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The Effect of Shadow Training and Muscle Endurance on Agility of Badminton Athletes 12-17 Years of Age

El efecto del entrenamiento en sombra y la resistencia muscular en la agilidad de los atletas de bádminton de 12 a 17 años de edad

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Abstract. The aim of this experiment was to investigate: (1) the difference in the effects of shadow training using an application and conventional methods on the agility of badminton athletes; (2) the difference in the effects of high and low muscle endurance on agility in badminton athletes; and (3) the interaction between shadow training methods and muscle endurance on agility in badminton athletes. This is an experimental study conducted to examine how a treatment or independent variable (variable x) affects the dependent variable (variable y). The study was designed as a 2x2 factorial, which involved two or more independent variables combined. The study population consisted of 55 members of the PB. UNJA Jambi club. The sample was selected using stratified and conditional sampling, specifically including individuals between the ages of 12-17 years old and who had a national PBSI ID. The sample was stratified based on leg muscle endurance, measured using the "Wall Squat Test." The data were collected using a leg exercise test instrument with a validity of 0.706 and a reliability of 0.808. The analysis of the study was conducted using Manova with a significance level of 0.05. The results showed that: (1) there was a significant difference in agility between shadow training using an application and conventional methods, with an F value of 38.37 and a significance value of 0.000 < 0.05; (2) there was a significant difference in agility between high and low muscle endurance, with an F value of 59.992 and a significance value of 0.000 < 0.05. The analysis showed that high muscle endurance increased by 1.5 from 15.10, while low muscle endurance increased by 0.40 from 14.10; and (3) there was no significant interaction between the treatment (shadow training using an application and conventional methods) and leg muscle endurance (high and low) on agility, with an F value of 0.634 and a significance value of 0.544 > 0.05.
Key Words*:* Shadow Training, Muscle Endurance, Agility

Resumen. El objetivo de este experimento era investigar: (1) la diferencia en los efectos del entrenamiento en la sombra utilizando una aplicación y los métodos convencionales en la agilidad de los atletas de bádminton; (2) la diferencia en los efectos de la alta y baja resistencia muscular en la agilidad de los atletas de bádminton; y (3) la interacción entre los métodos de entrenamiento en la sombra y la resistencia muscular en la agilidad de los atletas de bádminton. Se trata de un estudio experimental realizado para examinar cómo un tratamiento o variable independiente (variable x) afecta a la variable dependiente (variable y). El estudio se diseñó como una factorial 2x2, en el que se combinaron dos o más variables independientes. La población del estudio estaba formada por 55 miembros del club PB. UNJA de Jambi. La muestra se seleccionó mediante un muestreo estratificado y condicional, que incluía específicamente a personas con edades comprendidas entre los 12 y los 17 años y que tuvieran un carné nacional de PBSI. La muestra se estratificó en función de la resistencia muscular de las piernas, medida mediante el "Wall Squat Test". Los datos se recogieron utilizando un instrumento de prueba de ejercicio de piernas con una validez de 0,706 y una fiabilidad de 0,808. El análisis del estudio se realizó mediante Manova con un nivel de significación de 0,05. Los resultados mostraron que (1) hubo una diferencia significativa en la agilidad entre el entrenamiento de sombra utilizando una aplicación y los métodos convencionales, con un valor F de 38,37 y un valor de significación de 0,000 < 0,05; (2) hubo una diferencia significativa en la agilidad entre la resistencia muscular alta y baja, con un valor F de 59,992 y un valor de significación de 0,000 < 0,05. El análisis mostró que la resistencia muscular alta y la resistencia muscular baja eran significativas. El análisis mostró que la resistencia muscular alta aumentó en 1,5 desde 15,10, mientras que la resistencia muscular baja aumentó en 0,40 desde 14,10; y (3) no hubo interacción significativa entre el tratamiento (entrenamiento en la sombra mediante una aplicación y métodos convencionales) y la resistencia muscular de la pierna (alta y baja) sobre la agilidad, con un valor F de 0,634 y un valor de significación de 0,544 > 0,05.
Palabras clave: Entrenamiento de sombra, resistencia muscular, agilidad

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Introduction

The development of badminton at this time is very rapid, as seen from the various championships that are regularly held by the international badminton organization, namely BWF, countries are competing to send representatives to take part in the titles that are owned, judging by the enthusiasm and euphoria it shows how badminton is very popular throughout the world (Gómez Rodríguez et al., 2021).

