



# THE EFFECTS OF AN ALTERNATIVE TRAINING METHOD ON PHYSICAL AND TECHNICAL ABILITIES OF ADOLESCENT SOCCER PLAYERS: A PILOT STUDY

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**Abstract** This study examined the effects of an alternative strength training method during soccer training on the development of physical and technical abilities of youth soccer players. 17 soccer players (age: 15 ±0.5 years) were divided in a control

group (CG) and an experimental group (EG). The players of the EG wore a "weight shorts", with 300 gr of additional weight on each thigh, while they participated into 3 regular soccer training sessions per week, for 12 weeks. The CG followed the same training program without wearing the "weighted shorts". Before and after 12 weeks of training, anthropometric characteristics, 10- and 30-m speed, the Arrowhead change-of-direction test, the Illinois agility test with ball, the countermovement jump, and the 5-repetition maximum (5RM) load at the split squat, leg extension and leg curl were measured. The EG improved significantly ( $p < 0.05$ ) more in comparison with the CG in countermovement jump, leg extension and split squat (left leg) 5RM load. The addition of weights on the thighs using special shorts during soccer training sessions leads to increased jumping ability and lower limbs maximal strength in youth soccer players.

**Key words** youth, additional weight, lower limbs, vertical jump, strength

## Introduction

Successful soccer players are characterized by strength, power, and their derivatives (acceleration, sprinting, jumping, and changes of direction) (Hammami, Negra, Aouadi, Shephard, Chelly, 2016). This is in accordance to the activities involved in soccer which are intense and of intermittent nature, with changes in the actions executed every 3–5 sec, resulting in repeated high-intensity spells of play (Karakoç, Akalan, Alemardoğlu, Arslan, 2012). High-intensity actions such as sprinting, jumping, change of direction, kicking (Negra et al., 2018), dribbling, accelerations and decelerations, tackling and turning (Michailidis et al., 2013) represent major performance determinants not only in elite but also in youth soccer players. Likewise, elite youth soccer players are characterized by greater power, speed and acceleration capabilities than non-elite players at various youth age groups, including U13–U18 years (Murtagh et al., 2018) and they outperformed their sub-elite counterparts in various tests of physical performance (Waldron, Murphy, 2013). Consequently, power production of the lower extremities is necessary for a good athletic performance in soccer (Križaj, Rauter, Vodičar, Hadžić, Šimenko, 2019). Any improvement of youth soccer players' strength and power that can help them to improve their performance in short-lasting efforts during a game (Wong, Chamari, Wisløff, 2010) could be crucial to achieve sporting success in their future career (Negra et al., 2018). Thus, young soccer players should participate not only in regular soccer practice, but also in strength sessions.

Numerous studies have examined the effects of different types (e.g., machine based, free weights or combined, functional/complex/plyometric training) and durations of strength training programs in youths, with some of them finding a positive effect on selected parameters of general and soccer specific performance while others did not (Lesinski, Prieske, Granacher, 2016). Among them, some applied resistance training in addition to soccer training (Christou et al., 2006; Hammami, Negra, Shephard, Chelly, 2017), plyometric exercises into the regular soccer training (Söhnlein, Müller, Stöggel, 2014) or a combined resistance and plyometric training program added to regular soccer training (Zghal et al., 2019). Improvements were observed in maximal strength of the upper and the lower body (Christou et al., 2006), in sprint times from 5- to 40-meters (Christou et al., 2006; Söhnlein et al., 2014; Hammami et al., 2017; Zghal et al., 2019), in vertical jump height (CMJ, SJ or DJ) (Christou et al., 2006; Hammami et al., 2017; Zghal et al., 2019) and in agility (Christou et al., 2006; Söhnlein et al., 2014). However, no study examined how the effects of strength training applied by performing specific soccer movements with additional weight during regular training.

