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The effects of a repeated sprint ability program on youth soccer players' physical performance

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Abstract
Introduction. **Soccer trainers in their effort to be effective by saving time for technical tactical training try to use methods that have positive effects on multiple physical abilities. High-intensity interval training (HIIT) is widely used in soccer.** Aim of Study. **The purpose of the study was to investigate the effect of a repeated sprint training (RST) program on the performance of soccer players under the age of 17.** Material and Methods. **Twenty-nine youth players participated in this study. Players were randomly separated into two groups: control group (CG, n = 14) and intervention group which performed RST program (IG, n = 15). The duration of the training program was four weeks. Sprint 10 m, 30 m, countermovement jump (CMJ), squat jump (SJ), Illinois agility test, Yo-Yo intermitted recovery test 2 (YYIRT2) and repeated sprint test (RSA: RSAbest, RSAmean, RSAdecrement) were measured pre and post of the training program.** Results. **The performance in 30 m, RSAbest, RSAmean and RSAdecrement improved in IG group ($P = 0.049$, $\eta^2 = 0.171$, $P = 0.017$, $\eta^2 = 0.307$, $P = 0.002$, $\eta^2 = 0.622$, and $P < 0.001$, $\eta^2 = 0.774$, respectively). The performances of the two groups differed in post measurement of 30 m, RSAbest and RSAmean ($P = 0.044$, $\eta^2 = 0.160$, $P = 0.048$, $\eta^2 = 0.014$, and $P = 0.038$, $\eta^2 = 0.226$, respectively).** Conclusions. **This study supports that a short-term program of HIIT can improve sprint and repeated sprint ability performance. The results reflect the training principle of the specialization of the stimulus. The improvement in performance presented in tests that had similar characteristics to training stimuli.**

KEYWORDS: youth, soccer, fitness, high intensity interval training.

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Introduction

Soccer is an intermittent sport characterized by periods of low, moderate and high intensity efforts [4]. The development of technology has made it possible to record actions carried out both during matches and training sessions of teams. Thus, in professional soccer players during a match cover 9-14 km, of which about 10% is covered with a speed of more than 19 km/h [26]. It results both from literature sources and from practice that the distances covered at high intensity are the most important for the performance of the player and for the result of the match [11]. Knowledge of the requirements of the "match" helped trainers to focus on important factors they need to develop in order to improve performance of their players. Such key factors are the ability to repeated sprints, endurance, the ability to sprint and power.

Trainers in their effort to be more effective by saving time for technical tactical training try to use training methods that have positive effects on multiple physical abilities. One such method is the high intensity interval training (HIIT) proposed by Buchheit and Rabbani [6]. This form of training includes five subcategories: 1) training using racing games, 2) interval training with sprints >20-30 s with long breaks (3 min), 3) training of repeated sprints <10 s, 4) HIIT long time (no maximum exercise for 2-4 min), and 5) HIIT short time (no maximum exercise for <45 s) [4].

Several studies have shown positive effects of these training methods on power, speed, high intensity running and the ability to repeat speeds in youth soccer players [3, 5, 8, 10, 16, 23]. However, results of the studies are difficult to compare as they use different training protocols (different characteristics of the charge: volume, intensity, break, density) and different ages of participants. For example, it is known that age and biological maturity can affect effectiveness of a fitness program [13]. Therefore, any research on the effect of HIIT on performance of teenage soccer players contributes to an overall picture. Thus, the purpose of this study was to study the effect of a short 4-week repeated sprint training (RST) program on physical abilities of youth soccer players under 17 (U17) of a certain biological age. The hypothesis of the study was that this short program would improve performance in repeated sprinting ability, speed, power and endurance.

Material and Methods

Design

This study used a two-group (intervention group, IG, and control group, CG), randomized controlled trial design to compare effects of a short RSA training program on U17 youth soccer players. The study was conducted during the in-season period for four weeks. Each group participated in four training sessions and one soccer game per week. The CG performed only the conventional soccer practice. The IG performed a RSA program twice a week, 72 hours apart. The two experimental groups had the same duration of training sessions (90 min). The RSA program was performed immediately after warm-up to ensure full neuromuscular activation, and the CG during the intervention carried out technical and tactical exercises. Two weeks before the study the soccer players familiarized with the tests in order to minimize the learning effect error. During the first visit after the two weeks the soccer players had their body mass, height and percentage of body fat measured. During the next two visits they performed fitness tests: countermovement jump (CMJ), squat jump (SJ), speed (10 m and 30 m), change of direction (Illinois agility test), Yo-Yo intermittent recovery test level 2 (YYIR2). The tests were repeated after four weeks of training and were conducted 48 hours after the last training session and with the same sequence each testing day. At the beginning of each testing session the soccer players performed a 15-minute warm-up and at the end a 10-minute cool-down period. Soccer players consumed water ad libitum to ensure proper hydration during training and testing.