Countries around the world are currently competing to improve and perfect badminton in their respective countries to be able to compete on the international stage and be able to compete. Which is reckoned with in the world of badminton. The development of badminton in Indonesia is excellent, and this is supported by the many training centers managed by branch officials of the Indonesian Badminton Association (PBSI) in every city and district.

To achieve good performance, there are several components of physical condition in badminton that play an important role, namely speed, strength, endurance, explosive power, flexibility, and accuracy, these components influence improving the performance of badminton athletes. (Hinda Zhannisa et al., 2018) describes the components of physical condition, including strength, endurance, explosive power, speed, flexibility, coordination, balance, accuracy, and reaction. In badminton, the dominant components of physical conditioning are endurance, explosive power, speed, and agility. But of the many features that support achievement in the game of badminton, agility is one component that plays a vital role in being able to play well and achieve peak performance, and agility is the main thing for athletes to be able to reach the entire field and control the area to the fullest. This is also explained by (Nugroho et al., 2018). Agility is needed to master the match so that it is suitable for attacking (smash), defending (block), and serving.

To increase agility, there is a supporting component, namely endurance, endurance is a component that is very influential in increasing agility. (Sahara et al., 2019) argues that to carry out various parts of fitness, endurance is the main thing to get details such as agility well, an athlete's endurance will be better, which will later determine the athlete's achievements.

Agility is an essential aspect in the game of badminton, the magnitude of the contribution made by agility makes the agility component very important for an athlete to have, having good agility makes the athlete's footwork faster, and this creates an athlete able to master the field as a whole, also explained (Wong et al., 2019) athletes who have agility make footwork agile. This can make changing direction at short distances significant in defensive and attacking maneuvers during badminton training and competition.

In badminton, agility is critical because the sport requires fast, accurate movements and adequate body coordination and stability to change direction and location of action quickly. A badminton player's chances of winning a match are increased by his ability to take an advantageous position on the court. To increase the effectiveness of badminton players on the field, agility training is usually included in the training program (Rahmat Fitrianto et al., 2022). Agility and footwork are important components in badminton as they allow players to move quickly and accurately to corners of the court. Agility and speed of footwork are essential components for success in badminton, as they allow players to change direction quickly, speed up and slow down, and maintain balance and stability during play (Jabri et al., 2021).

The ability to use various racquet techniques, apart from physical and physiological factors, is the highest performance requirement in badminton, but from there, agility makes a substantial contribution in supporting achievement (Özgür & Hotaman, 2020). (Inglis, Paul, and Bird, 2016) agility is defined as a rapid movement of the whole body with a change of direction or speed in response to a stimulus. Agility is the ability to change direction and position quickly without losing balance. Agility combines tactical, technical, physical, and psychological (Latorre et al., 2020).

Badminton is a complete game such as the physical components that athletes must have, such as endurance, leg muscle explosive power, speed, agility, agility balance. (Andara & Wiriawan, 2017), the condition component includes several details: strength, speed, endurance, and explosive power. (Kresnapati et al., 2020) explained that the members of physical condition are how strength, speed, agility, endurance, and flexibility in sports have their respective dominant physical components.