Strength training for the improvement of muscular force production remains a key component of any training program for the adolescences both for performance and injury prevention reasons (Lloyd et al., 2015). It has

been stated, though, that strength training must be integrated with sport specific skills training to improve skill performance (Maio Alves, Rebelo, Abrantes, Sampaio, 2010). In this context, portable and relatively inexpensive training devices can provide positive training effects. To the best of our knowledge, no study has examined the effects of an on-field combined strength and power training for the lower limb's using a portable training equipment such as additional weights on the thighs. Relevant studies could provide scientific rationale for soccer coaches and strength and conditioning specialists to include a strength training program using portable training equipment, which could be used by any team as a feasible and cost-effective on-field strength training program while performing regular soccer training. Thus, the aim of the current study was to examine the effects of an on-field lower limbs' strength and power training program using a portable equipment on physical and technical abilities of youth soccer players. It was hypothesized that wearing a special portable, short-construction shorts with additional weight on each thigh, while participating for 12 weeks in soccer training sessions, would improve maximal strength, jumping ability, speed and agility of youth soccer players.

## Methods

### Participants

Seventeen adolescent, male regional soccer players voluntarily participated in the current study. The training age of the players was  $7.2 \pm 2.05$  years and the regular soccer training sessions took place 3 times per week. The players and their parents were informed about the nature and the aim of the study, its benefits and the risks. Afterwards, the parents of the participants signed an informed consent form which was approved by the University's institutional review board and ethics committee. All the procedures were in accordance with the Helsinki's Declaration. The participants were separated into a control group (CG; N = 7) and an experimental group (EG; N = 10) (Table 1).

**Table 1.** Mean and standard deviation of the participants' anthropometric characteristics before the intervention

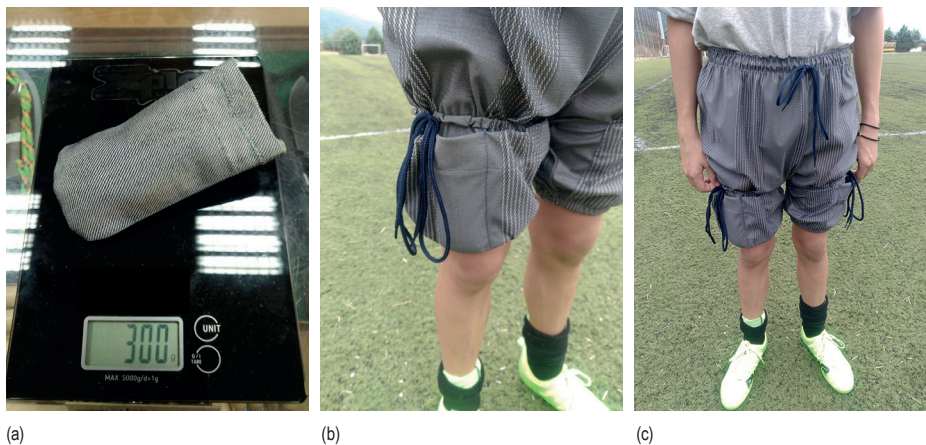
	Control Group (N = 7)	Experimental Group (N = 10)
Age (years)	15.1 $\pm$ 0.3	14.9 $\pm$ 0.7
Training Age (years)	6.8 $\pm$ 2.4	7.6 $\pm$ 1.7
Height (m)	1.75 $\pm$ 0.03	1.71 $\pm$ 0.06
Weight (kg)	62.2 $\pm$ 2.48	58.7 $\pm$ 8.56
BMI (kg/m <sup>2</sup> )	20.34 $\pm$ 1.31	19.94 $\pm$ 1.92
Waist Circumference	68.17 $\pm$ 1.94	66 $\pm$ 4.39

### Training program

Both the control and the experimental groups trained together, as one team, 3 times per week (Tuesday, Wednesday and Friday) for 12 weeks performing the same training sessions. Each training session lasted 80–90 min. In addition, all participants took part, as one team, once a week in an official regional soccer-match, usually on Sunday, lasting 80 minutes (2  $\times$  40 minutes/half time). The aim of the training sessions was to improve the players' technical, tactical and physical abilities. Table 2 presents analytically the training contents applied throughout the 12-week intervention program.

