mobility Performance session on the pitch (30 min): coordination, running technique and agility Team training session on the pitch (60 min)	Pre-activation in the gym (20 min): mobility, balance and core activation Team training on the pitch (75 min) Strength Training in the gym (40 min)	Individual technical session on the pitch at low intensity (45 min), or OFF	Pre-activation in the gym (10 min): mobility and muscular activation Power Training in the gym (25–30 min) Team training session on the pitch (60 min)	Pre-activation in the gym (10 min): mobility and muscular activation Performance session (15 min): agility and reactivity drills Team training session on the pitch (45 min) Video analysis related to the game plan	Official Game 2 × 45 min

To mitigate the effects of fatigue induced by eccentric loading during strength training, the session has been strategically scheduled as far as possible from the competition game, allowing adequate time for recovery, optimal performance, and avoiding an increase in the risk of injury for the players [32,33]. Each training session was supervised by at least one experienced coach. The strength sessions were scheduled 15 min after the main on-field football session to preserve the players' freshness for the football part.

To guarantee the health and safety of the players, the strength training started with sessions focused on a low load and correct execution of the movements since the players had no experience in strength training. The loads were progressively increased on an individualized basis. To encourage a certain variability in the proposed exercises and avoid monotony, while ensuring a minimum of repetition to achieve improvements, players were offered two strength programs, alternating on a weekly basis. In general, one session lasted approximately 40 min and consisted of a total of 7 exercises per session designed as a circuit training (2 sets and 6–10 reps per exercise): 4 exercises focused on the lower body, 1 on the core, and 2 on the upper body. Table 2 shows the two alternating two weekly programs. The intensity of the exercises was adjusted based on 1RM estimation [34] in the case of external loads, or the number of repetitions and speed of execution (e.g., when using elastic bands, slide boards, or suspension training).

Table 2. An example of two different strength and power sessions alternated within a week.

Strength Session A	Sets	Reps	Intensity	Rest	
Leg curl slides	2	6	Bodyweight	2′	
Barbell back squats	2	8	80% 1RM	2′	
Isometric Copenhagen side plank	2	20″ each side	Bodyweight	1′30″	
Dumbbells reversed lunges	2	6 each side	70% 1RM	1′30″	
Pallof press with rotation	2	8 each side	NA	1′	
Barbell bench press	2	8	80% 1RM	1′30″	
TRX pulls	2	15	65% 1RM	1′30″	
Strength Session B	**Sets**	**Reps**	**Intensity**	**Rest**	
Barbell deadlift	2	6	85% 1RM	2′	
Bulgarian split squat	2	6 each side	85% 1RM	2′	
Slide hip adduction	2	8 each side	Bodyweight	1′30″	
Kettlebell calf raises	2	10 each side	75% 1RM	1′30″	
Pallof press	2	8 each side	NA	1′	
Cables chest flies	2	8	80% 1RM	1′30″	
Dumbbell single arm row	2	8 each side	80% 1RM	1′30″	
Power Session	**Sets**	**Reps**	**Intensity**	**Rest**	**Main focus**
Medball horizontal throw	2	3	4–6 kg	2′	Throw as far as possible while avoiding momentum
Skater jumps	2	3 each side	Bodyweight	2′	As quick as possible jump side to side.
Box Jumps	2	5	60–70 cm height	2′	Quick countermovement before take-off
Drop Jumps	2	4	30 cm height	2′	Minimizing ground contact time
Resisted Accelerations (~6–7 m)	2	5	Elastic resistance	2′	Maximum push on the first steps of acceleration, controlled return
Resisted lateral runs (~4–5 m)	2	3 each side	Elastic resistance	2′	Quick to move away from the anchorage point, and controlled return

2.4. Power Training

Considering that this session was more oriented toward plyometrics, emphasizing power in the concentric phase of the movement and improving the stretch and shortening cycle, it was scheduled for MD-2 (see Table 1). These sessions had a lower volume (≈30 min) and were carried out prior to the main field session. Since maximum neuronal activation is necessary to optimize neuromuscular adaptations, it was decided to conduct the power session when the players were fresh and after a day of recovery. In general, the power session consisted of a total of 6 exercises designed as circuit training: 2 sets and 3–6 reps per exercise (Table 2 shows an example of a typical power session).