(Malwanage et al., 2022) agility, balance, jumps, steps, and flexibility are the physical components of playing badminton. (Charee et al., 2022) the badminton component contains four things, agility, strength, motor skills, and muscle endurance. (Ozmen & Aydogmus, 2016) components in the game of badminton can be defined as components that can support achievements such as agility, endurance, and dynamic balance. Agility, endurance, and balance are core components in supporting achievement, but apart from these components, there are components such as mood, stress, anxiety, and fitness that can also influence achievement (Luna-villouta et al., 2023; Salleh et al., 2021). (Grabara et al., 2021) The physical condition component consists of muscle strength, endurance, general endurance, flexibility, speed, coordination, agility, and balance. Developing or improving the physical condition means developing or increasing the athlete's physical abilities. Physical ability includes two components, namely, the physical fitness component and the motor fitness component. Physical fitness consists of muscle strength, muscle endurance, respiratory-circulatory endurance, and flexibility. At the same time, the components of motion freshness consist of speed, coordination, agility, muscle explosiveness, and balance. (De França Bahia Loureiro et al., 2017) there are many core components in badminton, but the most critical component is agility. From the experts' explanations regarding the components of physical condition, it is complete. Proper physical training is needed in training to have an excellent physical part. Physical condition is a core component that athletes must have to perform at their best and achieve achievements.

Badminton players must be agile to change direction quickly, respond to punches from opponents, and maintain balance when rushing on the court. Previous research has examined how agility training can improve the performance of badminton athletes. The main conclusions of earlier studies on agility training in badminton athletes will be reviewed in this section.

Several studies have investigated the impact of special agility training programs on the performance of badminton players. The research conducted (Hu & Zhang, 2018) discussed the effect of shadow badminton training on speed and foot movement, and the study was born on 20 university badminton players with an average age of 20 years, the results showed that shadow badminton practice could increase speed and movement player's feet in badminton game. Discusses agility training methods and techniques in badminton based on kinetic chain theory (Chen & Guo, 2022; Eduardo et al., 2022). The results of the analysis show that agility training can be done through training in balance, coordination, speed, explosive power, and others.

Another study by (Khoshnam et al., 2016; Li et al., 2022) focused on the effect of plyometric training on the agility of badminton players. The intervention involves high-intensity exercises such as depth jumps and jump drills. The findings revealed a substantial increase in the athlete's agility performance, as evidenced by the reduced time required to complete the agility test and increased on-court maneuverability.

In addition to specific agility training, the researchers also explored the role of shadow training in increasing the agility of badminton players. Shadow training involves simulating play-like movements and footwork patterns without an opponent. (Kasih et al., 2021; Nor et al., 2021) investigated the effect of shadow training on skill and reported a significant increase in participants' ability to change direction quickly and respond to sudden stimuli.

Furthermore, muscle endurance has been identified as an essential factor affecting agility performance in badminton. Studies have examined the relationship between muscular endurance and agility, highlighting the importance of muscle strength and fatigue resistance. Surveyed to determine the effect of muscle endurance training on skill in badminton players (J. T. Kim et al., 2019; Medina Corrales et al., 2020). The intervention consisted of resistance training targeting the lower body muscles, with findings suggesting that increased muscle endurance is positively correlated with increased agility performance. In research (Jankauskas et al., 2021; Mousavi Sarvarzi et al., 2020) there is a link between muscle strength, muscle endurance, and agility in badminton athletes.

Overall, previous research has consistently shown the positive effect of agility training, including special agility exercises and shadow training, on the performance of badminton athletes. Additionally, the relationship between muscular endurance and agility highlights the importance of incorporating muscular endurance training into agility programs. However, while these studies provide valuable insights, further research is needed to explore optimal training protocols, long-term effects, and transferability of increased agility to actual game performance. Understanding these factors can help coaches and athletes design effective training programs to increase agility and improve badminton performance.

Agility is an essential component in badminton, which requires athletes to change direction quickly, react to opponents' movements, and maintain balance during fast movements. To increase agility, athletes use various training methods, and shadow training is one method that attracts attention. This section reviews the literature on the role of shadow training in increasing agility in badminton athletes, supported by five relevant sources.

