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EFFECT OF PERIODIZED INTERVAL TRAINING IN COMBINATION WITH EXPLOSIVE STRENGTH AND SPEED IN GAME-LIKE SITUATION ON AGILITY AND HIGH INTENSITY AEROBIC CAPACITY OF YOUTH SOCCER PLAYERS

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Study purpose. High-intensity aerobic capacity (HIAC) is essential for soccer players because they have to perform sprints of short duration in the shortest possible time. At the same time, they need to quickly change direction with and without the ball, which requires agility. The purpose of the study was to investigate the effect of a periodized (8-week) training plan that combines interval training (IT), explosive strength (ES), speed, and game-like situations on agility and HIAC in youth soccer players.

Materials and methods. This research is an experimental study in which the population was male youth soccer players (N = 23) (aged 16.7±2.1). The Arrowhead Agility Test and the HIAC Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) have taken the pre- and post-data of agility. By using the formula for YYIR1 test: VO_2max (mL kg^{-1} min^{-1}) = IR1 distance (m) × 0.0084 + 36.4, we get an estimation of the volume of maximum oxygen consumption (VO_2max). The data analysis used a t-test at 0.05% as the significance level.

Results. Based on the results, the mean of the pre-tests in agility, YO-YO IR1, and VO_2max showed 17.911, 14.8100, and 55.25510. After training for eight weeks, there was an improvement: the mean showed 16.667, 15.9750, and 60.06960. As per the results of the data on the hypothesis in the study, it was found that there was a significant effect of periodized IT in combination with ES and speed on agility performance and HIAC of the youth soccer players.

Conclusions. There was a significant effect of periodized IT in combination with ES and speed on improving youth soccer players' agility performance and HIAC.

Keywords: interval training, explosive strength, high intensity aerobic capacity, agility and VO_2max.

Introduction

Soccer is a high-intensity intermittent exercise based on repeated short sprints within short breaks. It also comprises ES, useful for executing actions like jumping, kicking, and sprinting. Modern soccer is an energy-demanding sport, with the ability of players to repeat high-intensity actions during the game likely being of paramount importance for success (Helgerud et al., 2001). Training sessions in modern soccer are done in game-like situations, from simple to complex, so that players get the same amount of load that they get in the competition. This form of training can be used as a substitute for common running fitness drills because of the similarity of its effect on aerobic capacity levels (Hill-Haas et al., 2009). Developing skills and tactics are as essential as raising physical capacity levels. Therefore, young soccer players should use this form of practice. Games with a greater number of players and a larger surface area are applied to develop soccer-specific skills, which involve high-precision performance. The intensity of the training session depends upon the pitch area, number of players, coach encouragement, and rule modification (Rampinini et al., 2007).

Soccer includes intermittent loads from high to lower intensities (Aguiar et al., 2008). The varying nature of the sports gives rise to rapid changes in oxygen uptake during the training and the match (Helgerud et al., 2001), averaging 70–80% of VO_2max with a covered distance of about 10-12 km (Aguiar et al., 2008) at a mean intensity close to the

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anaerobic threshold. Within this context, recent studies have verified the importance of intensive aerobic training in soccer players in improving the VO_2max, considered the most important parameter of HIAC.

Decision-making and change of direction require good physical and perceptual abilities (Gabbett & Benton, 2009). The ability to change direction quickly is called agility; measuring basic and sports-specific physical ability is important in recreation and sport (Hribernik et al., 2021). Physical coordination, speed, and balance skills are called agility (João et al., 2014). A good football player requires ES and speed to change direction quickly and efficiently.