**Table 2.** Training contents applied throughout the 12-week intervention program

Training contents	Weeks											
	1	2	3	4	5	6	7	8	9	10	11	12
Warm up, Rondo games (i.e., 5vs2)	■	■	■	■	■	■	■	■	■	■	■	■
Practice games with goals (large or small) for retaining possession and passing the ball as a group		■		■	■	■	■					
Small side games								■	■	■	■	■
Pressure games frequent 2vs2, 3vs3 and 4vs4 situations		■	■	■	■	■		■	■	■	■	■
Multiple actions with goal shooting large goals			■	■	■	■		■	■	■	■	■
Games with tactic elements/ guided games			■	■	■	■	■		■	■	■	■
Final games free play (freedom of expression, spontaneity) Creativity				■	■	■	■	■	■	■	■	■



**Figure 1.** (a) Additional weight case of 300 gr; (b) Socket for the additional weight; (c) Additional Weight Shorts (AWS) (Photographs: Efthimios Bogiatzidis)

The only difference between the two training groups was that the players of the experimental group wore in each training session special shorts constructed for the purposes of the current study, the Additional Weight Shorts (AWS). In these shorts the additional weight for each leg was 300 gr (Figure 1a). The additional weight was added in a special socket at the height of the thighs (Figures 1b and 1c). The soccer-players wearing these shorts were

able to run, jump, pass, shoot and take part in soccer training without any discomfort. To fit well each participant, there were different sizes (XL youth-size, S-L adult-sizes) of shorts. There was a gradual increase in the time they wore the AWS, starting with a minimum of 10% up to a maximum of 80% of the total training time. Table 3 shows the training time wearing the AWS during the 12 weeks training period.

**Table 3.** Minutes in each training session wearing the AWS throughout the 12-week intervention program (minutes)

Week – Intervention	Training session 1	Training session 2	Training session 3
1	13	15	8
2	21	40	18
3	13	40	33
4	21	45	45
5	21	45	45
6	25	50	47
7	25	55	50
8	42	55	55
9	48	59	57
10	32	62	60
11	32	62	60
12	35	65	63

### Testing procedures

The jumping and strength abilities were evaluated one week before and one week after the 12 weeks intervention training period and the follow-up evaluation was performed 4 weeks after the post measurement. Due to Covid-19, speed, agility and technique were assessed only pre- and post- the 12-week intervention training period.

The tests were executed at an outdoor soccer field with natural grass, where the participants wore soccer shoes, and at a gym with fitness equipment, where they wore indoor shoes. The week before testing there was a familiarization with the execution of the physical and technical ability tests and proper form and technique of each test was practiced according to the instructions of the research assistants. Before testing, the soccer players abstained from physical exercise for 1 day. Verbal encouragement was used throughout all tests to achieve maximum effort. The same researcher measured all the participants.

*Sprint testing.* 10-meters sprint time was measured with 2 photocells using the New Test Powertimer 300-series (Oy, Finland). A photocell was placed at the start and at 10 m. The players started 50 cm behind the first photocell to avoid an early activation of the timing mechanism. The photocells were placed at a height of 80 cm from the ground. The participants run as fast as possible, reaching the finish point of the final photocell, which was placed at 10 meters. Timing was performed at the distance of 10 meters. After 1 practice trial, 2 sprint tests were performed, separated by a 3-min recovery period, and the fastest trial was used for further analysis. 30-meters sprint time was measured with 2 photocells. One photocell was placed at the start and one at 30 m. The players followed the same procedure as in the 10 m sprint. Timing was performed at the distance of 30 meters. After 1

practice trial, 2 sprint tests were performed, separated by a 5-min recovery period, and the fastest trial was used for further analysis.