1. The results show that shadow training significantly improves agility performance compared to traditional training. These findings indicate that shadow training can provide unique benefits for increasing agility in badminton athletes (Kasih et al., 2021).
2. The shadow badminton training program consists of six weeks of practice, each session lasting 60 minutes. The training sessions include warm-ups, shadow badminton drills, and cool-down periods which can significantly improve agility (Ting et al., 2020).
3. Shadow training is a method in which the player performs movements and punches without hitting the shuttlecock, and it is a widely accepted method for increasing player footwork, stamina, and agility (Vlkova et al., 2021).
4. The results show that shadow badminton exercises can increase the speed and movement of players' feet in badminton games. The author concludes that shadow badminton training can be one way to improve the athletic abilities of badminton players (Hu & Zhang, 2018).
5. Shadow training is a very effective exercise for increasing agility in badminton games (Wang et al., 2022).

Literature highlights the positive impact of shadow training on increasing agility in badminton athletes. Studies consistently show that shadow training can significantly increase dexterity performance and related skills. The intensity and duration of shadow training, as well as its neurophysiological effects, have been investigated and support the effectiveness of this training method. Additionally, the long-term application of shadow training has been shown to maintain agility gains over time. These findings emphasize the importance of integrating shadow training into training programs for badminton athletes who wish to improve their agility abilities.

Agility is an essential component of the game of badminton, requiring quick changes of direction, rapid acceleration, and deceleration. Athletes often undergo various training methods to increase agility, and one of the critical aspects recognized is muscle endurance. This section will discuss the importance of muscle endurance to agility performance which is supported by two relevant sources.

A study (Aertssen et al., 2016; Lima et al., 2020) showed that functional strength, which includes muscle endurance, is related to agility, found that muscle strength is related to agility and other motor skills. (Degens et al., 2019) athletes who have good endurance have an impact on the agility performance of badminton athletes.

Research conducted (S. Kim et al., 2018) shows that flexibility, speed, and muscle endurance exercises can increase agility in young badminton players. (Sudrajat et al., 2018), found that muscular endurance is positively related to agility in badminton players. this study shows that muscle endurance is positively related to agility in badminton players and can be an essential factor in improving performance (Kurniawan & Karimah, 2019; Sánchez-Lastra et al., 2020).

The physiological demands of exercise can explain the significance of muscle endurance on agility performance. Badminton requires repeated bursts of high-intensity movements, which rely on an anaerobic energy system. Muscles with a higher endurance capacity can sustain repeated efforts, leading to increased agility performance. In addition, muscle endurance contributes to overall stability and control during rapid changes of direction, allowing the athlete to maintain balance and execute precise movements.

In summary, muscular endurance is essential in agility performance among badminton athletes. The positive correlation between muscular endurance and agility highlights the importance of incorporating muscular endurance training into an athlete's training regimen. The findings from the research that I include in paragraphs 2 and 3 provide empirical evidence supporting the benefits of muscle endurance training to improve agility performance in badminton. Trainers and trainers should consider implementing structured athletic endurance training that targets specific muscles involved in agility movements to improve overall performance on the court.

Material

The technique for taking athlete criteria first uses stratified techniques, which are sampling techniques based on strata or levels (levels). This study used a conditional sample: male sex, aged 12-17 years, and already had a PBSI ID. After that, they were divided into two groups using ordinal pairing, divided based on leg muscle endurance, to get muscle endurance. Legs used "Wall Squat Test".

Methods

This study used a 2x2 factorial design, namely the presence of two or more independent variables combined. Borkowski explained in (Tisnganti et al., 2019), the 2x2 factorial design is an experimental design where data is collected for all possible combinations of the two desired factors. In this study, there were 4 factors, namely high muscle endurance will be given the treatment of shadow training with application and conventional, low muscle endurance the exercises given are the same as the treatment given to high muscle endurance.