The session was composed of plyometric exercises, accelerations, and throws of a medicine ball. The plyometric exercises included two vertical jumping exercises (the Box jump and the Drop jump): the first with a focus on power in the concentric phase and the second on the stretch-shortening cycle with a rebound immediately after ground contact and a horizontal jumping exercise (skater jumps). Two exercises were aimed at accelerations in the frontal and lateral plane, starting from an upright position and against an elastic resistance. The last exercise consisted of throwing a medicine ball horizontally against a wall. The intensity of the exercises was adjusted according to the participants' subjective perception of effort by increasing the external load (e.g., the height of the jump or fall, the weight of the ball, and resistance of the elastic) or the number of repetitions (e.g., number of jumps, throws, or accelerations). Depending on the exercise, the focus was on the quality of the movements, the landings (avoiding valgus knee), the ground contact time, and conducting the movement as fast as possible.

2.5. Testing Protocol

Before and after the intervention, the participants performed a battery of physical tests. The tests were conducted over two consecutive days. To avoid excessive fatigue in the players and to ensure normal participation in training sessions, the two testing days were separated by 24 h. In the 48 h prior to the assessment, the participants were asked not to perform any type of physical activity. On the first day, the players completed the tests in the following order: skinfold measurements, CMJ, SLJ, push-ups, pull-ups, and 30 m linear sprint. On the second day, players performed the Nordic hamstring exercise (NordBord) to evaluate eccentric hamstring strength, the submaximal shuttle run test, and the agility *t*-test. A standardized warm-up of 15 min was carried out before each testing day, consisting of low-intensity running and mobility exercises. To complete the warm-up, some specific actions were carried out before each test.

2.5.1. Skinfold Measurement

To estimate total body fat percentage, subcutaneous skinfolds were measured with a skinfold caliper (Harpenden Skinfold Caliper, HaB Direct, Southam, UK), with a 0–80 mm scale, a repeatability of 0.2 mm, and a constant pressure of 10 g/mm2. Skinfolds were taken on the right side of the body at four different sites: triceps, biceps, subscapular, and suprailiac. Three measurements were taken at each site, which were used to create a final average. To avoid interobserver variability [35], the measurements were obtained by the same practitioner at the same time of day.

2.5.2. Vertical Jump Tests

To evaluate the explosive strength of the lower limbs, subjects were asked to perform a set of three CMJs and a set of three SLJs on each leg on a jump platform (SmartJump, Vald Performance, Newstead, Australia). During the CMJ test, subjects kept their hands on their hips, with the depth of the countermovement self-selected [36], landing in an upright position and bending the knees after landing. For the SLJ, participants performed a deep squat followed by a maximum vertical jump landing on the same leg. Subjects could use their arms to help themselves during the take-off phase. If the landing was not performed correctly, the attempt was repeated. Each jump was followed by 45 s of passive recovery to avoid any form of accumulated fatigue. The best attempts for each jump and leg were recorded for subsequent statistical analysis.

2.5.3. Eccentric Hamstring Strength

Eccentric hamstring strength (EHS) was assessed using a NordBord machine (NordBord, Vald Performance, Newstead, Australia). Participants were asked to position themselves kneeling on the NordBord, with their feet tied to hooks. The hooks allowed recording of the vertical force exerted by the subjects while they remained in position. The hooks also allowed recording of the force value for both legs. After a standardized warm-up of 3 sets of 3 repetitions with progressive intensity (70%, 80%, and 90% of perceived maximal effort), participants performed a set of three maximal repetitions [37]. Participants kept their hands crossed over their chests until they had to use them to break their fall. During the tests, participants were encouraged to resist the movement for as long as possible over the entire range of motion, keeping a straight line from the shoulders to the knee. The position of the knees was recorded to ensure the repeatability and reproducibility of the assessment during the post-test. To determine an overall value for participants' eccentric hamstring strength, the force measured for the right leg was averaged with that of the left leg, and the best trial value was retained for subsequent statistical analysis.

2.5.4. Linear Sprint Test

Sprint performance was measured using portable photocells (SmartSpeed, Vald Performance, Newstead, Australia) over a linear distance of 30 m, with split measurements at 10 m. To best simulate specific football situations, participants were asked to start in a standing position and to place their front foot on a line 50 cm behind the first timing gate, starting when they were ready, to eliminate reaction time [38]. Subjects performed two maximal attempts, separated by 2 min of passive recovery. The best sprint time was recorded for subsequent statistical analysis.

2.5.5. Agility *t*-Test

To evaluate the agility of the soccer players the agility *t*-test was used. The agility *t*-test is a valid and reliable method for measuring athletes' agility, including changes in direction, acceleration, and deceleration [39]. In this study, minor changes were made to the classic protocol of Semenick [40] and are described in Figure 1.

