



The Effects of Football Training on Improving Aerobic Skills, Technique, and Anthropometry in Goalkeepers

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Abstract

Objectives. The study aimed to assess the impact of football training, particularly for goalkeepers, on children's motor skills and aerobic capacity over a 10-month period.

Materials and methods. This experimental study focused on evaluating the specific skills of goalkeepers and the aerobic capacities of children who took on the role of goalkeeper after undergoing training. The study involved totally 20 individuals aged 10-14 who played as goalkeepers and who were part of the entire population trained at the Real Madrid Foundation UNY Football School. The changes in the goalkeeper's aerobic capacity, reaction speed, and diving, as well as anthropometric measurements were found in the study. The instruments used for this research included a multi-stage fitness test, a test of the goalkeeper's reaction and diving skills, as well as height and weight measurements. The data analysis technique used was the t-test to determine differences in variables between the pretest and post-test, with a significance level of less than 0.05 ($p < 0.05$).

Results. The results revealed significant improvements in aerobic endurance ($p = 0.004$), reaction ability ($p = 0.007$), and goalkeeper diving ($p = 0.002$) after 10 months of football training. However, there were no significant changes in height, weight, and BMI, as the p value was greater than 0.05.

Conclusions. These findings have important implications for evaluating goalkeeper training programs and provide a basis for recommending more effective ones.

Keywords: goalkeepers, aerobics, reaction speed, anthropometry.

Introduction

The goalkeeper plays a crucial role in a football match, being one of the last players defending the team's goal from opponent attacks. Apart from preventing the ball from entering the goal, the goalkeeper also leads and organizes the team's defense and coordinates with other players on the field (Katanić et al., 2021). Over the years, goalkeeping has gained immense respect in the world of football, as demonstrated by the many famous goalkeepers who have achieved awards and set records in their careers. After Euro 1992, several football match rules changed, including the prohibition of back passes to the goalkeeper, emphasizing the need for

modern goalkeepers to have exceptional ball control skills. During a match, goalkeepers perform various techniques, such as making saves (41.6%), stopping the ball with their feet (27.8%), parrying the ball (12.6%), and executing flying movements (10.3%) (Rebello-Gonçalves et al., 2017). Despite this, the goalkeeper position is often overlooked in sports science research, and a multidisciplinary scientific approach is required to understand the talent scouting process (Knoop et al., 2013). The physical and technical abilities of young goalkeepers must be carefully considered when identifying special talents, as highlighted in the 2014 FIFA reports and statistics in Brazil, emphasizing the importance of the training process for junior and senior goalkeepers (Muracki, 2020).

While all players have the potential to act as a goalkeeper during a match, specific conditions are required (FIFA, 2022). The abilities of a goalkeeper differ significantly from those of other players on the team, as they also play a crucial

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role in organizing both slow attacks from behind and fast counterattacks (Parada & Vargas, 2020). The ability to concentrate, perceive the target of the kick and anticipate a player's kicking style are essential for a goalkeeper to effectively defend the goal (Wood & Wilson, 2010). Goalkeepers must possess the skills to read and react to these dynamic situations, requiring a high level of alertness during a game (Jarraya et al., 2014). A goalkeeper's decision-making abilities are central to their training (F. W. Otte et al., 2020), and aside from strong physical and technical attributes, mental capabilities are also crucial. These mental abilities include understanding how to approach penalty kicks, controlling the tempo to disrupt the opponent's concentration, and generating momentum for the team (Furley et al., 2017).

Aerobic endurance is a fundamental requirement for every sport, including football, especially considering the long durations and expansive fields involved (Hardinata et al., 2021). International soccer players typically exhibit aerobic endurance levels ranging from 50 to 75 ml kg/min, highlighting its significant contribution to players' overall quality (Jemni et al., 2018). The continuous 90 minutes of football gameplay heavily relies on the aerobic energy system (Dzimbova & Ivanov, 2023), emphasizing the critical nature of maintaining aerobic endurance throughout the season (Kalinowski et al., 2021). Aerobic exercise plays a vital role in enhancing heart function in young children (Suarez-Tijeras et al., 2023), and conflicting data exists in early childhood regarding approaches to aerobic endurance training, as highlighted in research by Charalampos et al. (2013). Without adequate aerobic endurance, soccer players may struggle to sustain their performance for the full 90 minutes of a match, underscoring the pivotal role of aerobic endurance in determining overall performance (Gonçalves, Clemente, Barrera, Sarmento, González-Fernández, Rico-González, et al., 2021).