Periodization is a superior method for developing an athlete's peak performance. The training for soccer players should be periodized as per game-like situation training sessions, with appropriate recovery in between the sessions. The game-like situation drills are mainly small-sided games (SSGs). For physiological and motor enhancement, SSG can be used as a daily training tool (Santos, 2021). Coaches can improvise the SSGs according to their requirements in the training session. Several studies (Köklü, 2012), (Little & Williams, 2007) have confirmed that during SSGs within a 3vs3 form, the highest intensity can be achieved when the player's pitch area ranges from 60 to 125m^2. The important aspect of playing SSGs is that power and anaerobic endurance in soccer players can be developed in addition to HIAC. These benefits are allotted to the repetitions of short and long runs alternating with recovery, which could be active or passive in soccer (Nédélec et al., 2013). For planning the training of the youth players, there is a need to pay specific attention at this age so that significant improvement can be attained within a short period of time. Few studies have analyzed the influence of ES, SSGs, or interval-running training on sports-specific skills in soccer players (Owen Adam et al., 2004).

Soccer players need more ES and speed to execute the skills and to overcome the load (ball or opponent) in the shortest possible time; at the same time, they must execute them in the condition of fatigue, which arises from quickly changing directions (agility) and continuous sprints with skill execution; for that, they require more HIAC. Therefore, the study's main aim was to determine the effect of periodized IT in combination with ES and speed in a game-like situation on agility and HIAC in youth soccer players. It was hypothesized that IT, combined with ES and speed in a game-like situation, would significantly improve agility performance and HIAC in youth soccer players.

Materials and methods

Study participants

A total of 23 players participated in the experiment. Three players were excluded from the study because of health problems and absences during training. Consequently, 20 players were analyzed (Table 1). All the players belong to the same team and have at least five years of playing experience. In the sample selection process, participants were randomly selected for the treatment group in which the pre- and post-effects of the experiment were recorded. Before the implementation of the experiment, written consent was received from all participants and guardians.

Table 1. Physical Characteristics of the subjects

Characteristic	Mean ± SD	N
Age (y)	16.7±2.1	20
Mass (Kg)	62.7±8.69	20
Height (cm)	170.0±6.23	20

Study organization

The experiment was conducted during the mid-season of a one-year periodization cycle. Weather: moderate winter (October–November). The experimental program's training was integrated with the standard regime of the team. The group underwent weekly high-intensity interval training, then ES, speed, technical, and tactical training in game-like scenarios. On the last day of the week, a match was organized. After the completion of a warmup by participants, which lasted for 20 minutes per session and was followed by 5 minutes of passive stretching, the interval training was performed for 40 m in a 6" run for 6 times 18" rest, and after rest for 2 min SSGs of 8 vs. 8 (80×50 m) 2 games 8 min play 2 min rest. The character of the SSGs was two touches per player so that player had to move quickly after the ball was passed for support. Each week, the load progressed through SSGs and interval training (Table 2). Moreover, coaches motivated the players to engage maximally during the SSGs.

Table 2. Proposed training plan of 8-week exercise intervention for selected participants

Monday	Endurance – 40 m in 6" run for 6 times 18" rest and 8 vs 8 (80 m × 50 m) 2 games 8 min play 2 min rest.
Tuesday	Passing and receiving technique-break the wall, cross the water and 1 vs 1 with 2 goals.
Wednesday	Explosive strength-jump squats, alternating lunge jumps 4-6 sets of 20-25 reps,1vs1 body covering.
Thursday	Speed – Sprints, Backpedal Repeats, Lean Fall and Sprint, with the ball catching the opponent.
Friday	Passing receiving and turning technique- cross the water, 3 vs 3 with 2 goals.
Saturday	Match
Sunday	Rest

The progression of the load was done after each week in Interval training, ES, Speed training

Because of the high intensity of the test, participants were asked to rest properly before the pre-data collection. A proper warmup was done, and all necessary information was conveyed to participants about the Arrowhead Agility and Yo-Yo Intermittent Recovery Test Level 1 (YYIR1). During the day, a test was conducted, and after that, those participants participated in 60 minutes of low-intensity skill training.

The Arrowhead Agility Test measured speed, explosion, body control, and the ability to change direction at various angles and directions. Before starting the test, participants completed their warmup and stretching. The test was conducted on artificial turf. Each participant was allowed to complete two paths; one left and one right, with a minimum of two minutes' rest. The test result is how long it

takes to complete the test for the left and right (Arrowhead Agility Test: Right + Left = Result). If a participant steps on the cone, it is considered invalid; participants must run around the cones.