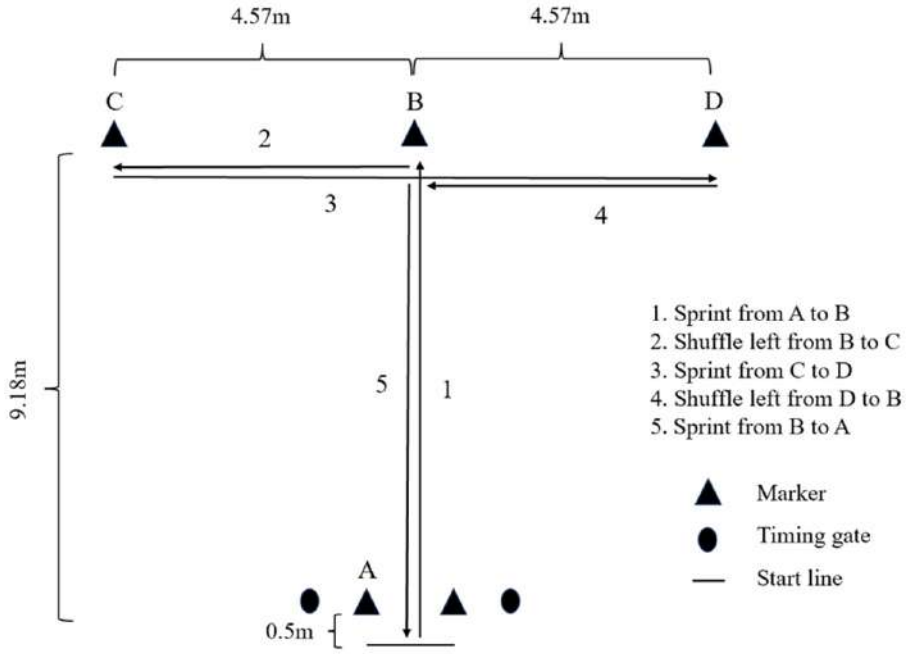


Figure 1. Modified *t*-test.

As in the previous test, the same starting protocol was used to best simulate specific football situations [38]. Subjects performed two maximal attempts per side (starting with a lateral shuffling to the left or to the right), separated by 2 min of passive recovery. An electronic timing system (SmartSpeed, Vald Performance, Newstead, Australia) was used to measure the time taken for each trial. The two timing gates were positioned facing each other on the starting line, at a height of 75 cm above the ground to record sprint time. For each side, the best attempt was recorded and subsequently averaged for statistical analysis.

2.5.6. Submaximal Intermittent Shuttle Run Test

The endurance ability of the players was measured using the submaximal intermittent shuttle run test (ISRT). This test is a valid and reliable tool to measure endurance capacity in team sports [41]. The submaximal ISRT was carried out according to previously described procedures [41]. Participants alternated 30 s of running (at a pace set by an acoustic signal) with 15 s of walking in shuttles of 20 m. The test started at a speed of 10 km·h^{-1} and was gradually increased by 1 km·h^{-1} every 90 s. From 13 km·h^{-1} onwards, the speed increased by 0.5 km·h^{-1} each period. The submaximal running test was terminated after

the participants completed 56 laps, serving as an arbitrary endpoint for the assessment. The heart rate was measured immediately at the end of the test and again 1 min after the end of the test. Participants were asked to stand without moving and without talking, trying to relax as much as possible during the entire recovery time. The difference between these two values was registered as ISRT 1 min recovery (bpm).

2.5.7. Push-Up and Pull-Up Test

The result obtained from the push-up and pull-up test corresponded to the total number of repetitions completed by performing the correct movement until failure. For the push-ups, players were asked to flex their arms until their chest touched a cone (5 cm height) and then fully extend their arms while maintaining a line with their body. For the pull-ups, any attempts that involved body swinging, not fully extending the arms when returning to the starting position, or lifting the chin were not counted. Only repetitions in which the chin was elevated above the bar were regarded as valid [42].

2.5.8. Training Load Monitoring

During all on-field training sessions and matches, all players (except goalkeepers) were equipped with global positioning systems (GPS) devices (Wimu Pro, Realtrack Systems, Almeria, Spain) to measure the external load. The analyzed external load variables in this study were the total distance covered (DC), the distance covered with high-speed running (DC > 18 $km \cdot h^{-1}$), and the number of accelerations and decelerations at an intensity greater than 2 $m \cdot s^{-2}$ (#Acc + Dec > 2 $m \cdot s^{-2}$).