Anthropometry involves the study of the size and proportions of the human body and their correlation with physical performance. Within sports, anthropometry is commonly utilized to identify factors that can impact an athlete's overall performance. In the context of football, anthropometry holds particular significance for the goalkeeper position, which demands physical strength and effective body coordination. Studies focusing on the anthropometry of goalkeepers have revealed that factors such as height and arm-to-body ratio can significantly influence their ability to defend the goal. Furthermore, human body proportions play a pivotal role in shaping team performance and the specific positions played (Karakaş et al., 2011). An understanding of anthropometry holds the potential to markedly influence performance in the field. The growing body of research in the field of anthropometry is indicative of the increasing emphasis placed on this area of study (Kaplánová et al., 2020).

Materials and Methods

Study Participants

This research employed an experimental one-group pre-test and post-test design to assess the development of technical abilities, aerobic endurance, and anthropometric changes following 10 months of football training, with a specific fo-

cus on goalkeepers. The study involved 20 goalkeepers aged 10-14 who underwent training at the Real Madrid Foundation Football School, Yogyakarta State University (UNY). All participating students received detailed information and provided written consent, signed by both the students and their guardians, consenting to their inclusion as research subjects.

Measurement

Before commencing a series of training programs, the data was gathered regarding the children's physical abilities, technique, height, and weight. The conducted tests encompassed the following: 1) anthropometric measurements, wherein body weight and height were assessed utilizing scales and a stadiometer, 2) measurements of aerobic endurance, which were conducted via a multistage test, 3) measurements of reaction ability to block the ball and diving, which were assessed through evaluations of reaction speed and goalkeeper diving.

Training protocol

Every child undergoes a warm-up session comprising a 3-minute static warm-up followed by a 7-minute dynamic warm-up, featuring movements derived from FIFA's Eleven Plus Movements and sports stretch book texts. Subsequently, each child engages in a 50-minute core training session, encompassing two main parts: 30 minutes of integrated technical training focused on goalkeeper physical skills and 20 minutes of game situation exercises. The goalkeeper training regimen occurs three times a week over a period of 10 months. Additionally, comprehensive class sessions are conducted every two months, providing in-depth explanations of goalkeeping techniques.

Table 1. Duration of each training session

No	Training Composition	Duration
1	Warming-up	10 minutes
2	Core Training:	
3	Physical Integration Technique Training	30 minutes
4	Game	20 minutes
5	Cooling down	5 minutes

Statistical Analysis

The data analysis technique employed in this research includes several key components: 1) Description test involving providing a descriptive summary of the data, 2) normality test, the Shapiro-Wilk test to assess whether the data exhibits a normal distribution; 3) homogeneity test, the Levene's Test with the F test to evaluate the homogeneity of variance, specifically to determine the similarity of variances in the pretest and posttest experimental group data. This test aims to establish if the data distribution (variance) of the two experimental groups is not heterogeneous, ensuring they possess balanced traits or characteristics suitable for comparison (van Breukelen & Candel, 2021). The data distribution (variance) of the two experimental groups is declared

homogeneous if the Levene test results show a significance value of $p > 0.05$; 4) t-test to ascertain differences in variables between the pretest and posttest in the experimental group. A significance value of less than 0.05 ($p < 0.05$) indicates a notable difference. The data from the initial test (pretest) and final test (posttest) are statistically analyzed using the t test within the SPSS version 27 program, with a significance level of 5% or 0.05; 5) Cohen's d test to assess the effect size before and after the intervention. The effect sizes are classified as small (0.2), medium (0.5), and large (0.8) based on the categorization by Hopkins et al. (2009). This comprehensive analytical approach provides a robust basis for evaluating the impact of the intervention.

Results

The Results of the Pre-Test's Descriptive Statistic

Based on measurements of aerobic ability, technique, and anthropometry conducted prior to the training/intervention, descriptive statistical results are presented in Table 2.