Table 1.
research design

	shadow with application (a1)	Shadow convesional (a2)
High muscle endurance (b1)	a1 b1	a2 b1
Low muscle endurance (b2)	a1 b2	a2 b2

Information:

A1 B1 : The type of shadow training using the application is given to athletes with high muscle endurance.

A2 B1: Conventional types of shadow training are given to athletes with high muscle endurance.

A1 B2: The type of shadow training using the application is given to athletes with low muscle endurance.

A2 B2: Conventional types of shadow training are given to athletes with low muscle endurance.

Data was collected using the footwork test with a validity value of 0.706 and reliability of 0.808. The pre-test data for this study came from the number of athletes who could do a 30-second leg exercise test, while the post-test data came from the number of athletes who could do a 30-second leg exercise test after being given treatment with the shadow training method using the application and shadow practice on cue by the coach.

Data analysis

In this study, first, the Normality and Homogeneity tests were carried out to see what further tests would be done with a significance level of 0.05. To test the hypothesis, the Manova test was used. Using the MONOVA test at the 95% confidence level or a = 0.05, the Manova test, all tests in this study were carried out with the help of the IBM SPSS Statistics 25 application.

Results

The data from this study are the results of the pretest and posttest data of the foot agility test. Collecting data in this study through four stages. In the first stage, collecting data on leg muscle endurance using the wall squat test, in the second stage, on the same day after collecting data on leg muscle endurance, directly retrieving pretest agility data, in the third stage, shadow training treatment is given using an application and using aba by the trainer (conventional).

This was carried out by the training program that had been prepared, which was carried out in 12 meetings, in the fourth stage after giving the treatment, posttest data were collected.

Table 2.
table of pretest and posttest

types of muscles	type of treatment	pretest	posttest	Difference
t	shadow app	15	17	2
t	shadow app	15	17	2
t	shadow app	19	21	2
t	shadow app	14	16	2
t	shadow app	16	18	2
t	convesional shadow	16	17	1
t	convesional shadow	13	14	1
t	convesional shadow	14	15	1
t	convesional shadow	15	16	1
t	convesional shadow	14	15	1
r	shadow app	14	14	0
r	shadow app	16	17	1
r	shadow app	13	14	1
r	shadow app	14	15	1
r	shadow app	15	16	1
r	convesional shadow	15	15	0
r	convesional shadow	14	14	0
r	convesional shadow	14	14	0
r	convesional shadow	13	13	0
r	convesional shadow	13	13	0

Statistical descriptive data

The attached data are descriptive statistical data from the pretest and posttest of the subject groups who have low muscle endurance who have been given treatment using the Shadow application and the conventional approach, as well as subjects with high muscle endurance who have also been given the same treatment using the Shadow application and the conventional approach.

Table 3.
descriptive data table

types of muscles	type of treatment		pretest	posttest
r	shadow app	mean	14.40	15.20
		n	5	5
		std. deviation	1.140	1.304
		minimum	13	14
		maximum	16	17
	convesional shadow	mean	13.80	13.80
		n	5	5
		std. deviation	.837	.837
		minimum	13	13
		maximum	15	15
	total	mean	14.10	14.50
		n	10	10
		std. deviation	.994	1.269
		minimum	13	13
		maximum	16	17
t	shadow app	mean	15.80	17.80
		n	5	5
		std. deviation	1.924	1.924
		minimum	14	16
		maximum	19	21
	convesional shadow	mean	14.40	15.40
		n	5	5
		std. deviation	1.140	1.140
		minimum	13	14
		maximum	16	17
	total	mean	15.10	16.60
		n	10	10
		std. deviation	1.663	1.955
		minimum	13	14
		maximum	19	21

Normality test

The normality data test in this study used the Shapiro-Wilk method. Normality data were taken from each group, and data analysis was performed using SPSS software version 25 with a significance level of 5% or 0.05. Data is loaded in the following table.