2.6. Statistical Analysis

Data were presented as mean ± standard deviation (SD). Statistical analyses were performed using Statistical Package for Social Sciences software (SPSS 2020, Inc., Chicago, IN, USA). The Shapiro–Wilk test was used to verify normality. Dependent *t*-tests were used to analyze within-group changes between pre- and post-training. An ANCOVA taking the pretesting values as covariates was performed to analyze between-group changes between pre- and post-training. Data were analyzed using a 2 (U16 vs. U14) × 2 (pre–post) factorial ANOVA with Bonferroni post hoc comparisons. Significance was set at $p < 0.05$. The effect size (ES) was determined, and the threshold values for Cohen's ES statistics were classified as trivial (0.0–0.19), small (0.2–0.59), moderate (0.6–1.1), large (1.2–1.9), and very large (>2.0) [43].

3. Results

3.1. Within-Group Analysis

The results of the within-group analysis for the U14 team are shown in Table 3. Analysis of the data indicated that after the intervention, there were significant improvements in body fat percentage ($p < 0.01$; small effect), EHS ($p < 0.01$; moderate effect), agility *t*-test ($p < 0.01$; moderate effect), SLJ ($p = 0.03$; moderate effect), push-up test ($p < 0.01$; moderate effect), and pull-up test ($p < 0.01$; small effect). In contrast, the other studied parameters showed no significant variations post-intervention ($p > 0.05$). Although the change was not significant, the ISRT showed an improvement with a moderate effect. The within-group response of the U16 team is shown in Table 4. After seven weeks of strength training, this group reported improvements in body fat percentage ($p < 0.01$; small effect), EHS ($p < 0.01$; moderate effect), CMJ ($p = 0.01$; moderate effect), and the pull-up test ($p < 0.01$; moderate effect). In contrast, ISRT, SLJ, sprint tests, agility *t*-test, and the push-up test did not show significant changes ($p > 0.05$).

Table 3. Within-group changes in the U14 group (n = 12) after training intervention.

Parameters	Pre Intervention	Post Intervention	Change in Mean (%)	Standard Differences (95% CI)	*p* Value
Body Fat (%)	10.0 ± 2.3	8.98 ± 2.31	−11.0 ± 3.4	−0.42 ± 0.11	0.000
ISRT 1 min recovery (bpm)	38.9 ± 7.2	46.1 ± 9.1	18.3 ± 21.5	0.89 ± 1.03	0.080
NHEes (N)	201.8 ± 45.3	235.4 ± 48.7	17.1 ± 6.9	0.69 ± 0.27	0.000
CMJ (cm)	35.7 ± 5.8	38.6 ± 4.8	8.6 ± 11.8	0.46 ± 0.61	0.128
SLJ (cm)	21.1 ± 2.2	22.8 ± 2.2	8.4 ± 6.9	0.73 ± 0.63	0.027
Sprint 10 m (s)	1.85 ± 0.10	1.84 ± 0.09	−0.3 ± 1.8	−0.05 ± 0.31	0.717
Sprint 30 m (s)	4.53 ± 0.27	4.48 ± 0.22	−1.0 ± 1.6	−0.17 ± 0.25	0.176
Modified *t*-test (s)	9.65 ± 0.38	9.30 ± 0.37	−3.7 ± 1.6	−0.87 ± 0.37	0.000
Pull Ups	2.0 ± 2.9	4.1 ± 4.2	65.0 ± 32.4	0.67 ± 0.38	0.003
Push Ups	23.3 ± 8.4	32.1 ± 9.1	39.9 ± 11.5	0.97 ± 0.33	0.000

ISRT: intermittent shuttle run test; NHEes: eccentric strength during Nordic hamstrings exercise; CMJ: countermovement jump; SLJ: single-leg jump.

Table 4. Within-group changes in the U16 group (n = 9) after training intervention.