Subjects

Power analysis was performed before the study by setting an effect size of 0.6, a probability error of 0.05 and a power of 0.9 for two groups and two measurements points (pre- and post-test). Power analysis (G*Power, version 3.1.9.2, Universität Kiel, Düsseldorf, Germany) estimations were based on studies that examined effects of training protocols on performance of soccer players [8]. The analysis indicated that 24 subjects were the smallest acceptable number of participants. The inclusion criteria to participate in the study were as follows: 1) no musculoskeletal injuries for ≥6 months prior to the study, 2) having participated in ≥95% of training sessions and seven or more of the intervention trainings for IG, and 3) not to be taking any medication. A total of 29 male youth soccer players under the age of 17 (U17) participated in the study. The players came from two local soccer academies. They did four training sessions and one game a week and all of them had at least 10 years of systematic soccer training. The players were randomly assigned into two groups, the intervention group (IG, n = 15) and the control group (CG, n = 14). All the participants were informed of the potential risks and benefits of the study and signed a consent form for their participation. For the research the requirements of the Research Code of Ethics of the Aristotle University of Thessaloniki were fulfilled in compliance with the Helsinki Declaration. The researcher conducting the assessment tests was blinded to the participants' allocated group. Participant characteristics are presented in Table 1.

Table 1. Participants' physical characteristics

	CG (n = 14)		IG (n = 15)	
	pre-training	post-training	pre-training	post-training
Age (years)	15.8 ± 0.2	15.9 ± 0.3	16 ± 0.2	16.1 ± 0.2
Height (cm)	177 ± 7	178 ± 6	176 ± 6	177 ± 6
Weight (kg)	65.7 ± 8.8	66.2 ± 8.6	66.4 ± 11.3	65.9 ± 11.9
Body fat (%)	15.4 ± 5.3	15.8 ± 5.8	16.5 ± 5.5	15.9 ± 6.2

Note: CG – control group, IG – intervention group

Intervention program

The intervention program lasted four weeks with a frequency of two times a week with two days being 48 hours apart. The total duration of the sessions was 90 minutes. In addition to the soccer teams' program, IG also performed the intervention program, while CG participated exclusively in the teams' athletic program. The intervention lasted 12-20 minutes (9 min in the first week to 22 min in the fourth week) and took place immediately after the warm-up period. The characteristics of the RSA program are presented in Table 2.

Table 2. Description of the four weeks of repeated sprint ability training program and features of each session

Week	Sessions	RST				Rest between	
		Set	Reps	Meters	Speed	Sprint (s)	Sets (min)
1st	1st	2	6	40	max	20	4
	2nd	2	6	40	max	20	4
2nd	3rd	3	6	40	max	20	4
	4th	3	6	40	max	20	4
3rd	5th	4	6	40	max	20	4
	6th	4	6	40	max	20	4
4th	7th	4	6	40	max	20	4
	8th	4	6	40	max	20	4

Note: RST – repeated sprint training

Anthropometric measurements

Body mass was measured to the nearest 0.1 kg using an electronic digital scale with the participants in their underclothes and barefoot. Standing height was measured to the nearest 0.1 cm (Seca 220e, Hamburg, Germany). Body fat percentage was estimated based on the sum of four (biceps, triceps, suprailiac, subscapular) skinfold thicknesses measured with a specific caliper (Lafayette, Ins. Co., Indiana) on the right side of the body as described [22]. Estimation of body density was calculated according to the Durnin and Rahaman [9] equation for males under the age of 16 and estimated by the equation of Siri [21].