Table 2. The results of the pre-test's descriptive statistic (n = 20)

Indicators	Mean	SD	Minimum	Maximum
Height, m	1.52	0.123	1.31	1.71
Weight, kg	49.75	13.42	29.50	71.60
BMI, kg/m ²	21.15	4.55	13.37	29.11
VO ₂ max, ml/kg/min	30.98	6.00	22.20	43.70
Reaction	4.10	1.37	2.00	7.00
Diving	4.70	1.38	2.00	7.00

The Results of the Post-Test's Descriptive Statistic

The following table shows the results of the descriptive statistics after the intervention was given in this study. It can be seen in Table 3 as follows.

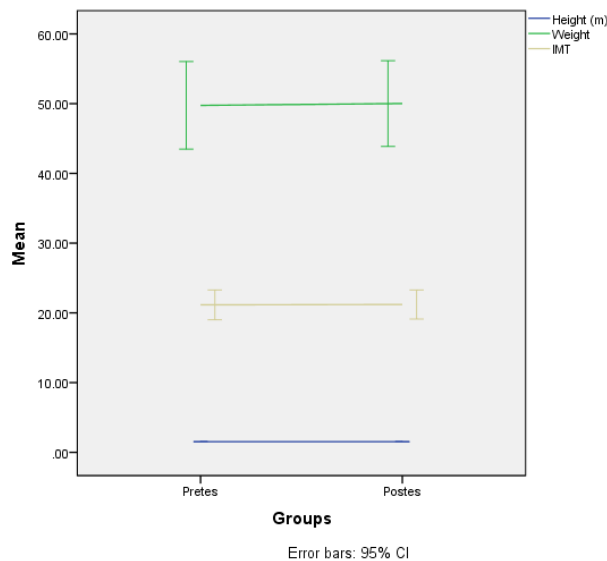


Table 3. The results of the post-test's descriptive statistic (n = 20)

Variables	Mean	SD	Minimum	Maximum
Height, m	1.53	0.121	1.32	1.71
Weight, kg	50.01	13.12	29.50	71.60
BMI, kg/m ²	21.20	4.45	13.20	29.11
VO ₂ max, ml/kg/min	35.75	6.19	24.30	45.30
Reaction	5.45	1.50	3.00	8.00
Diving	6.30	1.71	3.00	9.00

After conducting descriptive statistical tests, it is evident that there has been an increase in all variables. However, further analysis is required to ascertain the significance of these results. The mean value is depicted in the following picture.

The Results of the Normality Test

The normality test using the Shapiro-Wilk test explains that all data are normally distributed because all results obtained a significant value > 0.05 . These results can be seen in Table 4.

Table 4. The results of the data normality test

Indicators	Pre-test		Post-test	
	s-w	p	s-w	p
Height	0.946	0.310	0.944	0.279
Weight	0.945	0.301	0.953	0.420
BMI	0.957	0.479	0.961	0.572
VO ₂ max	0.963	0.605	0.961	0.567
Reaction	0.939	0.233	0.945	0.293
Diving	0.950	0.372	0.953	0.421

The Results of the Homogeneity Test

The homogeneity test uses the Levene Statistic. In Table 5, it is explained that all data are homogeneously distributed because all results obtained a significant value > 0.05 .

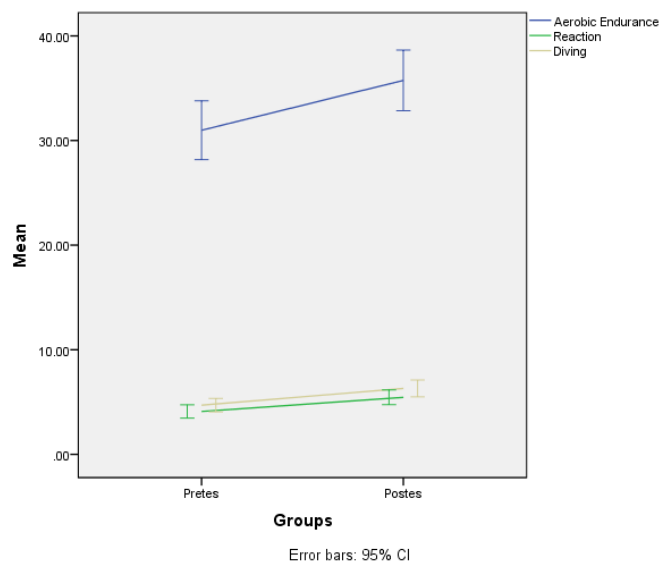


Fig. 1. The mean value is depicted

Table 5. The results of the homogeneity test

Indicators	Levene Statistic	p
Height	0.005	0.945
Weight	0.018	0.893
BMI	0.020	0.889
VO ₂ max	0.106	0.747
Reaction	0.700	0.408
Diving	1.317	0.258

Hypothesis Testing

Once the data has passed the prerequisite test, indicating that all data is normally distributed and homogeneous, hypothesis testing is conducted. The following presents the results of the Paired Sample T-test to address the hypothesis in this research.