Table 4.
Normality results

shadow app normality test			
	types of muscles	shapiro-wilk	
		significance	information
pretest	r	0.814	normal
	t	0.223	normal
posttest	r	0.421	normal
	t	0.223	normal
conventional shadow normality test			
	types of muscles	shapiro-wilk	
		significance	information
pretest	r	0.314	normal
	t	0.814	normal
posttest	r	0.314	normal
	t	0.814	normal

Based on the statistical analysis of the normality test conducted using the Shapiro-Wilk method in table 4 above, all pretest and posttest results of the leg agility test were obtained, data > 0.05, and this means that the data is significant, so it can be concluded that the data is normally distributed.

Homogeneity Test

The homogeneity test aims to test whether the data obtained from a sample has the same variance or is homogeneous. In this study, the homogeneity test aims to see that the pretest and posttest data have the same variance. The following table shows the homogeneity test results.

The results of the table above's significance are based on the homogeneity test conducted by Levene's test, and all significance results are > 0.05.

This means that the data in this study have the same variance or are homogeneous.

Hypothesis Test Results

Testing the hypothesis of this study used the results of the analysis of the Manova multivariate test with the help of SPSS 25 software.

The hypothesis of the difference in the effect of shadow training using application and conventional shadow training (cued by the coach) on agility.

This hypothesis examines the effect of differences in shadow training using applications and conventional shadow training (cued by the coach) on agility Guidelines to conclude if sig <0.05, then Ha is accepted. The first hypothesis tested is:

Ho: There is no significant difference between shadow training with application and conventional (cued by the trainer) on agility.

Ha: There is a significant difference between shadow training with application and conventional (cued by the trainer) on agility.

Table 5.
Homogeneity results

Shadow app homogenity test		
types of muscles	levene's test	
	significance	information
pretest	0.437	homogeneous
posttest	0.609	homogeneous
Conventional shadow homogenity test		
types of muscles	levene's test	
	significance	information
pretest	0.478	homogeneous
posttest	0.478	homogeneous

Table 6.
Results of the Manova test, the difference in the effect of shadow training using an application with conventional shadow training (instructed by the coach)

Conventional type of shadow application (on cue by coach)				
Value	F	Hypothesis df	Error df	Say.
0.837	38.37[b]	2.000	15.000	0.000

From the table above, we get an F result of 38.37 and a significance value of 0.000 <0.05, meaning that Ho is rejected. There is a significant difference between shadow training with application and conventional (cued by the trainer) on agility. This means that the hypothesis that there is a difference between shadow training with application and conventional (cued by the trainer) on agility has been proven.

The hypothesis is the difference between high muscle endurance and low muscle endurance for agility.

This hypothesis examines the difference between high muscle endurance and low muscle endurance agility Guidelines for concluding if sig <0.05, then Ha is accepted. The hypothesis tested is:

Ho: There is no significant difference between high muscle endurance and low muscle endurance for agility.
Ha: There is a significant difference between high muscular endurance and low muscular endurance for agility.

Table 7.
The results of the Manova test, the difference between high muscle endurance and low muscle endurance for agility.

High and low muscle endurance				
Value	F	Hypothesis df	Error df	Say.
0.884	59.992b	2.000	15.000	0.000

From the table above, we get an F result of 59.992 and a significance value of 0.000 <0.05, meaning that Ho is rejected. This means there is a significant difference between high and low muscle endurance for agility. Based on the analysis, high muscle endurance increased 1.5 from 15.10, and low muscle endurance increased 0.40 from 14.10. This means that the hypothesis that there is a difference between high and low muscle endurance for agility has been proven.

The interaction between treatment (shadow using application and conventional shadow) and leg muscle endurance (high muscle endurance and low muscle endurance) on agility. This hypothesis tests whether treatment (shadow using the application and conventional shadow) interacts with leg muscle endurance (high muscle endurance and low muscle endurance) on agility. Guidelines for concluding if sig <0.05, then Ha is accepted. The hypothesis tested is:

Ho: There was no significant interaction between treatment (shadow using application and conventional shadow) and leg muscle endurance (high muscle endurance and low muscle endurance) on agility.
Ha: There is a significant interaction between treatment (shadow using application and conventional shadow) and leg muscle endurance (high muscle endurance and low muscle endurance) on agility.