*Change of direction (COD) ability.* The Arrowhead test was used to evaluate COD ability. The New Test Powertimer 300-series portable photocells were used (Oy, Finland). The players started 50 cm behind the starting point, where the first photocell was placed, to avoid an early activation of the timing mechanism. The second photocell was placed at the finish line. Both photocells were placed at a height of 80 cm from the ground. The participants run as fast as possible until reaching the finish line. The test was conducted both turning left and right. After 1 practice trial, 2 trials for each left and right turning were performed, separated by a 5-min recovery period, and the fastest trial was used for further analysis.

*Technical – agility.* For the evaluation of technical agility the Illinois test was used. The New Test Powertimer 300- series portable photocells were used (Oy, Finland). The participants performed the test in the current study with a soccer ball. The players started 50 cm behind the starting point, where the first photocell was placed, to avoid an early activation of the timing mechanism. They started in the prone position with the chin touching the ground and the hands at shoulder level. The soccer ball was placed on the starting line. The second photocell was placed on the finish line. Both photocells were placed at a height of 80 cm from the ground. The participants run for the best possible time while dribbling a soccer ball with their feet without losing the control until reaching the finish line. After 1 practice trial, 2 trials were performed, separated by a 5-min recovery period, and the fastest one was used for further analysis.

*Vertical jump performance.* Vertical jump ability was assessed using the countermovement jump (CMJ) and the squat jump (SJ). Vertical jump height was calculated by the flight time measured with a contact mat (New Test Powertimer 300-series, Oy, Finland). For the execution of the CMJ, each participant placed his feet in the center of the contact mat and his body was in an upright position with the arms akimbo. The researcher gave a verbal signal and the participant moved from an upright position down to a semi-squat and performed a maximal vertical jump (stretching-shortening cycle), taking care to land on approximately at the same part of the contact mat with the legs kept outstretched during the jump. For the SJ, the participants placed their feet in the center of the contact mat with the arms akimbo, adopted the semi-squat position (knees angle at 90°) and without any pre-stretch performed a maximal vertical jump. The researcher was taking care that participants were descending at each jump until a knee angle of 90° was formed, landing with the toes and approximately at the same part of the contact mat.

*Maximum strength.* Maximum strength of the lower limbs was measured at the exercises leg extension, leg curl and split squat (single left and right leg). As an index of maximum strength, the maximum load that could lifted for 5 repetitions (5RM load) at each exercise was considered. As a warm-up, one set of 8 repetitions was performed with a load 50% of the estimated 5RM load and one set of 5 repetitions with a load 75% of the estimated 5RM load were executed. After those 5 repetitions with the load estimated to be the 5RM load were performed. If the trial was successful, the load was increased by 10% until the participants were unable to successfully perform 5 repetitions, which occurred within two to four attempts. The rest interval between sets was 3 min.

For the execution of the leg extension exercise the participants were seated on a leg extension machine (Super Sport, Athens, Greece) with their hands grasping handles. From this position they extended their legs until a full knee extension was achieved. Leg curl testing was performed on a leg curl machine (Super Sport, Athens, Greece) with the participants laying with face down, the hands grasping handles and performing a full knee flexion. The split squat testing was executed using a smith machine (Sfitness, Shanghai, China). The test started with the

participants standing upright on one leg. The top of the foot of the leg not participating in the movement was placed on a standard gym bench, positioned behind the participants, to ensure that the working leg was isolated to perform the attempt. The participants had to execute a single-leg squat until a 90° angle was formed between the thigh and the shank.

## Statistical analysis

Two-Way repeated measures ANOVAs were used for the statistical treatment of the data, with “Group” as between and “Time” as within factor, along with the post hoc test Bonferroni. The statistically significant level was set as  $p < 0.05$ . All results are reported as mean  $\pm$  SD.