Parameters	Pre Intervention	Post Intervention	Change in Mean (%)	Standard Differences (95% CI)	*p* Value
Body Fat (%)	9.9 ± 1.8	9.4 ± 1.6	−5.6 ± 5.0	−0.28 ± 0.25	0.031
ISRT 1 min recovery (bpm)	48.0 ± 8.5	51.1 ± 8.7	6.6 ± 9.0	0.33 ± 0.43	0.115
NHEes (N)	263.4 ± 45.8	291.3 ± 37.0	11.5 ± 6.7	0.55 ± 0.28	0.002
CMJ (cm)	36.8 ± 3.3	39.7 ± 2.6	7.8 ± 5.7	0.77 ± 0.57	0.015
SLJ (cm)	23.6 ± 2.8	24.2 ± 1.1	3.3 ± 7.9	0.21 ± 0.56	0.408
Sprint 10 m (s)	1.81 ± 0.07	1.79 ± 0.07	−1.2 ± 1.8	−0.28 ± 0.41	0.150
Sprint 30 m (s)	4.35 ± 0.14	4.36 ± 0.14	0.3 ± 0.8	0.09 ± 0.24	0.399
Modified *t*-test (s)	8.93 ± 0.12	8.91 ± 0.24	−0.3 ± 1.5	−0.18 ± 1.03	0.696
Pull Ups	4.1 ± 2.6	6.3 ± 2.6	72.1 ± 27.0	0.78 ± 0.26	0.000
Push Ups	33.6 ± 6.5	36.2 ± 9.6	6.8 ± 14.1	0.37 ± 0.65	0.226

ISRT: intermittent shuttle run test; NHEes: eccentric strength during Nordic hamstrings exercise; CMJ: countermovement jump; SLJ: single-leg jump.

3.2. Between-Group Analysis

Statistical analysis of the two groups showed (see Table 5) that the U14 group achieved significantly higher improvements in the *t*-test ($p < 0.01$; moderate effect) and push-up test ($p < 0.05$; moderate effect) than the U16 group. Although not statistically significant ($p > 0.05$), the U14 group showed a small magnitude of improvement in body composition, ISRT, SLJ, and the 30 m sprint (effect size from 0.22 ± 0.24 to 0.41 ± 0.88).

Table 5. Between-group differences.

Variables	Standard Differences (U16 vs. U14; 95% CI)	*p* Value
Body Fat (%)	−0.22 ± 0.24	0.069
ISRT 1 min recovery (bpm)	0.41 ± 0.88	0.320
NHEes (N)	0.10 ± 0.30	0.519
CMJ (cm)	0.01 ± 0.79	0.982
SLJ (cm)	0.37 ± 0.72	0.293
Sprint 10 m (s)	0.18 ± 0.45	0.420
Sprint 30 m (s)	−0.24 ± 0.30	0.112
Modified *t*-test (s)	−0.65 ± 0.38	0.002
Pull Ups	−0.04 ± 0.42	0.829
Push Ups	−0.62 ± 0.53	0.026

ISRT: intermittent shuttle run test; NHEes: eccentric strength during Nordic hamstrings exercise; CMJ: countermovement jump; SLJ: single-leg jump.

Differences in the measured external load parameters across the different days of the microcycle can be seen in Figure 2. The U16 group covered a greater total distance on MD (+18.8%, $p < 0.05$; large effect) and MD-2 (+15.6%, $p < 0.05$; large effect) than the U14 group, with no statistical differences for the other days of the week. The U16's number of accelerations and decelerations were also higher on MD (+20.6%, $p < 0.05$; large effect) and MD+2 (+9.4%, $p < 0.05$; moderate effect) in comparison with U16. The U16 team players covered more HSR on each day of the week ($p < 0.05$), except on MD-1 where there was no difference. On MD+2, the U16 group covered more HSR distance compared to the U14 group (+92.9%, $p < 0.05$, large effect size), on MD-4 (+100%, $p < 0.05$, large effect size), on MD-2 (+49.1%, $p < 0.05$, large effect size), and on MD (+42,3%, $p < 0.05$, very large effect). The total training duration for the U14 group was 2033 min, while for the U16 group, it was 1811 min. The total match duration for the U14 group was 579 min, while for the U16 group, it was 335 min. The total duration of activities (training + matches), total distance covered, and number of accelerations and decelerations during the intervention period were higher for U14 ($p < 0.05$) in comparison with U16 (see Figure 3). However, the total distance covered at high speed was higher in the U16 group ($p < 0.05$).

