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THE DIFFERENTIAL EFFECTS OF UPHILL SPRINT AND SIDE JUMP SPRINT EXERCISES AND VARIOUS ANTHROPOMETRIC CHARACTERISTICS ON THE SPEED OF SOCCER PLAYERS

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Abstract

Study purpose. To increase the running speed of soccer players, anthropometric factors need to be considered when choosing a training model.

Materials and methods. The experimental method with a 2×3 factorial design was used in this study. Purpose random sampling technique was used to select a sample of 60 participants from a population of 100 people. Then the sample was divided into six groups using a stratified random sampling technique (large UHS, n = 10 participants; moderate UHS, n = 10 participants; small UHS, n =10 participants; large SJS, n = 10 participants; moderate SJS, n = 10 participants; small SJS, n = 10 participants). The 20-meter running speed test and anthropometric measurements were used as data collection instruments. Data analysis uses a two-way ANOVA and normality and homogeneity tests as prerequisites.

Results. The results of the study found that there were significant differences in the two training models with a Sig value of 0.002 < 0.05, there were significant differences in the three anthropometric groups with a Sig value of 0.000 < 0.05, and there was an interaction between the training model and anthropometric characteristics in increasing the 20-meter running speed with a Sig value of 0.001<0.05.

Conclusions. This study concluded that the SJS training model was suitable for three levels of anthropometric ratios, while UHS was very suitable for small ones. Another conclusion was that the small anthropometric ratio had the greatest effect on the speed of the 20-meter sprint.

Keywords: uphill sprint, side jump sprint, anthropometry, 20-meter running speed, soccer.

Introduction

Running speed in a soccer game can be an added advantage for teams and individuals. In identifying the talent of elite young soccer players, the ability to run fast and sprint is very important (Murtagh et al., 2018). Running speed can be used in match situations such as attacking, defending, and transitions (Izquierdo et al., 2023; Owen, 2022; Power, 2020). When attacking running speed, an attacker is needed to penetrate with the ball or without the ball; when defending running speed, a defender is needed to intercept the ball; when transitioning, running speed is needed when counterattacking or anticipating counterattacks (Modric et al., 2023). Running speed is also needed when playing possession ball (Gong et al., 2021; Yi et al., 2019). Running speed is positively related to the ability to score goals in soccer players (Faude et al., 2012; Martínez-Hernández et al., 2023; Wilson et al., 2020). To evaluate the playing level of soccer players, running speed is one of the parameters used (Devismes et al., 2021). In 2018 Gonçalves et al. (2018) findings show that the speed and synchronization of the speed of soccer players tend to decrease in the second half of the match. However, the variation of speed synchronization between matches tends to increase. Therefore, soccer players must develop their running ability, especially within 20 meters, to optimize their running speed in various game situations, contributing to team success and individual achievements (Nicholson et al., 2022). According to the opinions of Rey et al. (2024) suggests that short-distance running exercises can improve sprint performance and turning speed. In addition, to evaluate players' physical abilities, a running speed of 20 meters is one of the parameters used (Altmann et al., 2019).

Another factor that affects the running speed of a soccer player is anthropometry. In the sports context, anthropometry is used to measure and analyze players' physical characteristics, such as height, weight, arm length, shoulder width, and body composition (Preedy, 2012). Each player has different anthropometric characteristics for both men and women (Pedersen et al., 2019). Differences in playing positions and ages of soccer players are also related to anthropometric characteristics (Taketomi et al., 2021). Anthropometric data can assist in determining training needs, designing appropriate training programs, and understanding how these physical factors can affect athlete performance in various sports. Especially the ratio of sitting height and standing height, plays an important role in the running speed of soccer players (Leão et al., 2019). This ratio refers to the ratio between sitting height (body length when sitting) and standing height (body length when standing upright). The ratio of sitting height and standing height can give an idea of the proportions of a player's body, especially the length of the legs relative to the overall body length. Players with small ratios tend to have longer legs compared to their height. Mechanical advantage will be obtained by players who have this ratio. More speed and distance will be obtained for players with longer leg reach (Parpa & Michaelides, 2022). In addition, stability and balance in the running are also influenced by anthropometric ratios. Balanced body proportions help players maintain good posture and balance when moving quickly. Understanding anthropometry, especially the ratio of sitting height and standing height, is important in selecting soccer players and developing appropriate training programs (Rebelo et al., 2013). Therefore, to increase the running speed of soccer players, it is important to pay attention to this anthropometric factor and use it as a guide in evaluating and developing players (Bordonau & Villanueva, 2012). Although running speed is an important aspect of soccer, gap analysis shows that training and research methods that specifically lead to an increase in sprint speed, taking into account the anthropometric factors of soccer players, still need to be completed (Bulqini et al., 2016). The need for optimal running speed in soccer is very important, given the dynamic nature of the game, and it often involves situations where players must pass opponents quickly. However, in many studies and exercise programs, the focus tends to be more on other physical aspects (Clemente et al., 2023).