The YYIR1 Yo-Yo intermittent recovery test measured the participant's ability to perform high-intensity aerobic work. Before the start of the test, participants completed their warmup and stretching. The test was conducted on artificial turf. Each participant was allowed to make only two consecutive failed attempts before they were withdrawn from the test. Once withdrawn from the test, the individual's score was recorded. The VO_2max was calculated by using the formula: YYIR 1 test: VO_2max (mL kg^{-1} min^{-1}) = IR1 distance (m) × 0.0084 + 36. VO_2max is considered to be the most important parameter of HIAC.

Statistical Analysis

Basic results are presented as descriptive statistics' mean and standard deviation (M±SD). The 20th version of SPSS was used for all types of statistical analysis. All the data sets were processed through SPSS for normality assessment using the Shapiro-Wilk test (table 1). A paired t-test was applied (because the data were found to be normally distributed) to analyze the post-effect of periodization; IT combined with ES and speed training. The level of significance was set at 0.05.

Results

Periodized IT combined with ES and speed significantly increased agility and HIAC in youth soccer players. Table 3 shows that the group mean of agility, IR1, and VO_2max pre- and post-data are significantly different ($p<0.05$). The percentage increase in pre- and post-difference in mean in the Agility, IR1, and VO_2max groups was recorded as 7.19%, 7.86%, and 8.71%, respectively, reflecting the enhancement of Agility performance from 17.911 to 16.667 and the increase in IR1 from 14.8100 to 15.9150 and VO_2max from 55.25510 ml × kg^{-1} × min^{-1} to 60.0690 ml × kg^{-1} × min^{-1}. HIAC-YYIR1 has been seen as a valid and reliable predictor of HIAC and VO_2max.

Table 3. Shapiro-Wilk test of normality for all pre and post data sets

Indicator	Statistic	df	Sig.
Pre data YO YO IR1	0.889	20	0.066
Post data YO YO IR1	0.908	20	0.059
Pre VO_2max	0.848	20	0.055
Post VO_2max	0.913	20	0.074
Pre Arrow Head agility test	0.948	20	0.331
Post Arrow Head agility test	0.926	20	0.067

Concerning Table 3, the normality assumption is thoroughly satisfied for the given data set as indicated $p>0.05$. As per the common agreement, the p-value obtained for test statistics should be higher than 0.05 if the significance level is set at 0.05. In this case, the Shapiro-Wilk test statistics of all concerned data are equal to or greater than 0.05. Thus, the given data is appropriate for further processing and is normally distributed.

In Table 4, the basic output of the concerned variables has been reported systematically. Mean, SD, minimum, maximum, skewness, and kurtosis have been presented. In particular, the recognized rule of thumb for a data set to be considered normal is that the associated test statistics should not be greater than twice its standard error in cases of skewness and kurtosis; the present dataset satisfies this assumption too.

Table 5 presents the results of two t-tests in the 2nd and 3rd rows. The first test compares the pre- and post-data of the Yo-Yo IR1 test. This output confirms that the mean of the pre-data differs significantly from the mean of the post-data

Table 4. Descriptive Statistics showcasing basic information regarding participants score in YOYO IR1 and VO_2max tests

Indicator	N	Min	Max	Mean	SD	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Pre data YO YO IR1	20	13.40	16.60	14.8100	0.84909	0.898	0.512	0.381	0.992
Post data YO YO IR1	20	14.80	17.40	15.9750	0.73619	0.447	0.512	-0.886	0.992
Pre_VO_2max	20	51.284	63.252	55.25510	3.591699	1.002	0.512	0.583	0.992
Post_VO_2max	20	55.636	66.516	60.06960	2.949532	0.604	0.512	-0.444	0.992
Pre Arrow Head	20	16.63	19.23	17.911	0.711	-0.293	0.512	-0.657	0.992
Post Arrow Head	20	16.12	17.89	16.667	0.435	1.002	0.512	1.630	0.992
Valid N (listwise)	20								