Speed testing

A 30-m sprint test with 10-m splits (0-10 m were measured as well) was used to measure speed performance. Sprint testing was performed with the participants wearing soccer shoes on the synthetic grass of a soccer field. After a 5-second countdown the participants ran in front of three infrared photoelectric gates (Microgate, Bolzano, Italy) that recorded times at each gate. The participants sprinted from a standing starting position with the toe of the front foot approximately 0.3 m behind the first gate. Photocells were placed 0.6 m above the ground (approximately at hip level) to capture the movement of the trunk rather than a false signal because of a limb motion [18]. The coefficient of variation for test–retest trials was 3.2%.

Vertical jump testing

Participants performed two vertical jump tests. The first test was the squat jump (SJ) where the players from a static half-sitting position (90° angle knee bend) performed a maximum vertical jump. The second test was the countermovement jump (CMJ). Participants started the jump from an upright position, making a quick preliminary movement by bending their knees and hips at 90°, followed by an explosive jump upwards extending their knees and hips. The jumps were performed with the hands on hips. Participants wore athletic shoes and made two attempts in each jump. The jump height was measured using with the Chronojump electronic leap mat (Chronojump, Boscosystem, Barcelona, Spain). The coefficients of variation for the test–retest trials were three and 2.8% SJ and CMJ, respectively.

Illinois agility test

Participants started from an upright position, 30 cm behind the gate. From position A (starting position) they sprinted to position B, where they turned out of the cone at position C and continued with zig-zags to position D and returned in the same way to position C. From this position they sprinted to position E, where they turned out of the cone sprinting to position F (finish position) (Figure 1). At the starting and closing points there were photocell-reflector gates (Microgate, Bolzano, Italy). The coefficient of variation for the test–retest trials was 3.9%.

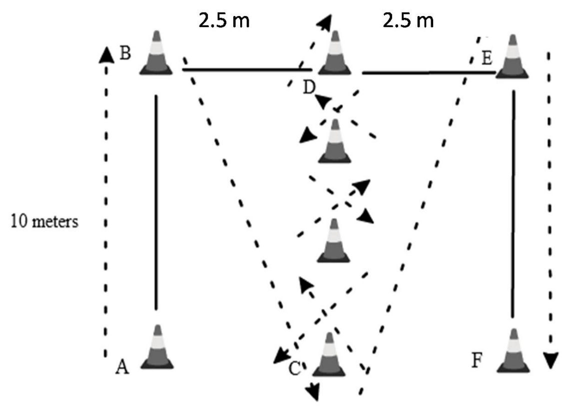


Figure 1. Description of the Illinois agility test

Repeated sprint ability test

The RSA test included 6 × 40 m (20 + 20 m sprints with 180° turns) shuttle sprints separated by 20 s of passive recovery (19). Participants started from an upright position, sprinted for 20 m, touched a line with a foot and came back to the starting line. At the starting line there was one photocell-reflector gate [19] (Microgate, Bolzano, Italy). Immediately after the warm-up each soccer player performed a single sprint of 20 + 20 m with a turn of 180°. This time was used to test the players' maximum effort in the RSA test. If the time of the first sprint in the RSA test was 3% greater than the single sprint test, the test was terminated and the subjects were required to repeat the RSA test with maximum effort after 5 minutes. Three seconds before the start of each sprint the subjects assumed the ready position and waited for the acoustic start signal. The best time (RSAbest – the best time of the six sprints), mean time (RSAmean – the average time of the six sprints) and decrement (RSAdec = RSAmean/RSAbest – the rate of performance decrement) were determined [19].

Yo-Yo intermitted recovery test level 2

The YYIR2 test consisted of 2 × 20 m intervals of running interspersed by regular short rest periods (10 s). Furthermore, signals were given by a CD-ROM to control the speed. The player run 20 m forward and he adjusted his speed so as to reach the 20-m marker exactly at the time of the signal. Additionally, a turn was made at the 20-m marker and the player ran back to the starting marker, which was to be reached at the time of the next signal. Then the player had a 10 s break to run slowly around the third marker, which was placed 5 m behind him. He had to wait at the marker until the next signal. The course was repeated until the player failed to complete the shuttle run two times in a row. The first time, when the start marker was not reached a warning was given ("yellow card"), while at the second one the test was terminated ("red card"). The last running interval that a player had completed before being excluded from the test was recorded and the test result was expressed as the total running distance covered in the test [7].