The implementation of speed training has found its application across various domains. Plyometric training and sprinting at maximum speed are commonly employed techniques to enhance the power generation of elite soccer players rapidly and with optimal efficiency (Loturco et al., 2022; Weldon et al., 2021). During practical training sessions, the emphasis is placed on cultivating muscle strength and explosive power, prompting the muscles to rapidly contract and shorten. In the context of soccer, this type of training aids in the development of muscular strength and endurance, enabling players to execute physically demanding actions. Additionally, this exercise is frequently incorporated into athletic training programs to enhance running speed by exerting stress on crucial muscles like the hips and knees (Cronin & Hansen, 2006). The training program should be specific and verities. It can help soccer players improve their agility that were related to overall soccer performance (Thongnum & Phanpheng, 2022). Collaboration between trainers, researchers, and practitioners is needed to cover the deficiencies above. The coach must be involved in developing research and theory to improve the quality of training planning.

Presently, the scientific literature offers scarce evidence regarding the relationship between anthropometric characteristics and the effects of speed training. This study aims to provide valuable insights into the specific anthropometric traits that influence a player's response to the training regimen. Furthermore, the comparative impact of practicing a single weekly plyometric session in conjunction with either sided jump sprint (SJS) training or uphill sprint training (UHS) remains relatively unexplored. This research has the potential to contribute towards the development of more effective training strategies and the adoption of a more personalized approach to optimize running speed performance within the context of soccer.

Materials and methods

Study participants

A total of 100 male soccer students aged 18 to 19 years became the population in this study. 60 samples were selected as samples using a purposive random sampling technique. Of the 60 samples, 30 received UHS training, and 30 received SJS training. Furthermore, each exercise group was divided into three groups based on the value of the large, medium, and small anthropometric ratios. Each group consists of 10 samples, with the group division technique using a stratified random sampling technique.

Study organization

The method used in this study is an experimental method with a 2×3 factorial design, where the UHS and SJS training methods are the independent variables, the small, medium, and large anthropometric ratios are the attribute variables, and the 20-meter running speed is the dependent variable. This 2×3 factorial design will allow observation of the interaction between the training method and the ratio of sitting height to standing height on the soccer player's sprint performance. After completing the pretest, the subjects underwent separate training between UHS and SJS. Both groups did exercises with the same frequency thrice a week for six weeks. The sprint distance during the exercise used by each group is 20 meters using high intensity. The UHS sprint exercise is carried out on an uphill area with a slope of approximately 8% (Delaney et al., 2022). SJS exercises use a hurdle with a height of 40 cm. The exercises were carried out for six weeks with a frequency of three times a week. Six weeks of training can improve physical abilities (Kumar & Pandey, 2023).

Statistical analysis

The data collection techniques included measuring sitting and standing height and a 20-meter sprint test to measure sprint performance. The collected data were analyzed using the Analysis of Variance (ANOVA) test with a 2×3 factorial design at a significance level of $\alpha = 0.05$. Previously, a normality test (Shapiro Wilk test) was carried out to ensure the data met the assumption of normality and a homogeneity test of variance (Levene's test) to ensure homogeneity of variance between groups.

Results

This research was conducted for one month and a half, with a total of 20 days of practice with details of one pretest, 18 treatments, and one post-test. The number of participants is as many as 60 players. The results of calculating speed ability are obtained as follows.

It is descriptive statistical data in this study. The results of Table 1 above, show that the SJS training model has the greatest increase, namely 0.399 ± 0.157. The anthropometric group with a small ratio has the largest result, namely 0.501 ± 0.098.

Table 2. Shows the results of the normality test using the Shapiro-Wilk test. Based on the output of Table II above, it is known to have a sig value > 0.05, so it can be concluded that the UHS Training model data and Sided Jump Sprint with small, medium, and large anthropometric characteristics are normally distributed.

Levene's test determines whether each variant of the dependent variable is the same or homogeneous. Based on Table 3 above, it is known that the sig. Based on the respective mean of 0.276 and 0.675 > 0.05, it can be concluded that the variance of the data resulting from the SJS training model and the UHS training model is homogeneous.