Table 6. The results of the hypothesis testing

Variables	Indicators	EG			ES
		Mean	t count	p value	
Anthropometry	Height	0.003	1.831	0.083	0.41
	Weight	0.260	0.806	0.430	0.18
	BMI	0.049	0.396	0.696	0.09
Aerobic Endurance	VO ₂ max	4.770	3.275	0.004	0.73
	Reaction	1.350	3.048	0.007	0.68
Technique	Diving	1.600	3.606	0.002	0.81

Based on the above Table 6, this research found no significant changes in the goalkeeper's weight and height. However, the goalkeeper experienced significant changes in aerobic endurance ($p = 0.004$), reaction technique ability ($p = 0.007$), and diving technique ability ($p = 0.002$) as their P-values were less than 0.05. Upon examining the Effect Size (ES), it is observed that the anthropometric variable shows small changes (small effect), whereas the aerobic endurance and technique variables exhibit large changes (large effect).

Discussion

The study results did not indicate a significant difference between height before and after exercise; however, the average height of children did increase. Typically, height increases by 5 cm per year during the growth period. Growth starts at 0.2 m at birth and reaches 1.73 m in adolescence (Alvear-Vasquez et al., 2023). The growth of children's height is influenced by the hormones estrogen and testosterone, which stimulate bone and body tissue growth. Testosterone plays a significant role in growth for boys. Moreover, genetic factors also contribute to a child's height growth, as the height of both parents can influence the child's height.

Aligned with the research conducted by Mohr et al. (2015), physical activities such as football, swimming, and brisk walking were found to influence bone density, consequently impacting a child's height. Similarly, the study by Larsen et al. (2017) indicated that long-term physical

activity led to high levels of bone mineral content and bone mineral density in the lower limbs of football players.

In general, children between the ages of 10 and 15 will undergo natural height changes as part of their physical development. The final height is influenced by genetic, nutritional, hormonal, and environmental factors. Parents and coaches can offer support and education to facilitate optimal growth. A balanced diet, including sufficient protein, calcium, vitamin D, vitamin C, and iron, plays a crucial role in a child's height. It is important to avoid fast food to prevent obesity. Regular exercise promotes the optimal functioning of growth hormones, while adequate rest also contributes to children's growth.

Anthropometry can significantly impact a goalkeeper's performance in a football match, particularly height. While height is not the sole determining factor for a team's success, it plays a crucial role. Each position on the field possesses distinct characteristics. A goalkeeper's height greatly aids in defending the goal, while tall defenders are adept at thwarting overhead ball attacks and are challenging to bypass. Conversely, height is not a primary consideration for players in other positions. Notably, the French national team, runners-up in the Qatar 2022 World Cup, had an average height of 185.4 cm. It is essential to consider factors that can support the optimal growth of young children and teenagers.

In this study, no significant difference in body weight was observed before and after 10 months of training, with the average body weight ranging from 49.75 kg to 50.01 kg. The most significant weight changes in children typically occur during infancy, while from ages 4 to 10 years, the ideal weight change is 2 to 3 kg per year. From ages 11 to 18 years, this changes to 3 to 5 kg per year. Maintaining an ideal body weight facilitates football players in enhancing speed, agility, and endurance, while also reducing the likelihood of easily sustaining injuries, as opposed to overweight players who are more susceptible to muscle and ligament injuries.

The body weight is influenced by food, exercise, and lifestyle changes, with the food consumed being adjusted to match the expended energy needs. Children need to avoid unhealthy lifestyles, such as staying up late and smoking, to maintain a healthy weight. Regular exercise has a significant impact on children's overweight levels. According to Muracki et al. (2021), goalkeepers sometimes have a higher fat percentage than players in other positions. Maintaining body weight is crucial for agility in movement, speed, and the body's reaction to the arrival of the opponent and the ball. The goalkeeper position requires the player to cover the shortest distance compared to other positions on the field.