Statistical analysis

The SPSS software (version 18.0, SPSS Inc., Chicago, IL) was used for all analyses. Data are presented as means ± standard deviation (SD). In addition, confidence intervals (CIs) were reported for fitness variables. Data normality was verified by the 1-sample Kolmogorov–Smirnov test. Therefore, no non-parametric test was necessary. The two-way analysis of variance (ANOVA) (trial × time) with repeated measurements was performed. Wherever a significant difference was found, post hoc LSD was applied. Furthermore, the effect size via η^2 was calculated. The significance level was set at $P < 0.05$. As mentioned earlier, power analysis was performed to estimate the smallest acceptable number of participants to analyze the interaction between group and time points of measurements.

Results

The two groups did not differ in chronological age, height, body fat and all other fitness tests at the beginning of the study. Also, soccer training and the intervention program did not affect the participants' anthropometric profile (Table 1).

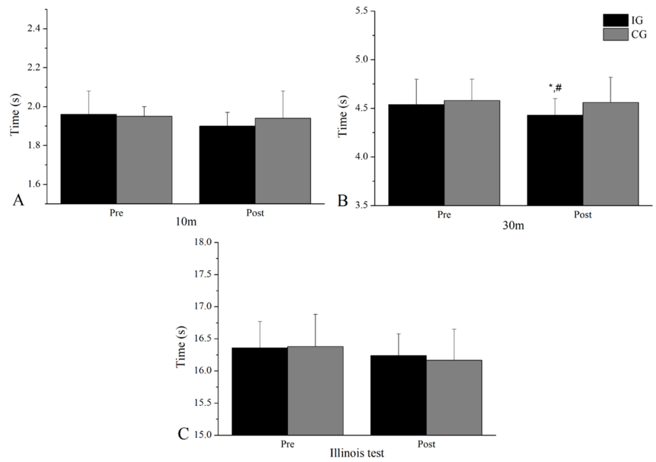
After the intervention the IG participants demonstrated a reduction of sprint time in the 30 m sprint (IG: 2.4%, $P = 0.049$, $\eta^2 = 0.171$). No differences were observed in the 10 m results (IG: 3.6%, $P = 0.454$, $\eta^2 = 0.047$). In the CG results no changes were observed between the pre- and post-test measurements for both tests, 30 m (CG: 0.4%, $P = 0.216$, $\eta^2 = 0.039$) and 10 m (CG: 0.5%, $P = 0.632$, $\eta^2 = 0.024$). Differences between the groups were found in post measurements for the 30 m sprint ($P = 0.044$, $\eta^2 = 0.160$). The differences are presented in Figure 2. The confidence intervals of all the measurements are presented in Table 3.

Table 3. Confidence intervals of fitness measurements

	Confidence interval			
Variable	IG	CG	Pre	Post
30-m (s)	4.21-4.76	4.46-4.68	4.42-4.71	4.33-4.65
10-m (s)	1.83-2.06	1.89-2	1.91-2	1.84-2
SJ (cm)	25.49-33.85	25.84-33.21	26.13-31.56	27.28-33.41
CMJ (cm)	28.34-37.09	25.59-35.11	28.64-34.33	30.21-35.95
Illinois test (s)	15.89-16.71	16.04-16.51	16.11-16.63	15.96-16.45
YYIR2 (m)	611-796	207-872	409-750	473-854
RSAbest (s)	7.26-7.59	7.33-7.56	7.39-7.63	7.23-7.47
RSAmean (s)	7.63-8.09	7.65-7.98	7.8-8.08	7.57-7.9
RSAdec	1.03-1.06	1.03-1.05	1.05-1.06	1.03-1.04

Note: CG – control group, IG – intervention group, SJ – squat jump, CMJ – countermovement jump, YYIR2 – Yo-Yo intermittent recovery test level 2, RSAbest – the best time of the six sprints, RSAmean – the average time of the six sprints, RSAdec – the rate of performance decrement