Based on the output results in Table 4. Then the results of testing the hypothesis can be concluded as follows. The first hypothesis, based on the output, is a sig value of 0.002 < 0.05, so there is a difference in the increase in running speed of 20 m based on the 2 training models. The second hypothesis, based on the output, is a sig value of 0.000 < 0.05, so there is a difference in the increase in running speed of 20 m based on anthropometric characteristics. The third hypothesis, based on the output, is a Sig value of 0.001 < 0.05 so that there is an interaction between the training model and anthropometric characteristics in increasing the running speed of 20 m.

Table 1. Data Description

Anthropometry Group	Training Model	Mean	Std. Deviation	N
Small	Sided Jump Sprint	0.4920	0.10799	10
	Up Hill Sprint	0.5100	0.09262	10
	Total	0.5010	0.09835	20
Medium	Sided Jump Sprint	0.4820	0.09496	10
	Up Hill Sprint	0.2830	0.09604	10
	Total	0.3825	0.13806	20
Large	Sided Jump Sprint	0.2240	0.09107	10
	Up Hill Sprint	0.1780	0.05884	10
	Total	0.2010	0.07826	20
Total	Sided Jump Sprint	0.3993	0.15783	30
	Up Hill Sprint	0.3237	0.16266	30
	Total	0.3615	0.16342	60

The data are presented by means ± SD.

Table 3. Homogeneity Test

Group	A	Sig	Result
Up Hill Sprint (UHS)	0.05	0.276	Homogeneous
Side Jump Sprint (SJS)	0.05	0.675	Homogeneous

The data are presented by significant value; In the Levene's test, the data is homogeneous if the sig. ≥ 0.05.

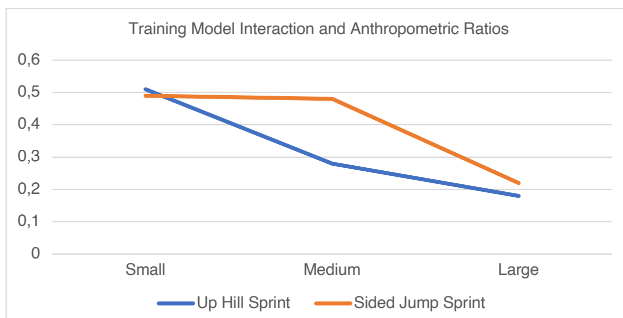

Fig. 1. Interaction Plot Diagram of training models and anthropometric ratios

Table 2. Normality Test

Training Model	Group	N	M	SD	A	Sig	Result
Up Hill Sprint (UHS)	Small	10	0.5100	0.09262	0.05	0.199	Normal
	Medium	10	0.2830	0.09604	0.05	0.595	Normal
	Large	10	0.1780	0.05884	0.05	0.431	Normal
Sided Jump Sprint (SJS)	Small	10	0.4920	0.10799	0.05	0.263	Normal
	Medium	10	0.4820	0.09496	0.05	0.558	Normal
	Large	10	0.2240	0.09107	0.05	0.390	Normal

The data are presented by means ± SD and sig. value; In the Shapiro-Wilk test, the data is normally if the sig. ≥ 0.05.

Table 4. Anova Two Way Test

Tests of Between-Subjects Effect					
Dependent Variable : Sprint 20 meter					
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Corrected Model	1.123[a]	5	0.225	26.835	0.000
Intercept	7.841	1	7.841	936.480	0.000
Group	0.913	2	0.457	54.536	0.000
Training_Model	0.086	1	0.86	10.257	0.002
Group* Training_Model	0.124	2	0.62	7.424	0.001
Error	0.452	54	0.008		
Total	9.417	60			
Corrected Total	1.576	59			

a. R Squared = .713 (Adjusted R Squared = .686)

The data are presented by means ± SD; *statistically significant difference when compared within group, mean scores at point comparisons from baseline: * p ≤ 0.05 and *t p ≤ 0.01 when comparing the difference between experimental group.

Figure I. The above is useful for assessing whether there is an interaction effect between variables. However, this diagram cannot be used as a valid reference. However, to give an overview of the interactions that occur. An interaction effect is suspected if the lines do not show parallels. The diagram above shows a misalignment of the lines, so it is suspected that there is an interaction effect between the training model and the anthropometric ratio

The study results should be presented in tables and described in a logical sequence.