Conducting football training over a 10-month period, with three sessions per week, can significantly enhance aerobic endurance, a crucial requirement for the sport. Numerous studies have explored the impact of regular and intensive football training on aerobic endurance. Naser et al. (2017) conducted research indicating that just eight weeks of football training can enhance an individual's aerobic endurance. Similarly, Krustup et al. (2010) found that 12 weeks of football training can notably increase an individual's maximum oxygen capacity (VO₂max), a key measure of aerobic endurance. VO₂max reflects the body's ability to effectively utilize oxygen during physical activity. Furthermore, Dzimbova and Ivanov (2023) have affirmed

that exercise plays a significant role in improving aerobic endurance.

The enhancement of aerobic endurance is influenced by factors such as age, exercise intensity, and duration. Football has been shown to boost lung capacity, enabling increased oxygen intake. Both aerobic and anaerobic endurance play pivotal roles in maintaining physical fitness during football matches and are crucial determinants of victory (Gonçalves, Clemente, Barrera, Sarmiento, González-Fernández, Vieira, et al., 2021). Additionally, these types of endurance contribute to the efficient functioning of the heart in circulating blood throughout the body. Aerobic endurance is particularly vital for football players, as they must sustain their performance over 90 minutes, covering 10-12 km with 70% oxygen intensity. Improving aerobic endurance enhances the heart and lungs' efficiency in supporting physical movements. Football training has been found to enhance endurance (Hoff et al., 2002), thereby improving a player's running distance, intensity, and ball involvement (Helgerud et al., 2001).

Goalkeepers rely heavily on various physical abilities to maintain concentration throughout the match (Lisenchuk et al., 2021). Research by F. W. Otte et al. (2020) emphasizes the need for goalkeepers to develop strength, endurance, speed, coordination, and agility. While goalkeepers may excel in jumping ability, their VO_{2max} might not be as high (Muracki et al., 2021). In football, goalkeepers require strong visual abilities, including spatial awareness, reaction comprehension, and coordination between eyes and limbs (Shafizadeh & Platt, 2012). The physical training of goalkeepers demands a prolonged period to cultivate specific automation and achieve optimal physical adaptation. The degree of physical fatigue and the speed of recovery are greatly influenced by the effectiveness of the training regimen. Hence, coaches must have a deep understanding of how to provide both physical and technical training tailored to the unique demands of goalkeeping (Jara et al., 2019).

The study's findings revealed a significant improvement in goalkeepers' reaction speed following 10 months of training. This aligns with research by Rozi et al. (2023), which emphasizes that agility training can enhance a goalkeeper's reaction speed, a factor influenced by reflexes. A goalkeeper's reaction speed is vital for thwarting opponents' goal attempts, making it essential for goalkeepers to consistently work on enhancing this attribute. The ability to react swiftly is crucial in determining a goalkeeper's proficiency, as it often determines whether they can successfully block the opponent's shots. To improve reaction speed, goalkeepers can engage in specific training exercises, such as practicing turns and stops, training with their back to the ball before swiftly turning to catch it, and working with bouncing balls (Singchainara et al., 2022). Additionally, the development of goalkeeping skills can be facilitated through various visual training methods (Rusu et al., 2011).

A goalkeeper's reaction speed becomes crucial during scenarios such as free kicks, corner kicks, or when the ball is headed towards the goal. Immediate response to a fast-moving ball is essential for the goalkeeper to effectively defend the goal. Engaging in specific warm-up routines, such as simulating match movements, can help goalkeepers enhance their reaction time (Obetko et al., 2020). When facing a penalty kick, goalkeepers must possess the ability to analyze and anticipate the opponent's kicking technique

(Noël et al., 2021). Training for accuracy in predicting and intercepting kicks is a fundamental skill that goalkeepers must continually refine (Dicks et al., 2011).

The goalkeeper position holds significant importance within any football club (F. Otte, 2021). Key elements of goalkeeper techniques encompass the fundamental goalkeeper stance, positioning, as well as the skills to catch and save low and high balls, roll the ball to a teammate, execute kicks, punch the ball, and make throws. Milanović et al. (2012) observed that the most commonly utilized techniques by goalkeepers were saves (41.6%), foot controls (27.8%), clearances (12.6%), and aerial plays (10.3%).

