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Combination of plyometric and ladder drill: Its impact on improving speed, agility, and leg muscle power in badminton

Muhammad Labib Siena Ar Rasyid[1acde], Oce Wiriawan[2ab], Gigih Siantoro[2bd], Donny Ardy Kusuma[3cf], Afif Rusdiawan[3ef]

[1]Faculty of Sport and Health Science, Universitas Negeri Surabaya & Sport Exercise and Research Centre, Universitas Negeri Surabaya

[2]Department of Master of Sports Education, Faculty of Sports Science, Universitas Negeri Surabaya, Indonesia

[3]Department of Sport Coaching Education, Universitas Negeri Surabaya & Sport Exercise and Research Centre, Universitas Negeri Surabaya

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Abstract

Badminton is the fastest racquet sport in the world, so training methods are needed that can increase speed, agility, and leg muscle power. This research aims to determine the impact of a combination of plyometric and ladder drill training methods in increasing leg muscle speed, agility, and power. This research is a quantitative study with a quasi-experimental type and uses a nonequivalent control group design. Purposive sampling technique was used from 36 trained male students aged 12-16 years old from junior high school 1 to 36 years old badminton students. The research subjects were divided into three groups, namely TR (tuck jump-double leg run), SH (squat jump-double leg hop), and C (conventional exercise), which were divided using matched ordinal pairing. Each group consists of twelve students doing treatment with a frequency of three days a week for six weeks. The research instruments used were the 30-meter sprint, agility T-test, and Jump MD. Data collection was carried out twice during the pretest and posttest. Data analysis techniques using Manova and post hoc tests. The study's results on the Manova test showed significant differences in the three groups with sig. 0.000 ($p<0.05$). The Manova test results showed significant differences in the three groups' increasing speed, agility, and leg muscle power simultaneously. The post hoc test showed that the TR and SH groups differed significantly from the C group ($p<0.05$). The conclusion is that combining plyometric training and ladder drills significantly impacts increasing leg speed, agility, and muscle power.

Keywords: Plyometrics, ladder drill, speed, agility, leg muscle power.

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Author's contribution: a – Preparing concepts; b – Formulating methods; c – Conducting research; d – Processing results; e – Interpretation and conclusions; f - Editing the final version

INTRODUCTION

Badminton is one of the sports achievements that is the pride of Indonesia because Indonesia's badminton achievements worldwide are

Correspondence author: Muhammad Labib Siena Ar Rasyid, Universitas Negeri Surabaya, Indonesia.
Email: labibsiena@gmail.com

quite encouraging (Maksum & Indahwati, 2023). It has become Indonesia's leading sport in obtaining championship titles in multi-event events such as the Olympics (Supriyanto et al., 2022). However, in the last decade, the inconsistency of Indonesian badminton players has become increasingly apparent, which has resulted in a decrease in the performance and achievement of athletes (Purwanti, 2023). We know that the highest sports achievements cannot be achieved instantly but require a long and complex process (Asri et al., 2021; Winarni et al., 2021). Many factors affect the achievement of sports achievements, including physical condition, mastery of techniques and tactics, mental factors, and strategies (Alim, 2018). Physical conditions can be defined as components that become a unified whole, and each component cannot be separated, both in the context of maintaining and improving the components of the physical condition (Sidik et al., 2019). In addition, the physical condition has an essential role because it is the foundation for training activities (Piyana et al., 2020; Santika et al., 2020). However, to significantly improve physical condition, attention must be paid to the components of the dominant physical condition and the characteristics of the sport (Subarkah, 2020).

Badminton is one of the most popular sports in the world (Phomsoupha & Laffaye, 2015) and is the fastest racquet sport in the world (Stovba et al., 2020) because the speed of the shuttlecock can reach more than 250 km/hour in matches at the elite level (Malwanage et al., 2022). Thus, badminton is a sport that requires speed in changing directions, explosive movements, lots of reflex movements, and good motor skills (Sholeh et al., 2020). Thus, speed, agility, and leg muscle power are essential and needed components in badminton. Experts note that speed and power are the determining factors for badminton athletes (Karatnyk et al., 2016). In addition, agility is also an essential component in badminton (Frederick et al., 2014). Knowing that speed, agility, and leg muscle power are essential in badminton show that training methods are needed to improve these three components.

In badminton, explosive jumping movements and short-distance sprints are the most dominant elements (Liu & Wang, 2023). Agility in footwork is also vital for badminton athletes to win in competition (Jianping, 2021). Therefore, badminton has training methods that can be used to increase speed, agility, and leg muscle power, including plyometrics and ladder drills. Research has stated that plyometrics is a training method to increase leg muscle speed, agility, and power (Chandra et al., 2023), likewise with the ladder drill, which is more dominant in increasing the agility and speed components of badminton athletes (Anggraeni et al., 2019; Chandrakumar & Ramesh, 2015).