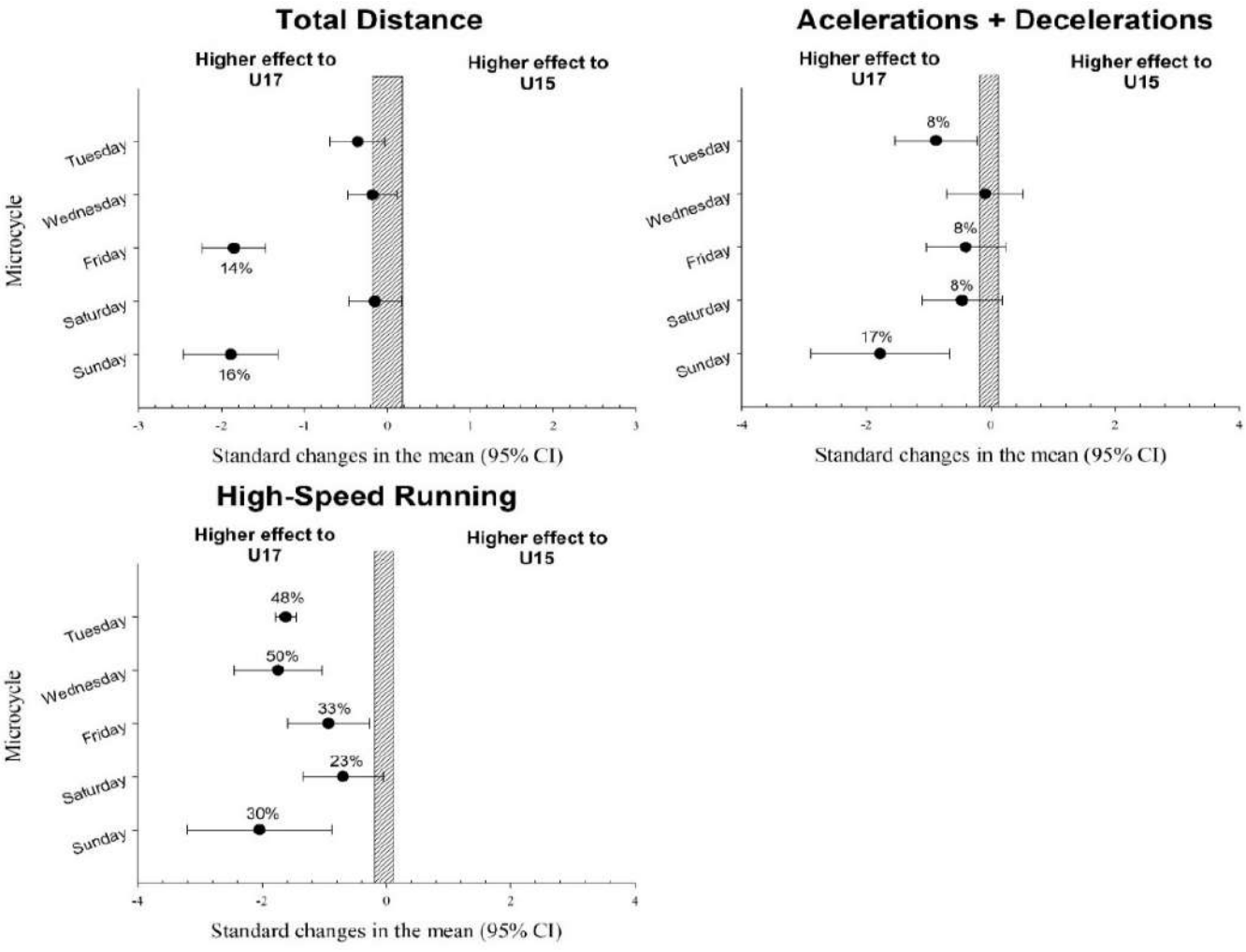


Figure 2. Differences in the external load parameters (effect size (ES ± 95%CI)) across the different days within the microcycle.