## Results

Seventeen participants successfully completed the study, without reporting any injury due to the intervention or the overall soccer training program. The control group and the experimental group did not differ significantly in any of their anthropometric characteristics before the beginning of the intervention program ( $p > 0.05$ ).

Analysis of variance for repeated measures revealed statistically significant interactions between the two factors (“Group” and “Time”) in the Countermovement Jump [ $F_{(2, 30)} = 3.763$ ;  $p = 0.035$ ], the Leg Extension [ $F_{(2, 26)} = 17.120$ ;  $p = 0.001$ ] and the Left-leg Split Squat test [ $F_{(2, 26)} = 3.499$ ;  $p = 0.045$ ]. The experimental group showed statistically significant greater improvement in the above variables in comparison with the control group (Table 4). The analysis of interaction revealed significant differences between the control and the experimental group in the Leg Extension in the follow up measurement [ $F_{(1, 13)} = 5.124$ ;  $p = 0.041$ ] and in the Left-leg Split Squat both in the post intervention measurement [ $F_{(1, 13)} = 4.305$ ;  $p = 0.048$ ] and the follow up measurement [ $F_{(1, 13)} = 4.131$ ;  $p = 0.043$ ]. In the countermovement jump a significant simple main effect of the within factor “Time” was observed only in the experimental group [ $F_{(2, 14)} = 6.856$ ;  $p = 0.008$ ], and the post hoc Bonferroni test revealed significant differences between the pre intervention and the follow up measurement (Table 4).

In Leg Extension a significant simple main effect of the within factor “Time” was observed both in the experimental [ $F_{(2, 12)} = 73.222$ ;  $p = 0.001$ ] and the control group [ $F_{(2, 12)} = 10.205$ ;  $p = 0.003$ ]. However, in the experimental group the post hoc Bonferroni test revealed significant differences between all measurements, while in the control group significant differences were found between the post intervention and the follow up measurements in comparison with the pre intervention measurement (Table 4).

Regarding the Left-leg Split Squat test a significant simple main effect of the within factor “Time” was observed both in the experimental [ $F_{(2, 12)} = 66.890$ ;  $p = 0.001$ ] and the control group [ $F_{(2, 12)} = 19.837$ ;  $p = 0.001$ ], and the post hoc Bonferroni test revealed significant differences between all measurements (Table 4).

A statistically significant main effect of the within factor “Time” was observed in the Right-leg Split Squat test [ $F_{(2, 26)} = 62.583$ ;  $p = 0.001$ ] and in the Leg Curl test [ $F_{(2, 26)} = 69.323$ ;  $p = 0.001$ ], regardless of “Group”, and the post hoc Bonferroni test revealed significant differences between all measurements. As far as the Squat Jump is concerned, a significant main effect of the within factor “Time” was also found [ $F_{(2, 30)} = 6.489$ ;  $p = 0.005$ ], regardless of “Group”. The post hoc Bonferroni test revealed significant differences between the pre intervention and the follow up measurement (Table 4).



**Table 4.** Mean and SD values of the vertical jump and 5RM strength test variables pre-intervention, after 12 weeks of the training intervention, and after a 4 week follow up period in the control and experimental groups