Table 8.
Manova test results Interaction of treatment (shadow using conventional application and shadow) with leg muscle endurance (high muscle endurance and low muscle endurance)

Interaction of type of treatment with type of leg muscle endurance				
Value	F	Hypothesis df	Error df	Say.
0.078	0.634b	2.000	15.000	0.544

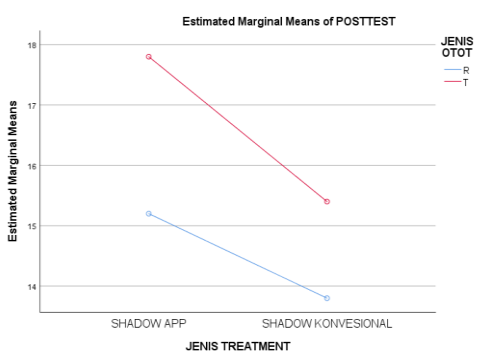

Figure 1. Graph of the interaction between the type of shadow training and the type of muscle endurance.

From the table above, we get an F result of 0.634 and a significance value of 0.544 > 0.05, meaning that Ho is accepted. It can be interpreted that there is no significant interaction between treatment (shadow using the application and conventional shadow) and leg muscle endurance (high muscle endurance and low muscle endurance) on agility. This means that the hypothesis that there is an interaction between the shadow training model and muscle endurance on badminton athletes' agility has yet to be proven. Below is a graph of the interaction between the type of exercise or treatment and the type of muscle. Below is a graphic image of the interaction between types of shadow training and muscle endurance.

Dicussion

This study aimed to evaluate the effectiveness of shadow training using apps and conventional methods. This approach is expected to provide in-depth insight into the benefits and effectiveness of both methods in improving specific skills. Through apps, participants are expected to access exercises more flexibly and get instant feedback. On the other hand, the conventional method offers direct interaction and personal guidance. The evaluation will include skill improvement, participant comfort level, and overall positive impact. By comparing the results of both approaches, this research has the potential to provide valuable guidance for developing more effective training programs that suit individual needs, whether through technology or traditional methods.

The hypothesis of the difference in the effect of shadow training using the application and conventional shadow training (cued by the coach) on agility.

From testing the hypothesis using the Manova test, the results show differences in the effect of shadow training using the application and conventional shadow training (cued by the trainer) on agility. This is supported by descriptive statistical data showing that the shadow training group using the application is superior to the conventional shadow training group (cued by the trainer). Based on the results of statistical descriptive data analysis, shadow training using an application has an average posttest value of 16.50 and conventional shadow training (on cue by the trainer) an average posttest value of 14.60 with a difference in scores of 1.90, from the difference in the data This type of shadow exercise uses special applications to increase agility. In increasing agility shadow exercises are effective for increasing agility. Shadow training is an effective tool for increasing agility, footwork, and hitting accuracy in badminton players (Naranjo et al., 2016). This opinion is also supported by (Wei-Hsiu Lian, Che-Chia Hu, 2020) shadow training can increase the accuracy and agility of motion. Shadow training is indeed superior in increasing agility, but there are types of shadow training that are even better at increasing agility, namely by using technology-based shadow exercises such as using an application, or smartphone-based. Mobile-based shadow badminton training shows a more significant effect on agility than traditional shadow badminton training (Dong Won Kim, Seok Jun Moon, 2021). Virtual reality-based shadow training is more effective than traditional shadow training in increasing agility, so it can be a valuable addition to training programs for athletes looking to increase agility (Park, 2019). Shadow training with the help of applications on badminton athletes can increase agility. The preparation of a good training program must support this.

The hypothesis is the difference between high muscle endurance and low muscle endurance for agility.