This type of plyometric training involves repeated rapid stretching and muscle contraction to increase power. It is also called an "explosive-reactive" form of strength training (Hariyanto et al., 2022). Plyometric training can increase speed, agility, and vertical jump (leg muscle power) (Poomsalood & Pakulanon, 2015). In this study, the plyometric training models used were tuck jumps and squat jumps, which are popular variations of these exercises in increasing leg muscle strength and power (Hansen & Kennelly, 2017).

Various variations of ladder drill exercises are known to significantly increase the speed and agility components (Alviana et al., 2020; Anggraeni et al., 2019; Nawir & Jamaluddin, 2020). The ladder drill has many variations of the exercise, but this study uses variations of the double-leg run and double-leg hop. The double leg run has another name, namely fast feet or quick feet, which has the characteristic of the movement, namely that in one box, the ladder will be entered by both legs alternately between one leg and the other with fast movements (such as running movements) (Mbabho, 2021). On the other hand, the double-leg hop variation is also known as bunny hop or double-leg bunny hop, which has the characteristic of a jumping motion, where both feet enter one box to another by using the jumping motion of both legs simultaneously (Ravi & Kalimuthu, 2019; Syahrastani & Fadillah S, 2021).

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The plyometric and ladder drill training methods have many positive impacts on athletes. However, when this research was made, researchers had yet to find a research topic that revealed the effect of a combination of plyometric and ladder drill exercises on speed, agility, and leg muscle power, especially in badminton athletes. Thus, this study aims to reveal the impact of a combination of plyometric and ladder drill exercises on badminton players' speed, agility, and leg muscle power so that this research will be able to contribute to developing the dimensions of sports coaching science that sports practitioners can implement in the training process. The subjects of this study were male badminton extracurricular students at SMP Negeri 1 Jogoroto, Jombang, who were trained and aged 12-16 years.

METHOD

Research design

This research is quantitative research with a quasi-experimental research type. This type of research is known as the development of a true experiment, which has a control group. However, the control group cannot fully function to control various external variables that can affect experimental research (Sugiyono, 2017). Quasi-experimental research was applied because the researcher did not have full control over the research subjects on independent variables, such as rest time and daily food intake for each research subject. Meanwhile, the research design used was a nonequivalent control group design. This design provides treatment to the experimental group and provides a control group or other groups to serve

as a comparison (Sugiyono, 2022). The following is a picture of the research design shown below.

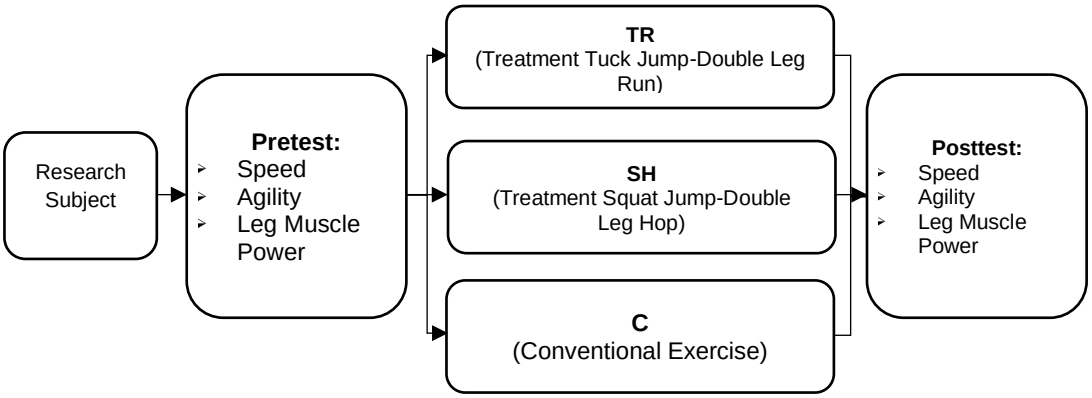

Figure 1. Research Design

Research Subjects

The research subjects in this study were male junior high school 1 Jogoroto students, Jombang Regency, who participated in badminton extracurricular activities and were trained. The total number of research subjects was 36, obtained using a purposive sampling technique (Lenaini, 2021; Maksum, 2018). The criteria for research subjects are 1) male, 2) ages between 12-16 years, 3) physically and mentally healthy, and 4) willing to follow the research stages until completion. The 36 research subjects were divided into three groups based on the matched subject ordinal pairing method Gumanti et al., (2016) with details: 1) TR group (tuck jump & double leg run exercises) with 12 research subjects, 2) SH group (squat jump & double leg hop exercises) with 12 research subjects, and 3) Group C (conventional exercises) with 12 research subjects. Ordinal pairing is done by ranking the results of the pretest.