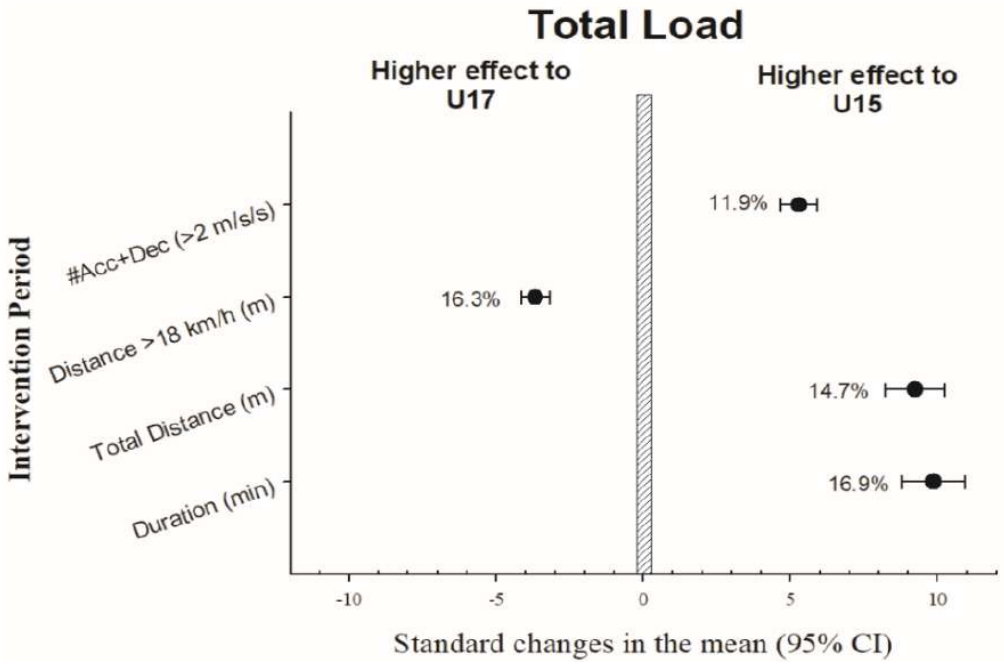


Figure 3. Differences in the total external load parameters (effect size (ES ± 95%CI)) measured over the entire intervention period. # (number) Acc+Dec:accelerations plus decelerations.

4. Discussion

The aim of this study was to analyze the effects of a 7-week combined strength and power training on the body composition, strength, agility, and sprint of elite youth soccer players. The main findings of this work reported that seven weeks of combined strength training produced improvements in body composition, EHS, jump, and pull-up tests of both groups of players. In addition, the U14 team also showed improvements in the agility test. When the U14 and U16 teams were statistically compared, the younger players achieved greater enhancements in the agility and push-up tests.

Strength and power are considered requisites for many important soccer actions such as tackling, jumping, change in direction, and kicking [44,45]. In young footballers, interest in the development of these skills has increased considerably, as a higher ability would increase their chances of reaching the professional level. The combined method seemed to be effective in improving these physical skills in young football players. In this study, one strength session, accompanied by one power session, per week was combined with regular football training. A pre-test and a post-test were performed 7 weeks apart to measure the impact of this protocol on body composition, aerobic capacity, sprint, hamstring eccentric strength, agility, and jumping performance.

Our results confirm those of previous studies, showing that there was a decrease in body fat percentage during the pre-season and when normal soccer training was combined with strength training [46,47]. The decrease in body fat percentage could be associated with improved performance [48], although not all studies confirm this claim [47]. The possible association between a lower body fat percentage and a reduced risk of injury has also not been proven [49,50]. There were no significant differences between groups in changes in body composition, despite the difference in exposure to official matches during the 7-week period. This agrees with the study by Carling and Orhant [51], which showed no relationship between the evolution of body composition during the season and exposure time. Further studies are needed to better understand what impact body composition has on performance and injury risk in young football players.

During the seven weeks of training, there was an improvement in the aerobic capacity of both groups, as measured by the ISRT submaximal. Although strength training can improve running economy and performance in time trials [52], it was not possible to determine in this study to what extent it contributed to this improvement, given the absence of a control group. What can be stated is that concurrent endurance training (through football training) and strength training did not prevent adaptations of the aerobic system of these youth teams [53], although the presence of an interference effect cannot be excluded [54].

The eccentric strength of the hamstrings increased in both groups, with a higher percentage improvement, although was not statistically significant in the U14 group. This difference may be due to a higher trainability resulting from a lower initial level. This improvement was not associated with an enhancement of sprint test performance, even though this muscle group plays a key role in sprinting [55,56]. Our results confirm those of Freeman et al. [57], who after 4 weeks of eccentric training (Nordic hamstring exercise (NHE) twice a week with between 10 and 18 repetitions) found no improvement in sprinting ability, despite an increase in eccentric hamstring strength. Suarez-Arrones et al. [47] also showed no clear correlations between eccentric hamstring strength and sprint performance, or between changes in both after a strength training intervention. Ishøi et al. [58], after 10 weeks of strength training with male amateur players including the NHE, achieved a similar increase in eccentric hamstring strength (+17–19%). In contrast to our results, they witnessed a likely to very likely medium increase in sprint time over 10 m. One reason for the lack of association between the hamstring eccentric strength and sprint performance may be that the NHE (in this case, used as a test to measure EHS) is not a movement specific enough to replicate the main function of hamstrings during sprinting. In fact, not only does the speed of movement differ but also the activation of the semitendinosus (−58%) and the biceps femoris long head (BFl; −46%) during the NHE is much lower than in a sprint [56]. As suggested by Suarez-Arrones et al. [47], the NHE is suitable for targeting the biceps femoris short head, while other exercises are preferable if the aim is to focus on the BFl, which is maximally activated during the late swing and early stance phases of the running [59]. Additionally, the validity of the test has also been questioned, as the athlete's body mass has a significant influence on the force applied to the dynamometer [60]. Loturco et al. [61], after performing 12 strength training sessions over 4 weeks, did not observe an improvement in 20 m sprint performance, although they achieved improvements in strength and CMJ. Other studies have obtained similar results, with increases in several performance parameters not associated with sprinting [62]. This suggests several possibilities: (1) a longer duration of strength training is required to improve performance in sprinting; (2) improvements at the strength level must be greater to translate into improved sprinting; (3) the exercise selection targeting the hamstring muscles must be more specific to the activity those muscles perform while sprinting; or (4) strength training must be accompanied by specific sprint training to achieve technical improvements in running mechanisms.