Table 5. Output of t-test showcasing proof of observed mean differences

		Paired Differences				
S.N	Pair name	Mean	SD	Std. error of mean	t	Sig. (2-tailed)
Pair 1	Pre data YO YO IR1 – Post data YO YO IR1	-1.165	0.382	0.085	-13.607	0.000
Pair 2	Pre_VO_2max – Post_VO_2max	-4.814	2.836	0.634	-7.591	0.000
Pair 3	Pre data Arrow Head Agility – Post Data Arrow Head Agility Test	1.24	0.460	0.103	12.065	0.000

Table 6. Paired Samples Statistics

	Indicator	N	Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre data YO YO IR1	20	14.8100	0.84909	0.18986
	Post data YO YO IR1	20	15.9750	0.73619	0.16462
Pair 2	Pre VO_2max	20	55.25510	3.591699	0.803128
	Post VO_2max	20	60.06960	2.949532	0.659535
Pair 3	Pre Arrow Head	20	17.9110	0.71144	0.15908
	Post Arrow Head	20	16.6675	0.43510	0.09729

(p.000<0.05). The second row is concerned with observing the effect of training on the VO_2max capacity of soccer players. In Table 5, it is evident that, due to the following of the training program, both means differ significantly from each other. The third row is concerned with observing the effect of training on the agility performance of soccer players. In Table 5, it is evident that, due to the following of the training program, both means significantly differ from each other.

In Table 6, it is visible that the mean of the pre-data in both pairs is less than the mean of the post-data. Thus, the selected training program is effective in both pairs as long as the results of Table 3 are valid.

Discussion

The study aimed to compare the pre- and post-effects of eight weeks of periodized IT in combination with ES and speed in game-like situations (SSG) on agility and HIAC in youth soccer players. It was concluded that high-intensity interval training, realized in two forms (running and SSGs) in combination with ES and speed, would significantly improve the agility and HIAC of youth soccer players. Moreover, we hypothesized that periodized IT in combination with ES and speed in a game-like situation would improve the agility and HIAC of youth soccer players. The result of the present study supports this hypothesis with p.000>0.05.

The two most important factors influencing the effectiveness of the performance of the soccer players were noted as the load and recovery during and after the training session. However, these factors are difficult to measure in soccer because of the limited form of individualization during and after training. Thus, periodization is useful in determining the appropriate load and recovery, and weight training is more effective. Table b shows the proposed plan for one-week microcycle periodization for youth soccer players. (Balsom P, Lindholm T, Nilsson J, Ekblom B. Precision Football. Kempele, Finland: Polar Electro Oy. 1999., n.d.) Revealed that continuous exercise without a ball (intermittent exercise at 100% VO_2max) and 4 vs. 4 SSG will have a similar effect on HIAC.

Moreover, (Dupont & Berthoin, 2004) contemplates that for developing VO_2max, intermittent exercise at 120% of VO_2max for 15–15 sec is the most effective form of IT. The training load applied to the players during the 6–6 sec and increased after each week in combination with ES and speed in our study turned out to be significantly improving HIAC. (Dellal et al., 2008) Assert that if there is appropriate load application, it plays a crucial role in aerobic capacity development. Appropriate loads can be given through periodization.

It has been examined in several studies that IT, in combination with ES and speed, is effective in developing the agility performance of youth soccer players. (Mathisen & Pettersen, 2015) has concluded that the agility performance of 10-year-old soccer players is increased through short bursts of high-intensity IT. Training ES and speed helps a player develop the ability to execute a quick takeoff from a stationary or slow-moving position, a quick change in direction, and cover the distance in the minimum possible time. ES training, or plyometric training, considerably increases the agility of elite basketball players (Huang et al., 2023). (Fajrin et al., 2018) It has been concluded that agility performance can be improved by high-intensity IT.

Several studies have examined this phenomenon. However, no consensus existed regarding the effectiveness of different forms of SSG or IT on physical capacity. Some coaches prefer SSG, but others practice both forms equally, as in our study. We believe this split results more from the coach's philosophy and experience than from scientific reasons.