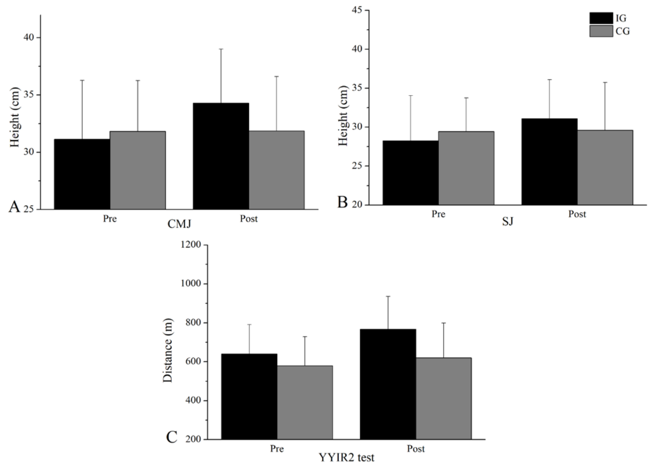
The performance of both groups did not change in the Illinois agility test (IG: $P = 0.075$, $\eta^2 = 0.104$, CG: $P = 0.124$, $\eta^2 = 0.088$). No differences were observed between the groups at the post measurement ($P = 0.902$, $\eta^2 = 0.001$). The differences are presented in Figure 2.



Note: CG – control group, IG – intervention group
* denotes significant differences with Pre ($P < 0.05$); # denotes significant differences with CG ($P < 0.05$)

Figure 2. Performance changes in: A) 10 m, B) 30 m, C) Illinois agility test

Jumping performance for both groups between pre- and post-test measurements was not changed. The IG results showed an increment of 10% both in SJ ($P = 0.056$, $\eta^2 = 0.237$) and in CMJ ($P = 0.063$, $\eta^2 = 0.258$). The performance of CG in SJ changed by 1.6% ($P = 0.223$, $\eta^2 = 0.078$) and in CMJ by 0.1% ($P = 0.869$, $\eta^2 = 0.022$). Additionally, no differences were observed between the groups in post-test measurements for SJ ($P = 0.956$, $\eta^2 = 0.015$) and CMJ ($P = 0.736$, $\eta^2 = 0.006$). The differences are presented in Figure 3.

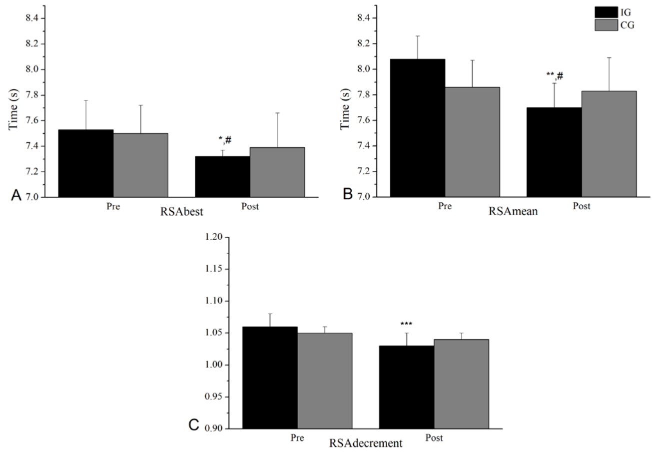


Note: CG – control group, IG – intervention group, CMJ – countermovement jump, SJ – squat jump, YYIR2 – Yo-Yo intermittent recovery test level 2

Figure 3. Performance changes in: A) countermovement jump, B) squat jump, C) Yo-Yo intermittent recovery test level 2

No changes were observed for both groups in the post-test measurement for the YYIR2 test (IG: 20%, $P = 0.115$, $\eta^2 = 0.307$; CG: 6.9%, $P = 0.322$, $\eta^2 = 0.082$). No differences were observed between groups. The differences are presented in Figure 3.

The IG group improved its performance in RSAmean (4.7%, $P = 0.002$, $\eta^2 = 0.622$). The change in RSAbest was 2.8% ($P = 0.017$, $\eta^2 = 0.288$), while in RSAdecrement it was 2.8% ($P < 0.001$, $\eta^2 = 0.774$). In CG no changes were observed in all the variables of the RSA test (RSAbest: 1.5%, $P = 0.386$, $\eta^2 = 0.096$; RSAmean: 0.4%, $P = 0.625$, $\eta^2 = 0.116$; RSAdecrement: 0.95%, $P = 0.784$, $\eta^2 = 0.126$). Differences between the groups were observed in post-test measurements of RSAmean ($P = 0.048$, $\eta^2 = 0.226$) and RSAbest ($P = 0.038$, $\eta^2 = 0.014$). The differences are presented in Figure 4.



