



ORIGINAL SCIENTIFIC ARTICLE

IMPROVEMENT OF QUALITATIVE AND QUANTITATIVE ASPECTS OF THE SPORTS PERFORMANCE OF YOUNG PLAYERS THROUGH HIGH INTENSITY INTERVAL TRAINING

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Abstract

Objective. One of the most widely used training methodologies in football is high intensity interval training (HIIT), which aims to improve performance through training sessions characterised by exercises that involve alternating percentage load intensity. In the literature, although there are studies that demonstrate the effectiveness of HIIT in improving quantitative aspects, i.e. different expressions of strength, there are not as many studies that attest to the same effectiveness in improving qualitative components, i.e. elements related to the precision of specific football gestures.

The study purpose was to verify whether the application of a specific HIIT protocol for football over a given period of time can be equally effective in simultaneously improving the quantitative and precision components.

Materials and methods. The sample analysed consisted of 16 movement players from the ASD Nuova Antoniana sports club, aged between 14 and 15 years. The sample was subjected to a mesocycle of training lasting 8 weeks characterised by the HIIT methodology. Before and after this period, data were collected by means of a battery of tests aimed at assessing rapid, explosive, fast and resistant strength, and passing and shooting skills: the parameters relating to expressions of strength were assessed by means of quantitative tests specific to each parameter; passing and shooting skills were assessed by means of accuracy score tests (from 0 to 4 according to accuracy).

Results. The results showed an improvement in all tested parameters ($p \leq 0.05$). Therefore, the effectiveness of the protocol in improving football performance in terms of quantity and accuracy is confirmed.

Conclusions. This study has increased knowledge of the effects of the HIIT protocol on the performance of young football players.

Keywords: High Intensity Interval Training, football training, football technique, physical skills.

Introduction

Football is one of the most popular sports in the world. It is a team sport played by two teams of 11 players (substitutions are possible due to injuries or tactical reasons). The aim of the game is to score goals against the opposing team by getting the ball all the way across the goal line. Youth teams play according to their category, with varying playing times, field sizes and goals.

It is a situational, open skill sport (Wang et al., 2013), with a high competitive commitment (Altavilla et al., 2018) that assumes an adequate level of individual technique and

tactical sense within the team group (Raiola et al., 2020a,b). An important role is also given by the physical characteristics of the athletes, i.e., the ability to express adequate levels of strength both in general and specific terms (D'Isanto et al., 2017) with respect to the role and situations. Finally, the psycho-motivational components should not be forgotten, i.e. determination, courage is the ability to control aggression and tension (Castro-Sánchez et al., 2018).

The type of force that is applied is mixed, as one goes from fast to resistant force in a short time, furthermore, depending on the circumstances one can have concentric and eccentric muscle contraction regimes (Mitchell et al., 2022; Arden et al., 2015). High levels of maximal strength are not required, but rather a good level of general strength, on which a good expression of fast strength, resistant strength and explosive strength can be built.

Football can be defined as a mixed-energy sport, as the actions of the game last several minutes, or follow each other quickly, giving the body the opportunity to alternate work in both aerobic and anaerobic conditions (Coppola et al., 2019). Especially in modern football, qualitative aspects (Ceruso et al., 2019) should be considered: it is not useful to separate the technical and tactical aspects of the game from the physical abilities of the players, as all these aspects influence, in a decisive way, the quality of the game (Esposito et al., 2019).

For these reasons, the programming of the training process, in order to effectively achieve the set objectives, must include training protocols that, in an integrated manner and with the right load, consider the greatest number of variables, from the subjective ones, related to the structural and psychomotor characteristics of the athletes, to the overall ones of the team as a complex adaptive system, in which the multitude of parts that constitute it, continuously form coordinated (or synergistic) patterns (D'Isanto et al., 2021; Renshaw et al. 2019). One of the most widely used training protocols in football is high-intensity interval training (HIIT) (Aliberti et al., 2021), as it optimally addresses the needs listed above. The first scientific studies demonstrating the effectiveness of HIIT were published in the late 1950s and early 1960s (Roskamm et al., 1962; Astrander et al., 1960). The ability to perform exercises with intermittent intensity levels for prolonged periods is now a key prerogative in competitive football (Federici et al., 2019). Consequently, training strategies and tests have been proposed to monitor and improve players' ability to perform high intensity activities during competition (Raiola & Altavilla, 2020).