Using other explosive and speed exercises in the IT periodic program is very convenient and effective in improving agility and HIAC. (Michailidis, 2022) This study agrees that a short-term IT program can improve sprint and repeated sprint ability performance, i.e., HIAC, in soccer players. The results are consistent with previous studies such as (Naimo et al., 2015), which called IT in combination with ES has a positive effect on performance in Ice hockey players reveals the same thing that IT is able to provide a significant improvement to the HIAC of athletes. (Astorino et al., 2012) Concluded that IT workouts can improve endurance and increase agility and speed in athletes.

Conclusions

The current study suggested that IT, combined with ES and speed, enhanced youth soccer players' agility performance and HIAC. The study proves that the preparation of a good periodized program has a significant effect on improving the performance of players. Coaches may use a combination of both without the ball and with the ball IT in game-like situations in combination with ES and speed in their periodic training plan to develop agility, HIAC, and soccer-specific skill development. To maximize external validity, more experiments need to be conducted in which participants from different regions of the world are encouraged to participate. The present study encourages future researchers to conduct related studies with a larger sample size using precise tools for measuring data.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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ВПЛИВ ПЕРІОДИЗОВАНИХ ІНТЕРВАЛЬНИХ ТРЕНУВАНЬ У ПОЄДНАННІ З ВИБУХОВОЮ СИЛОЮ ТА ШВИДКІСТЮ В ІГРОВІЙ СИТУАЦІЇ НА СПРИТНІСТЬ ТА ВИСОКОІНТЕНСИВНІ АЕРОБНІ МОЖЛИВОСТІ ЮНИХ ФУТБОЛІСТІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 4 табл., 4 рис., 20 джерел.

Мета дослідження. Високоінтенсивна аеробна здатність (ВІАЗ) є важливою для футболістів, оскільки вони мають виконувати короткі спринт-забіги за найкоротший час. При цьому їм потрібно швидко змінювати напрямок із м'ячем і без нього, що вимагає спритності. Метою дослідження було вивчити вплив періодизованого (8-тижневого) плану тренувань, який поєднує інтервальні тренування (ІТ), вибухову силу (ВС), швидкість та ігрові ситуації на спритність і ВІАЗ у юних футболістів.

Матеріали та методи. Це дослідження є експериментальним дослідженням, у якому вибірку складали юні футболісти чоловічої статі (N = 23) (віком 16,7±2,1 року). Дані про показники спритності були зібрані на етапах попереднього та підсумкового тестування в тесті на спритність під час бігу зі зміною напрямків за стрілоподібною траєкторією та в тесті Йо-йо з переміжним відпочинком (рівень 1) (YYIR1) на ВІАЗ. Використовуючи формулу для тесту YYIR1: VO_2max (мл кг$^{-1}$ хв$^{-1}$) = відстань переміжного відпочинку IR1 (м) × 0,0084 + 36,4, ми отримуємо оцінку об'єму максимального споживання кисню (VO_2max). Для аналізу даних використовували t-критерій Стьюдента за рівня значущості 0,05%.

Результати. На підставі одержаних результатів, середні значення попередніх тестів на спритність, YYIR1 на ВІАЗ та VO2max становили 17,911, 14,8100 та 55,25510. Після тренувань протягом восьми тижнів спостерігалося покращення: середні значення становили 16,667, 15,9750 та 60,06960. Відповідно до результатів даних щодо гіпотези, висунутої в дослідженні, було встановлено наявність статистично значущого впливу періодизованих ІТ у поєднанні з ВС та швидкістю на показники спритності та ВІАЗ юних футболістів.

Висновки. Спостерігався статистично значущий вплив періодизованих ІТ у поєднанні з ВС і швидкістю на покращення показників спритності та ВІАЗ юних футболістів.

Ключові слова: інтервальні тренування, вибухова сила, високоінтенсивна аеробна здатність, спритність та максимальне споживання кисню (VO_2max).

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