The goalkeeper's role extends beyond defending the goal; they also play a pivotal part in the team's offensive strategies (Struzik, 2020). In addition to possessing exceptional technique, goalkeepers require intelligence, decision-making acumen, and robust physical capabilities. Their distinct ability to utilize their hands in the game contributes to their high and intricate level of uniqueness (F. W. Otte et al., 2020). Goalkeepers must adeptly balance basic football playing skills with the ability to prevent goals. Furthermore, they need specialized proficiency in thwarting penalty kicks (Navarro et al., 2013). The effectiveness of a goalkeeper can be gauged by their adeptness in making saves and securing victories for the team (Montesano, 2016). Understanding a goalkeeper's value necessitates knowledge of their reaction speed and physical condition data.

In formulating conclusions from this study, it is crucial to acknowledge several limitations that could impact result interpretation and the applicability of the findings. Firstly, the study's sample was confined to children aged 10-14 years of training at the Real Madrid Foundation UNY Football School, potentially limiting the extension of the findings to the broader football population. Furthermore, the 10-month training duration may not suffice to observe the long-term effects of football training on anthropometric variables. Other constraints encompass the utilization of measurement methods, such as multistage tests, which may not comprehensively represent overall aerobic capacity. Hence, further research involving larger sample sizes, prolonged training periods, and more sophisticated measurement techniques may be necessary to validate and broaden these findings. Despite these limitations, the study's results still offer a valuable contribution to comprehending the impacts of football training in children, while also indicating avenues for future research in this domain.

Conclusions

Based on the research findings, it is evident that football training spanning a 10-month period yielded noteworthy alterations in aerobic endurance ($p = 0.004$), reaction ability (0.007), and goalkeeper diving technique ($p = 0.002$). Conversely, no significant changes in height, weight, and BMI were observed, as evidenced by p values exceeding 0.05. These discoveries carry substantial implications for assessing goalkeeper training regimens and lay the groundwork for recommending more efficacious training programs. Moreover, these observations underscore the significance of accounting for children's growth phase within the 10-14-year age range, necessitating careful consideration of anthropometric aspects when devising optimal exercise programs.

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Conflict of interest

The authors guarantee that no conflicts of interest exist.

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Вплив футбольних тренувань на покращення показників аеробних навичок, техніки та антропометрії воротарів

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

Реферат. Стаття: 8 с., 6 табл., 44 джерела.

Мета дослідження. Дослідження мало на меті оцінити вплив футбольних тренувань, зокрема для воротарів, на розвиток рухових навичок та аеробних можливостей у дітей протягом 10-місячного періоду.

Матеріали та методи. Це експериментальне дослідження було сфокусовано на оцінці специфічних навичок воротарів та аеробних здібностей дітей, які взяли на себе функцію воротаря після проведення тренувань. Загалом у дослідженні взяли участь 20 осіб віком від 10 до 14 років, які грали на позиції воротаря і були частиною всієї групи, що тренувалася у футбольній школі UNY Фонду «Реал Мадрид». В ході дослідження було встановлено зміни в показниках аеробних можливостей воротаря, швидкості реакції та техніці виконання стрибків за м'ячем (сейв), а також антропометричних вимірюваннях. У дослідженні застосовано такі методики, як багатоступеневий фітнес-тест (човниковий біг), тест на визначення реакції воротаря та вправи на розвиток навичок виконання стрибків за м'ячем, а також вимірювання зросту та ваги. Для аналізу даних було застосовано t-критерій для визначення відмінностей у показниках між до- і післятестовими періодами з рівнем значущості менше 0,05 ($p < 0,05$).

Результати. Після 10 місяців тренувань з футболу у воротарів було зафіксовано значне покращення показників аеробної витривалості ($p = 0,004$), швидкості реакції ($p = 0,007$) та техніки виконання стрибків за м'ячем ($p = 0,002$). Однак не було встановлено значних змін у зрості, вазі та ІМТ, оскільки р-значення становило більше 0,05.

Висновки. Отримані результати мають важливе значення для оцінки програм підготовки воротарів і є основою для рекомендацій щодо впровадження більш ефективних тренувальних програм.

Ключові слова: воротарі, аеробіка, швидкість реакції, антропометрія.

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