The effectiveness of this protocol is attested by several recent studies (Dupont et al., 2004; Ibba et al., 2016) that, however, focus their attention mainly on quantitative aspects (Hostrup et al., 2019; Leahy et al., 2020).

High Intensity Interval Training can be considered as a hybrid of aerobic and anaerobic training. It comprises intense exercises of approximately 30/45 seconds, alternating with 15/30 second rests. This continuous variation of intensity allows both anaerobic and aerobic energy systems to be exploited (Rago et al., 2017; Iaia et al., 2009). The particularity of this methodology is that it can be appropriately adapted to specific performance needs. It can include exercises for the development of strength, under the various expressions and with the intensities most useful for the purpose, or even dexterity, a very important characteristic in the game of football. Dexterity has been defined (Valero-Cuevas et al., 2003) as the ability of a part of the body (e.g. lower limb) to dynamically regulate the intensity and direction of the end-point force when interacting with the environment, such as, for example, in the precision of the pass or the final goal and in the choice of the timing and intensity of force appropriate to the situation.

As can be seen from the literature, it is not clear whether a period of training with the HIIT protocol can bring the same level of improvement in physical abilities and qualitative aspects, i.e. the effectiveness of the gestures with respect to the objectives.

The aim of this work was to verify whether the use of a High Intensity Interval Training protocol specific for football, lasting 8 weeks, was able to improve the sporting performance of young footballers, in terms of both qualitative aspects, relating to the accuracy of the finalisation and passing, and quantitative aspects, i.e. the levels of VO_2max , explosive strength, fast strength, and speed.

Materials and methods

Study participants

Sixteen young male ($n=16$) soccer players (age: 15.81 ± 0.83 years, height: 162.9 ± 0.6 cm, weight: 58.4 ± 3.8 kg, BMI 22.05 ± 1.22) participated in this study. All players were members of the same youth football team (Società Nuova Antoniana, in the province of Naples), participating in the provincial under-16 championship. All the players had been practicing for about 5 years.

All participants were in good health and participated in all competitions and training sessions.

All players and parents were informed about the research procedures, requirements, benefits and risks and written informed consent was obtained prior to the study.

Study organization

The study lasted a total of 10 weeks: one week of inbound testing, 8 weeks of training with the experimental protocol, one week of outbound testing (Table 1).

The tests, after an adequate warm-up, had a succession and adequate recovery times to allow full psychophysical recovery of the athletes from one test to the next. For each day of testing, first a qualitative test inherent to accuracy was done and then one or two quantitative tests.

On the first day, the ability to finalise and quick strength were assessed. A scoring test was used for the finishing ability: the goal was divided into 6 areas and each area was given a score (4 points for high corners; points for low corners; 2 points for high central area; 1 point for low central area). Each player took 4 shots at three different distances (11 metres, 18 metres and 22 metres). At each distance, 2 shots were taken from a standing position and 2 shots were taken with the ball in motion, with a grazing pass coming from the edge of the penalty area. At the end of the shots, total scores were recorded for each player. Quick strength was assessed with a timed test: a 2.5-metre speed ladder with 6 spaces was placed on the ground, and when the instructor gave the go-ahead the athletes touched each space twice (once with the right and once with the left) in the shortest possible time and were timed.

On the third day, passing ability and explosive strength were assessed. With regard to the passing ability, a scoring test was used: the player led the ball to a line and from that point tried to pass the ball inside a mini-goal measuring 1 metre wide by 50 centimetres high, positioned 11 metres away. Points are awarded according to the accuracy of the pass (3 points for each ball that ends up in the goal, 1 point if the ball hits the post or crossbar, 0 points if the ball ends up outside). Then another ball was placed in the position where the player was at the end of the first pass, with this the player made a high pass from his position to another circular target of radius 2 metres placed 36 metres away, the circle was placed in the centre of a square area of 10 x 10 metres. A further score was then awarded (3 points if the ball lands in the circle or touches its circumference; 1 point if the ball falls inside the larger square; 0 points if the ball ends up outside the square). The total score achieved on 3 attempts was noted. For fast strength (speed), the athletes sprinted 15 metres, the times were recorded and finally the speed values in m/s were calculated using the space-time formula.