Several studies with youth [63–65] and adult [11,15,18,66–68] football players have shown the effectiveness of different strength training methods and protocols on vertical jump performance. Our results are very similar to those of Rodriguez-Rosell et al. [69], who after a similar duration of intervention (6 weeks), achieved an improvement in CMJ of between 5.7 and 12.7% following a combination of strength and plyometric training. In this study, we observed a similar improvement in CMJ for both groups (8.6% U14 vs. 7.8% U16), although for the U14 group, it was non-significant due to a large standard deviation. For the SLJ, the U14 group had a higher improvement than the U16 group (8.4% vs. 3.3%). This difference could be explained by an improvement in coordination and balance aspects

that are more important in this type of unilateral jumping compared to a CMJ. Indeed, in a recent study, Cohen et al. [70] showed that during an SLJ, the concentric peak ground reaction force was 60% higher than during a double-leg jump. This also suggests an increase in strength and power output that was superior in the U14 group.

The agility *t*-test showed improvements in performance only for the U14 group, with a significantly greater improvement compared to the U16 group. Chaabene et al. [71], in a meta-analysis looking at the impact of resistance training on the speed of changes in directions, noted that RT is an effective way to improve change-in-direction speed in young and adult athletes, with youth showing larger adaptive potential. Based on this, we expected to see an improvement in both groups. Our results are also in contrast to those of Asadi et al. [72], who analyzed the impact of plyometric training in relation to maturation status on various performance tests and noted that this type of training improved the change-in-direction speed. Participants who are more mature, specifically those in the mid- (ES = 0.95) and post-pubertal stage (ES = 0.99), display a greater inclination toward training-related adaptations compared to less mature participants in the prepubertal stage (ES = 0.68). One explanation may be that the U16 group, being in a more advanced state of growth and having a higher basic level of physical performance, needed a higher volume in terms of strength training and/or high-intensity actions on the field. The same thought has been shared by Otero-Esquina et al. [62]. They suggested, after a 7-week intervention, that young elite players with a much higher weekly training volume need a second weekly strength session to improve change in direction performance.

There are few studies reporting data on upper body strength in football players, especially in youth players. In our study, after 2 strength training sessions per week for a duration of 7 weeks, both the U14 and U16 groups showed significant and similar improvements in the pull-up test, while only the U14 group improved in the push-up test. In a population of young football players (approximately 18 years old), Hertzog et al. [73] showed that the less-trained group (with less than one year of RT experience) showed a greater improvement than the more-trained group after 10 weeks (1 RT of 60 min per week) in the bench press and bench pull tests. This improvement in muscular strength is mainly due to neural adaptations, which normally occur in the early phases of RT [74]. Our results therefore seem to be justified by the different initial levels of the participants, with the younger group having a higher 'trainability' [75]. In fact, the U16 group was more used to push-ups, often used as a punitive measure by coaches during regulated football drills. Based on this principle, we would also expect to see a greater improvement in the pull-up test. One interpretation could be that, given the low initial strength level of the U14 group, the pull-up is too demanding an exercise for their level.

Although this study presents novel findings on strength training in young players, certain limitations should be considered. The present study did not include a control group, only comparing intervention groups; therefore, it is not possible to draw definitive conclusions about the efficacy of the intervention. Future studies should compare the effects of the intervention group with a control group (without strength training) for a better understanding of the effects. The nutritional intake of the players was not monitored in detail, although they all ate the same food at the academy after each training session. Future studies should account for this factor to ensure more precise evaluations.

5. Conclusions

The results of our research indicate that a protocol of 7 weeks of training combining strength, power, and regular football practice is effective in improving the body composition and physical performance in strength and agility tests of young elite football players in the pre-season period. The U14 group showed greater improvements than the U16 group in

the agility and push-up tests. Sprint performance remained unchanged for both groups, suggesting that specific training is required to improve this quality.

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