The hypothesis results obtained by using the Manova test that there is a significant difference between high muscle endurance and low muscle endurance on agility, this is supported by the results of descriptive statistical data showing that the group with high muscle endurance obtained an average posttest of 16.60 and the group low muscular endurance obtained a posttest average of 14.50, the difference between the two groups was 2.10. This shows that the high muscular endurance group improved after treatment in increasing agility. The results show that there is a significant difference between low muscle endurance and high muscle endurance. Good leg muscle endurance is significant in increasing agility (Alizadeh et al., 2020). Athletes with higher muscle endurance and strength tend to have better leg movement agility (Lai, K. C., Chou, C. C., Huang, C. J., & Chang, 2016). Athletes with high muscular endurance show better agility performance than athletes with low muscular endurance in badminton (Yunianto et al., 2017). A good training program must also support it. (Luna et al., 2019; Mirzaei et al., 2016) With good resistance training can improve agility and ability in playing badminton. (Nasrullah et al., 2021) athletes who undergo power limit and agility training show better improvements in agility and speed. From the explanation above, good leg muscle endurance, supported by a structured training program, is proven to increase agility.

The interaction between treatment (shadow using application and conventional shadow) and leg muscle endurance (high muscle endurance and low muscle endurance) on agility. Based on the results of the hypothesis, there is no significant interaction between the type of treatment and leg muscle endurance. However, when viewed from the descriptive statistical data, it shows that the type of treatment given to the group of high leg muscle endurance and low leg muscle endurance has a big difference, as seen from the results of the total pretest, the low muscle endurance group with the type of treatment given obtained an average - an average of 14.10, at the time of the posttest at 14.50 it only increased by 0.40, and the total pretest results for the high muscle endurance group with the type of treatment given obtained an average of 15.10, at the time of the posttest it increased by 16.60 by 1.50.

The descriptive statistical data shows that there is an interaction between the type of treatment and leg muscle endurance in terms of the total results *post-test*, but the results of the hypothesis show that there is no interaction between the two things, this happens because the difference in the results is not too far.

This problem that researchers get often occurs in studies involving muscle endurance and exercise programs that are made without interaction. (Jaydip Bhalodia & Thakor, 2019) Conducted a study where one of the results found no interaction between plyometric training types and muscle endurance in badminton players in increasing agility and power. (Dastpak et al., 2017) the results showed a significant increase in strength and speed, but there was no interaction between the types of exercise (workouts with weights and exercises with body weight) and muscle endurance in badminton players in increasing power and speed. (Mohammad Azharuddin, 2021) research shows that the two training groups (plyometric and circuit training) experienced a significant increase in agility and muscle endurance, but during interaction testing, the results showed that there was no interaction between the type of plyometric and circuit training exercises and muscle endurance in players badminton in increasing agility and endurance. This is what makes the researchers not so disappointed with the results that there is no interaction between the type of exercise and the type of muscle endurance, things like this are every day in the world of research.

Conclusions

Based on the analysis of the data and discussions, the following conclusions can be drawn, this study revealed significant differences between shadow training using an app and conventional methods in the context of movement speed. An F result of 38.37 and a significance value of 0.000 (less than 0.05) highlighted the effectiveness of using technology in improving movement speed through shadow training. In addition, the impact of muscular endurance on movement speed also proved significant, with a notable difference between high and low muscular endurance (F result 59.992, significance value 0.000). Further analysis revealed a marked increase in movement speed for individuals with high muscular endurance (1.50 increase from 15.10) and a moderate increase for low muscular endurance (0.40 increase from 14.10). However, although these two factors had a significant impact separately, the study showed the absence of a significant interaction effect between the training method and leg muscle endurance on moving speed (F result 0.634). Thus, the conclusion of this study confirms that integrating technology in shadow training can improve movement speed, and muscular endurance plays a crucial role in such improvement. Nonetheless, the interaction between the training method and muscular endurance is insignificant, indicating the complexity of the relationship between the two variables in the context of physical skill improvement.

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