Table 1. Experimental protocol

Before the experimental protocol				After the experimental protocol		
Days	Tests	Parameters evaluated	Training period	Days	Tests	Parameters evaluated
1	Warm up 10' (rest 2') Finalization test (rest 5') Speed ladder Test	Shot accuracy Speed	Eight weeks of HIIT protocol training	1	Warm up 20' (rest 2') Finalization test (rest 5') Speed ladder test	Shot accuracy Speed
2	Rest			2	Rest	
3	Warm up 20' (rest 2') Abalakov JS test (rest 5') Passages ball test	Explosive Strength Passage accuracy		3	Warm up 20' (rest 2') Abalakov JS test (rest 5') Passages ball test	Explosive Strength Passage accuracy
4	Rest			4	Rest	
5	Warm up 15' (rest 2') Cooper test	Endurance		5	Warm up 15' (rest 2') Cooper test	Endurance
6	Rest			6	Rest	
7	Rest			7	Rest	

Finally, on the fifth day, endurance strength was assessed using the yo-yo endurance test. Using a conversion table (Bangsbo, 1997), VO_2 max levels were derived.

After the incoming tests the players underwent an 8-week training protocol. The players trained 3 days a week for about 1 hour and 15 minutes per session. On each day, there was a low-intensity warm-up phase lasting 20 minutes, a middle phase with a HIIT protocol lasting about 25 minutes, and a cool-down phase lasting about 20 minutes.

Table 2 shows the structure of a typical training session developed for the study.

In the first mesocycle (4 weeks), after the warm-up phase, the players underwent HIIT training lasting 27 minutes, followed by defatigue.

The training in the first mesocycle (Table 3) was structured as follows: seven training stations were set up on the pitch, four for developing strength and one for shooting.

At each station there are two players, who, when the instructor gives the go-ahead, start to perform their exercise.

The exercise must be completed as many times as possible in 1 minute, which allows the players to work at a maximum intensity of between 75 and 90% of VO_2max .

Table 2. Structure of the training session

Phase	Exercises	Sets	Rest between exertations	Exercitation duration	Rest between series	Phase duration
Warm up	Neuro-muscular activation Core Ability and core stability Dynamic stretching				60"	20'
Core Phase	Circuit with 5 exertations (alternating work phases of 60" at 75-90% of VO_2max with active recovery of 30")	3	30"	60"	60"	23'10"
Final phase	Low intensity exercise Stretching					20'

Table 3. Structure of the first 4-week mesocycle

Exercise	Equipment	Description
1	3 cones	The 3 cones are placed along a straight line 10 meters apart. the subject sprints from the first to the second cone, stops and sprints from the second to the third cone, stops and sprints back
2	4 hoops, 1 cone	Four circles have been placed on the ground in a staggered manner and a cone at a distance of 10 meters, the subject performs a monopodal lunge inside the circle, with a hop inside the next circle and lunge with the opposite foot, at the end of the circles perform a sprint of 10 meters
3	1 trampoline, 1 cone, 1 hoop	The trampoline and hoop were placed close together and the cone 10 meters away. The subject performs a bipodal jump on the trampoline, lands inside the hoop, and sprints to the cone;
4	4 obstacles 50cm high, 1 cone	The four obstacles have been positioned at a distance of 50 cm from each other and the cone at a distance of 10 m. the subject performs a series of 4 bipodal jumps to overcome the obstacles and immediately after performs a sprint towards the cone
5	1 ball	The subject passes the ball to a teammate who performs a support pass or a high pass, after which the subject kicks the ball into the goal, either by stopping the ball or kicking it directly.