Discussion

The results of testing the first hypothesis indicate a significant difference in the effect of the UHS and SJS training models on the 20-meter sprint performance. In this study, the group that underwent the SJS training model showed a better increase in running speed than the group that underwent the UHS training model. This finding can be explained through several relevant reinforcement theories. First, the speed-solidity principle states that to achieve maximum speed, it is important to develop sufficient muscle strength (Kenney et al., 2021; Kusnanik, 2011). The SJS training model, which emphasizes developing leg muscle strength and explosive power, conforms to this principle. By training the muscles involved in sprinting movements, we can increase the strength and explosive power needed to reach maximum speed (Ramirez-Campillo et al., 2020). Second, the specificity theory states that specific training by the goals will give better results (Harsono, 2018; Sidik et al., 2019; Tudor, 2019). The SJS training model is designed to increase running speed, focusing on technique and movements similar to the 20-meter sprint.

Previous research has shown that running and jumping are the most frequent actions before scoring situations, and, most importantly, sprint distance and maximal sprint count have increased substantially in professional soccer over the past few years (Bush et al., 2015). Therefore, this exercise specifically prepares students for the physical and technical demands they will face. In addition, the theory of functional adaptation explains that the body will adapt to regular exercise by developing the physiological systems needed to meet the demands of the exercise (Kenney et al., 2021; Kusnanik, 2011). The SJS training model, which involves speed and explosive power training, will stimulate the body's physiological adaptations that align with the 20-meter sprint. The stretching-shortening cycle, enhanced by the exercise, is a major adaptation contributing to improved athlete performance. This adaptation is due to increased stiffness at the muscle-tendon junction and more efficient use of the elastic component of the muscle. The muscles will become stronger, the anaerobic energy system will improve, and the coordination of body movements will improve. In line with the results of a study Loturco et al. (2015) who demonstrated that plyometric training has an important role in influencing neuromechanical responses in high-level soccer players. In the context of this study, neuromechanics refers to the changes that occur in soccer players' nervous and muscular systems in response to plyometric training, this includes neuromuscular adaptations, such as increased strength, explosive power, and jumping ability, which can improve players' sprint and jumping performance. Finally, the theory of anaerobic training states that training with high intensity and focus on anaerobic training will involve the body's anaerobic energy system, which is important in achieving high running speeds (Assunção et al., 2018; Kenney et al., 2021). In line with this, according to Andrzejewski et al. (Andrzejewski & Chmura, 2008) the speed of soccer players requires high-speed maintenance through an energy regeneration process that involves the breakdown of phospho-creatine and free oxygen glycolysis. Another study found that a combined plyometric and sprint training program in soccer practice had a positive effect on the explosive and technical actions of soccer players during a competitive season, with significant increases in jumping ability, sprinting, change of direction, and ball shooting speed (Ceylan & Demirkan, 2017; Sáez De Villarreal et al., 2015). Similar studies have also found that training with speed affects anaerobic capacity in soccer players (Kusnanik et al., 2019).

The results of testing the second hypothesis indicate that the anthropometric ratio significantly affects the 20-meter running performance. Biomechanical theory can be used to explain this phenomenon. According to biomechanical theory, stride length while running is directly related to running speed (Huston, 2013; Knudson, 2007; Sudarmada & Wijaya, 2015). The principle of balance influences the anthropometric ratio of sitting height and standing height. The difference in the sitting and standing height ratio will affect the center of gravity and coordination of body movements. Someone with a small ratio of sitting height to standing height tends to have longer limbs, affecting the center of gravity and body stability when jumping in exercise. The balance will be maintained when a person has the correct movement and distribution of body mass to provide a mechanical advantage (Huston, 2013; Knudson, 2007; Sudarmada & Wijaya, 2015). In addition, anthropometric theory can also be applied in this context. The ratio of sitting height and standing height reflects the proportions of a person's body (Preedy, 2012). Someone with a small ratio of sitting height to standing height tends to have more ideal body proportions to achieve high running speed. The longer body proportions in the limbs provide an advantage in producing longer, more efficient strides while running.

It should be noted that although the ratio of sitting to standing height has a significant effect, other factors can also play a role in 20-meter running performance. General fitness, upper body muscle strength, running technique, and genetic factors also affect sprint performance (Campa et al., 2019). Therefore, in training and developing running speed, it is necessary to consider these factors holistically.