	Control Group (N = 7)			Experimental Group (N = 10)		
	pre	post	follow up	pre	post	follow up
Countermovement Jump (cm)	34.43 ±5.96	33.57 ±3.69	34.29 ±5.93	31.30 ±3.68	33.40 ±4.88	35.60 ±4.88 †
Squat Jump (cm)	28.71 ±3.81	28.86 ±3.67	30.00 ±3.36 †	28.60 ±4.88	31.00 ±3.33	32.70 ±3.43 †
5RM Leg Extension (kg)	38.83 ±3.43	44.33 ±3.26 †	45.00 ±3.09 †	37.67 ±5.91	47.89 ±6.54 †	53.11 ±8.31 †§*
5RM Leg Curl (kg)	36.33 ±5.16	45.17 ±5.38 †	47.50 ±6.68 †§	36.56 ±7.68	46.56 ±7.29 †	51.78 ±7.34 †§
5RM Split Squat Right-leg (kg)	22.50 ±3.39	31.67 ±8.50 †	39.50 ±13.23 †§	25.11 ±4.85	37.33 ±5.36 †	49.11 ±10.15 †§
5RM Split Squat Left-leg (kg)	21.67 ±3.26	29.50 ±6.53 †	37.00 ±10.46 †§	25.33 ±6.26	37.00 ±7.05 †*	48.78 ±11.31 †§*

\* Significantly different from the control group.

† Significantly different in comparison with the pre-intervention measurement.

§ Significantly different in comparison with the post-intervention measurement.

No significant differences were found in all the sprint and agility variables neither between the two groups, nor between the pre- and post-intervention measurements (Table 5).

**Table 5.** Mean and SD values of the sprint test pre-intervention, after 12 weeks of the training intervention, and after a 4 week follow up period in the control and experimental groups (sec)

	Control Group (N = 7)		Experimental Group (N = 10)	
	pre	post	pre	post
10 m sprint time	1.97 ±0.40	2.04 ±0.24	1.92 ±0.36	2.01 ±0.16
30 m sprint time	4.82 ±0.65	4.84 ±0.38	4.80 ±0.59	4.77 ±0.30
Arrowhead COD right	8.93 ±0.57	9.10 ±0.61	8.78 ±0.53	8.74 ±0.30
Arrowhead COD left	9.08 ±0.60	9.10 ±0.63	8.86 ±0.65	8.89 ±0.33
Illinois test	22.96 ±2.24	23.17 ±2.74	21.75 ±2.18	21.23 ±1.07

## Discussion

This study examined the effects of using a specific strength training tool, a weighted shorts with 300 gr on each thigh worn while participating in regular soccer training sessions, on the development of physical abilities of youth soccer players. The main findings of the current study were that strength of the lower limbs and vertical jumping ability of the young soccer players were improved while sprinting speed, change of direction (COD) and technical - agility abilities were less or not affected.

In the current study the EG achieved a higher performance compared to the CG after 12 weeks of training in the split squat only with the left-leg. This can probably be interpreted by the fact that 8 of the 10 players had the right leg as the dominant leg and due to the use of the AWS they improved more the strength of their left leg. They did not show significant differences compared to the control group in other tests, maybe because there were residual effects of the training period on the lower limbs, since the post-training evaluation was performed the following week. However, in the follow-up measurement, 4 weeks after the end of the training period, although the EG-players did not wear the AWS during training for 4 weeks, they improved significantly compared to the



CG in maximal strength in the split squat left-leg and the leg extension, and the countermovement jump. This was probably due to the physical adaptations that occurred during the 12-week training period. Probably, a tapering period of reduced stress, training without additional load on the thighs, was necessary for the positive outcomes of this specific training method to appear. This aspect is further supported by the fact, that also the squat jump, maximum strength in the right-leg split squat and the leg curl improved from post- to follow-up measurement, although not significantly compared to the control group. On the other hand, the improvement of the CG in the follow-up period in the squat jump, leg curl, split squat (single right and left leg) may be due to growth of the participants who were in adolescence but also from the participation in soccer training alone that leads to improvements in the performance of the lower body. In this context, Christou et al. (2006) showed significant increases in lower-body strength (leg press) after 8 and 16 weeks of strength/soccer and soccer training but in a control group as well, in males aged  $13.8 \pm 0.4$  years.