Table 4. Structure of the second 4-week mesocycle

Exercise	Equipment	Description
1	1 speed ladder, 1 cone	A speed ladder of 2.5 meters and 6 spaces and a cone at 6 meters distance from the last space has been placed. the subject performs several gaits on the speed ladder and makes a sprint towards the cone
2	2 obstacles, 1 cone	Two obstacles have been placed on the ground parallel to each other at a distance of 50 centimeters and a cone at a distance of 6 meters. the subject positioned between the two obstacles, performs jump with passage over the obstacle on the right, then returns to the center and performs jump over the obstacle on the left, returns to the center and shoots towards the cone
3	2 sticks, 1 cone	The two rods were placed 50 centimeters apart, and a cone 6 meters away. Subjects positioned themselves before the two rods, performed a single-footed jump between the rods, once they had passed both, returned between the two rods, and then sprinted toward the cone.
4	4 football goals in different colours (1.2×0.8 m), 2 cones 1 ball	Two cones are placed 6 metres apart and the goals on a line 10 metres away from the second cone. The subject leads the ball with his feet from one cone to the other, after which he tries to hit the goal of the colour indicated by the coach.
5	8 cones 1 ball 1 football	The players pass the ball to the instructor who makes a support pass, the players then receive the ball and afterwards either pass it to the small door in the centre of the field goal or throw it to one of the two squares in the corners of the field.

The training in the second mesocycle (Table 4) was structured as follows: four stations for the development of quickness and fast strength, one for the improvement of dribbling, passing and quickness, two for the improvement of passing and receiving.

Statistical analysis

Data were represented as mean $\pm$ SD. The Shapiro-Wilk normality test revealed that all recruited data were normally distributed. Within-group differences in psychophysiological responses between pre- and post-protocol results were assessed using the paired sample t-test. Statistical analyses were performed using SPSS software. The level of statistical significance was set at $p \leq 0.05$.

Results

Table 5 shows that there were improvements in all the parameters tested after the period of training with the HIIT protocol. These improvements, as shown in Table 6, are significant ($p \leq 0.05$) in all the parameters tested.

Discussion

The aim of the study was to investigate whether an 8-week HIIT protocol training intervention adapted to football could bring about significant improvements in quantitative parameters (aerobic power, explosive strength, speed) and qualitative parameters of accuracy (in passing and finishing) in young male footballers. The results demonstrated

Table 5. Test results

N=16	VO ₂ max (ml/min/kg)		Abalakov JS Test (cm)		Speed ladder Test (seconds)		Finalization (score)		Passages (score)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	38,10 $\pm$ 3,92	42,31 $\pm$ 5,36	39,1 $\pm$ 3,38	42,37 $\pm$ 3,97	2,78 $\pm$ 0,35	2,33 $\pm$ 0,39	20,19 $\pm$ 3,49	23,25 $\pm$ 4,42	9,06 $\pm$ 2,98	11,56 $\pm$ 2,85

Table 6. T-test results for paired samples

Paired Samples Test									
Paired Differences									
Indicators		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Abalakov pre –post	-3.26875	.96728	.24182	-3.78418	-2.75332	-13.517	15	.000
Pair 2	VO ₂ max pre - post	-4.20750	1.57363	.39341	-5.04603	-3.36897	-10.695	15	.000
Pair 3	Speed ladder pre –post	.45438	.05933	.01483	.42276	.48599	30.636	15	.000
Pair 4	Finalization pre –post	-3.06250	1.38894	.34724	-3.80262	-2.32238	-8.820	15	.000
Pair 5	Passages pre –post	-2.50000	.81650	.20412	-2.93508	-2.06492	-12.247	15	.000

the effectiveness of the protocol, with improvements in every parameter tested.

The results of the study with regard to quantitative aspects are consistent with other previous studies. In a study by Sperlich et al. (2011), it was shown that the 5-week HIIT protocol in youth and adult football improves oxygen uptake (VO_2) and thus performance. The study involved a sample of 19 male football players with an average age of 13.5 ± 0.4 years. The $\text{VO}_{2\text{max}}$, after the HIIT protocol applied, increased significantly (7.0%) from pre to post. Another more recent study (Arslan et al., 2020), which compared the results of two training protocols on two samples of football players with an average age of 14.2 ± 0.5 , showed significant improvements in $\text{VO}_{2\text{max}}$ levels between pre- and post-training. In addition, the same study found significant results in repeated sprinting as well as other parameters. However, these studies reviewed emphasised the quantitative aspects, leaving out the qualitative ones. The integration of both parameters is the fundamental prerequisite for an optimal performance level (Nelson & Groom, 2012; McCullagh et al. 1990).