Note: CG – control group, IG – intervention group, RSAbest – the best time of the six sprints, RSAmean – the average time of the six sprints, RSAdec – the rate of performance decrement
* denotes significant differences with Pre ($P < 0.05$); ** denotes significant differences with Pre ($P < 0.01$); *** denotes significant differences with Pre ($P < 0.001$); # denotes significant differences with CG ($P < 0.05$)

Figure 4. Performance changes in: A) RSAbest, B) RSAmean, C) RSAdecrement

Discussion

From the results of the study it appeared that this type of training did not affect the participants' performance. However, the IG had the tension to improve its performance in the YYIR2 test. A recent study comparing RSA programs in terms of recovery time showed that a shorter time (15 to 30 s) had a greater effect. More specifically, the program with the 15 s rest between the sprints further improved the performance in YYIRT2 [16]. Perhaps the shorter break activates to a greater extent both the anaerobic mechanism and the aerobic mechanism in the body's effort to respond to the continuous maximum stimuli without adequate recovery [4]. In a more recent study comparing repeated sprint training (RST) programs performed in a straight line or with a change of direction no changes in performance were recorded in the YYIR1 test [1]. Sanchez-Sanchez et al. [20] compared the effect of different aerobic levels in young footballers on the effectiveness of RSA programs. The results showed that the programs improved performance of YYRT1 in players with lower aerobic capacity, which however did not differ from those with high aerobic capacity. As mentioned above, the impact of the programs is difficult to compare as they differed in many characteristics of the load. However, this type of training places a greater strain on the body's anaerobic mechanism, with footballers receiving a greater neuromuscular load and the respiratory chain of the aerobic system being less burdened. It seems that this type of training is not the most suitable for improving aerobic capacity [4].

In the present study it was shown that IG improved its performance. In a similar study reported recently, Tønnessen et al. [25] observed an improvement in performance in the RSA test. Also improvements in indicators of RSA tests are reported by recent studies [1, 8, 16, 20]. However, there are also studies that do not report any improvement in performance in RSA after a repeated sprint training program [10, 14, 15]. The similarity of the RSA evaluation tests to the form of training may be a reason for an improvement in this ability. Also, the ability of RSAs depends on metabolic, nervous and mechanical factors [2]. Training programs that can improve one or more of these factors at the same time cause improvement in the RSA.

Based on the results it seems that IG improved its performance in the 30 m test. The literature shows that the impact of RST programs on the RSA is not clear. More specifically, there are studies that report significant improvement in a 30-40 m sprint [8, 25], but also studies that did not observe any improvement in performance [3, 16, 17]. Beato et al. [1] studied the incorporation of a change of direction in RST and while they noticed no improvement in the sprint (>20 m), they observed that the group that trained with a change of direction improved its acceleration in the 10 m test. The improvement may be due to various mechanisms. The RST training may have increased muscle metabolites, such as phosphocreatine, leading to better performance. Also neuromuscular changes such as increment in muscle fiber recruitment, firing frequency and motor unit synchronization can lead to improved performance [24].

In the present study no changes were observed in jumping performance. Based on literature sources it may be concluded that the jumping ability does not improve after the application of RST [12]. This method of training stimulates neuromuscular factors that could affect the jumping ability; however, it seems that the stimulus is not sufficient to act in this way. Since the goal is to improve jumping ability, more targeted contents in the reactive strength and stretch-shortening cycle (SSC) need to be applied.

No changes were observed for agility performance. In the available literature there are studies, which findings are in agreement with ours [1]. However, some studies mentioned improvement in the performance of soccer players in agility tests [8]. Agility tests include accelerations and decelerations, therefore the use of the stretch-shortening cycle (SSC) phenomenon is crucial in this performance. As in the jumps, a more specialized training stimulus is required in order to have an improvement in performance.

As mentioned above, each of the five different types of high intensity interval training causes different adjustments in athletes. Also, differences of programs in the characteristics of the load may explain the different findings. Finally, another factor that makes it difficult to compare the results is the different evaluation tests used in the studies.

Conclusions

In conclusion, in this study a significant improvement in performance was observed in the 30 m test, the RSAbest, the RSAmean and the RSAdecrement after the implementation of a HIIT-RST program that was applied two times a week for four weeks. The use of HIIT training is particularly widespread, as it improves performance in a short period of time, saving time for technical and tactical training. However, the lack of improvement in some tests indicates a relationship between the type of load and the adjustment achieved.

Conflict of Interest

The authors declare no conflict of interest.

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