There are controversial results regarding the effectiveness of strength training on sprint performance. The current findings are in contrast with studies that observed an improvement in sprint performance in youths (Christou et al., 2006; Hammami, et al., 2017) following a strength training period but in agreement with other studies that found no effect or even a negative effect of strength training on sprint performance (Gorostiaga et al., 2004; Buchheit, Mendez-Villanueva, Delhomel, Brughelli, Ahmaidi, 2010; Lopez-Segovia, Andres, Gonzalez-Badillo, 2010). In the current study the performance at 10 m sprint time remained unchanged in both groups. We speculate that this finding is explained by the age ( $15 \pm 0.5$  years) and the growth period our players were at. Cavaco et al. (2014) reported, that in these ages' growth affects motor coordination. The intra/inter muscular coordination and the neural control of the movement are affected at these ages by the constant modification of the anthropometric structure. Also, the performance at 30 m sprint time remained unchanged in both groups. Christou et al. (2006) showed no significant improvements in 10 m sprint time but a significant improvement in 30 m sprint time after a combined strength/soccer training program. In addition, improvements in sprint performance were found in studies where the speed ability was specifically trained (Kotzamanidis, Chatzopoulos, Michailidis, Papaiakevou, Patikas, 2005; Spinks, Murphy, Spinks, Lockie, 2007; Dasteridis, Pilianidis, Mantzouranis, 2011; Lockie, Murphy, Schultz, Knight, Janse de Jonge, 2012), something that was not done in the current study.

Regarding the absence of changes in COD performance found in the current study, this is consistent with the findings of other studies, that found no positive effects after a strength training intervention (Maio Alves et al., 2010; Shalfawi, Haugen, Jacobsen, Enoksen, Tonnessen, 2013). However, some previous studies observed a positive effect of strength training on COD performance (Nimphius, McGuigan, Newton, 2012; Söhnlein et al., 2014; Negra et al., 2018). Brughelli, Cronin, Levin, Chaouachi (2008) stated that the training protocols reporting improvements in COD performance have utilized exercises that more closely mimic the demands of COD, which include horizontal/lateral jump training (unilateral/bilateral), loaded vertical jump training, sport-specific and general COD training. In the current study this wasn't separately targeted.

To the best of our knowledge this is the first study that examined the effects of the use of a weighted shorts during regular soccer training on the improvement of physical abilities of young soccer players and positive effects were found on the strength of the lower limbs and vertical jumping ability. This is of importance since the weighted shorts is: a) a portable training tool that can be easily added and removed, b) appears to be a safe alternative way of strength training, as no training-related injuries were reported, and c) it allows the execution of all soccer-specific movements and the coaches have nothing to change in their planning as wearing it, players can participate

normally in the soccer training sessions. However, a limitation of the present study is the small sample size of the participants. A bigger sample could have offered better results about the effect of AWS on the physical performance of young soccer players. Moreover, the results of the present study are restricted only on the particular age category of male adolescent soccer players. Future attempts should extend these findings in other age groups and even in females. In any case, it should be noted that in this study an alternative on-field strength training method was applied, using a new and practical tool into regular training sessions for improving soccer-specific performance, without any differentiation in the training plan and this make this study practically important.

## Conclusions

Soccer is a demanding sport in terms of physical characteristics. Strength and power are essential for players during running or jumping or to catch the ball before their opponents. The findings of the current study revealed that young U-16 (age: 15 ±0.5 years) soccer players who carried an additional weight of 300 gr on each thigh with a progressively increasing duration of their use for 12 weeks during the in-season period and participating normally in regular soccer training sessions (passing, shooting, sprinting, jumping, games, tactic etc.), have a positive effect on some of the parameters of the physical abilities. The strength and power of the lower limbs and their jumping performance were increased, using a cheap, practical and portable equipment, without extra training time and without disturbing the training sessions. These findings have important and direct implications for coaches and sport scientists involved in the development and training of youth soccer players. However, the current study also showed that to improve abilities such as speed, change of direction and technique-agility, more targeted and specific intervention related to these skills should be organized and this could be a perspective for future studies.

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