Our study sought to investigate the effects of HIIT on these characteristics. And, indeed, improvements determined by the protocol were evident. The improvement in shooting and passing accuracy observed in this study is probably also attributable to a better physical condition achieved through the protocol used, which indirectly contributed to improving these aspects. The fitter athlete generally has a higher tolerance to the effects of fatigue, both central and peripheral (Bartolomei et al., 2017; Noakes, 2012) and, therefore, has a higher level of concentration that allows him to complete motor tasks with precision and effectiveness.

One of the main limitations found in the present study is the relatively small sample size of young male footballers. For this reason, our results may not be generalised to players of different sexes, levels or age groups. Another limitation is represented by the choice of only some of the parameters that may affect the performance of the young footballer. Therefore, further studies could broaden the knowledge on the topic by selecting larger samples and choosing additional parameters that adequately address the needs of footballers according to age, level, gender and role.

Conclusions

In conclusion, this study has increased knowledge of the effects of the HIIT protocol on the performance of young football players. The statistical analysis confirmed the initial hypothesis of a significant improvement in the performance capacity of the subjects. Therefore, the results suggest that athletic trainers and coaches can effectively use this methodology to improve the performance levels of young footballers not only in strength-related aspects, but also in the characteristics of accuracy in passing and finishing. The improvement of these aspects is probably linked to the better physical condition that athletes achieve through this training protocol. Further future studies will aim to investigate this issue.

Conflict of interest

All authors have declared no conflict of interest.

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ПОКРАЩЕННЯ ЯКІСНИХ ТА КІЛЬКІСНИХ АСПЕКТІВ СПОРТИВНОЇ ПІДГОТОВКИ ЮНИХ ГРАВЦІВ ШЛЯХОМ ВИСОКОІНТЕНСИВНОГО ІНТЕРВАЛЬНОГО ТРЕНУВАННЯ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

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Мета дослідження. Однією з найбільш широко використовуваних методологій тренувань у футболі є високоінтенсивні інтервальні тренування (ВІТ), спрямовані на підвищення показників за допомогою тренувальних занять, що характеризуються вправами, які передбачають змінну інтенсивність навантаження у відсотках. Хоча є дослідження, які демонструють ефективність ВІТ у покращенні кількісних аспектів, тобто різних проявів сили, існує не так багато досліджень, які свідчать про таку ж саму ефективність у покращенні якісних компонентів, тобто елементів, пов'язаних з точністю конкретних футбольних рухів.

Метою дослідження було перевірити, чи може застосування конкретного протоколу ВІТ у футболі протягом певного періоду бути однаково ефективним для одночасного покращення компонентів кількості та точності.

Матеріали і методи. Проаналізована вибірка складалася з 16 рухових гравців зі спортивного клубу ASD Nuova Antoniana у віці від 14 до 15 років. Досліджувані приймали

участь у мезоциклі тренувань тривалістю 8 тижнів, з використанням методології ВІТ. До та після цього періоду збиралися дані за допомогою батареї тестів, спрямованих на оцінку швидкісної, вибухової сили, швидкісно-силових якостей, а також навичок передачі та удару: параметри, пов'язані з проявом сили, оцінювалися за допомогою кількісних тестів, призначених для кожного параметру; навички передачі та удару оцінювалися за допомогою тестів на влучність (від 0 до 4 балів за влучністю).

Результати. Результати показали покращення за всіма перевіреними параметрами ($p \leq 0,05$). Таким чином, ефективність протоколу у покращенні футбольних показників кількості та точності підтверджено.

Висновки. Дане дослідження розширило знання про вплив ВІТ на результативність молодих футболістів.

Ключові слова: високоінтенсивне інтервальне тренування, тренування з футболу, футбольна техніка, рухові навички.

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