The results of testing the third hypothesis showed a significant difference in the effect of training models and the ratio of sitting height to standing height on the performance of the 20-meter sprint. Interesting things were found in this study, although previous explanations concluded that the SJS model has advantages over the UHS. However, if it is related to anthropometric characteristics, UHS has a significant impact when applied to players with anthropometric characteristics with a height ratio, this can be explained by functional adaptation theory and specific fitness theory. Functional adaptation theory explains that the human body has the ability to adapt to certain training stimuli (Kenney et al., 2021; Kusnanik, 2011). The UHS training model, which emphasizes leg muscle strength and anaerobic speed endurance, provides an appropriate stimulus for students with a small ratio of sitting height to standing height. Their body proportions that allow for longer and more efficient strides provide a mechanical advantage in increasing running speed. However, the case is different if UHS is applied to anthropometric characteristics with medium and high ratios. Training will not be efficient because players need help maintaining balance when running on uphill terrain. If forced, it will have an impact on joint injuries and others.

On the other hand, the SJS model conforms to all anthropometric characteristics. The SJS training model, which focuses on developing leg muscle strength and explosive power, provides a more effective stimulus for students with these body proportions. With straight terrain, players will have no trouble doing this exercise. In line with research which states that plyometric exercises are suitable for use on flat surfaces or grass (Marzouki et al., 2022; Pereira et al., 2023). Thus, they can achieve a significant increase in running speed. In addition, anthropometric theory can also provide a deeper understanding. The ratio of sitting height to standing height reflects the length ratio between the upper and lower parts of the body (Preedy, 2012). In line with research conducted by Bongiovanni et al. (2021) who found that anthropometric features of the upper and lower body were significantly related to sprint performance and aerobic fitness in young elite soccer players.

Conclusions

The SJS training model has advantages in increasing the running speed by 20 meters. However, if we look at the anthropometric characteristics, UHS training is highly recommended for players with a small ratio of anthropometric characteristics. Through developing muscle strength, specific exercises, functional adaptations, biomechanical principles, and anaerobic exercises, students can significantly increase their 20-meter sprint performance. These results provide important insights for coaches and athletes in designing suitable training programs. Introducing the sitting and standing height ratio of students and adjusting individual training programs can help improve sprint performance.

Conflict of interest

Authors do not receive endorsement from any organization for submitted work. The author has no relevant financial or non-financial interest to disclose.

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ДИФЕРЕНЦІАЛЬНИЙ ВПЛИВ ВПРАВ ЗІ СПРИНТУ ВГОРУ ТА СПРИНТУ ЗІ СТРИБКАМИ ВБІК І РІЗНИХ АНТРОПОМЕТРИЧНИХ ХАРАКТЕРИСТИК НА ШВИДКІСТЬ ФУТБОЛІСТІВ

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

Реферат. Стаття: 8 с., 4 табл., 1 рис., 50 джерел.

Мета дослідження. Для підвищення швидкості бігу футболістів під час вибору моделі тренувань потрібно брати до уваги антропометричні фактори.

Матеріали та методи. У цьому дослідженні використовували експериментальний метод із факторним планом 2×3. Для відбору вибірки із 60 учасників із генеральної сукупності 100 осіб використовували метод цільової випадкової вибірки. Потім вибірку розділили на шість груп за допомогою методу стратифікованої випадкової вибірки (велике співвідношення антропометричних параметрів (САП), спринт угору (СУ), n = 10 учасників; середнє САП, СУ, n = 10 учасників; невелике САП, СУ, n = 10 учасників; велике САП, спринт зі стрибками вбік (ССВ), n = 10 учасників; середнє САП, ССВ, n = 10 учасників; невелике САП, ССВ, n = 10 учасників). Як інструменти збору даних використовували тест на швидкість бігу на 20 метрів та антропометричні параметри. Для аналізу даних використовували двофакторний дисперсійний аналіз і тести на нормальність і однорідність як передумови.

Результати. Результати дослідження показали наявність статистично значущих відмінностей у двох моделях тренувань зі значенням показника значущості 0,002 < 0,05; навяність статистично значущих відмінностей у трьох антропометричних групах зі значенням показника значущості 0,000 < 0,05 та наявність взаємовпливу між моделлю тренувань та антропометричними характеристиками в контексті підвищення швидкості бігу на 20 метрів зі значенням показника значущості 0,001< 0,05.

Висновки. Результати цього дослідження дозволяють дійти висновку, що модель тренувань ССВ підходить для трьох рівнів співвідношень антропометричних параметрів, тоді як модель СУ дуже підходить для учасників із невеликим САП. Також на підставі результатів цього дослідження можна дійти висновку, що невелике співвідношення антропометричних параметрів мало найбільший вплив на швидкість бігу на 20 метрів.

Ключові слова: спринт угору, спринт зі стрибками вбік, антропометрія, швидкість бігу на 20 метрів, футбол.

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