Instrument and data measurement

Three instruments are used in this study and used twice (during the pretest and posttest). The three instruments are a 30-meter sprint to measure speed (Altmann et al., 2019; Chiwaridzo et al., 2017), an agility T-test to measure agility (Kamuk, 2020; Wiriawan, 2017), and the Jump MD to measure jump height (Wiriawan, 2017) then the results of the jump height are converted into the power formula (Wismanadi et al., 2020):

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$$P = \frac{m \times g \times h}{t} \quad (1)$$

Note:

P= power (watt), *m*= mass (kg), *g*= gravitation (9,8 m/s^2), *h*= jump height (m), *t*= time (second) (Haryono & Pribadi, 2013; McGinnis, 2013).

Research treatment

All 36 research subjects started the research phase with a pretest, and the pretest results were used as a reference for grouping with matched subject ordinal pairing (Gumanti et al., 2016). After grouping, the research subjects performed the treatment according to their respective groups. Treatment is carried out with a training frequency of three days a week which is carried out for six weeks, with a total of 18 meetings (Guo et al., 2021). After the last meeting for treatment, the final stage of the research was carried out, namely the posttest. The training program compiled for the group that was given the combined treatment of plyometric and ladder drill exercises (TR and SH groups) can be seen in Table 1.

Table 1. Exercise program in the group that was given treatment (TR and SH groups)

Group	Week	Name of exercise	Freq	Intensity	Set	Recovery	Interval
TR	1 – 2	Tuck Jump Double Leg Run	Three days/week	50% MR	3	2 min	3 min
	3 – 4	Tuck Jump Double Leg Run	Three days/week	60% MR	3	2 min	3 min
	5 – 6	Tuck Jump Double Leg Run	Three days/week	70% MR	3	2 min	3 min
SH	1 – 2	Squat Jump Double Leg Hop	Three days/week	50% MR	3	2 min	3 min
	3 – 4	Squat Jump Double Leg Hop	Three days/week	60% MR	3	2 min	3 min
	5 – 6	Squat Jump Double Leg Hop	Three days/week	70% MR	3	2 min	3 min

Note: MR = Maximum Repetition

The table above presents the exercise program for the TR and SH groups for six weeks, each week doing three days. The TR group combined tuck jump and double leg run exercises, while the SH group did squat jump and double leg hop exercises. The group in conventional training (Group C) was used as the control group in this study because they were not given plyometric treatment and ladder drills.

Data analysis

Data analysis techniques used were descriptive statistics, data requirements tests (normality and homogeneity tests), and inferential tests (paired sample t-test, Manova, and post hoc LSD). The data analysis process in this study used Microsoft Excel and SPSS applications.

RESULT

The research results obtained the characteristics of research subjects regarding age, height, and weight (N = 36). Thus, descriptive statistical analysis data are presented regarding the characteristics of research subjects using the mean and standard deviation (SD) values in Table 2 below.

Table 2. Characteristics of research subjects

Variable	Mean ± SD		
	TR	SH	C
Age (years)	13.58 ± 1.240	13.58 ± 1.084	13.75 ± 1.36
Weight (kg)	43.92 ± 9.746	43.33 ± 10.219	45.75 ± 12.871
Height (m)	1.598 ± 0.083	1.588 ± 0.092	1.577 ± 0.134

Considering that the research subjects were aged between 12-16 years, from Table 2 above, all research subjects had normal height and weight according to the growth of Indonesian children (Pulungan et al., 2018).

Before the inferential tests (paired sample t-test, manova test and post hoc) were carried out, data requirements tests, including normality and homogeneity tests. The normality test used is the Kolmogorov-Smirnov normality test which can be seen in the table below.

Table 3. Normality Test

Variable	Sig. (2-tailed)
Pretest speed	0.672
Pretest agility	0.880
Pretest limb muscle power	0.744
Posttest speed	0.833
Posttest agility	0.826
Posttest limb muscle power	0.993
Δ speed	0.500
Δ agility	0.977
Δ leg muscle power	0.609

p>0.05, the data is stated to be normally distributed

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The results of the Kolmogorov-Smirnov normality test presented in Table 3 show that all research variable data are normally distributed (p>0.05). The homogeneity test used next is Levene's Test homogeneity test which is presented in Table 4 below.

Table 4. Homogeneity Test

Variable	Sig. (2-tailed)
Δ speed	0.500
Δ agility	0.977
Δ leg muscle power	0.609

p>0.05 variance of homogeneous data

From the results of the homogeneity test above, it can be concluded that this study has a homogeneous variant of the data (P>0.05). After going through normality and homogeneity tests, the data in this study can be ascertained to be normally distributed and have homogeneous data variants. So that data analysis can be continued with the paired sample t-test, Manova and Post Hoc tests.

Table 5 contains the delta values or the difference between the posttest and pretest (posttest-pretest) of the three dependent variables, along with the results of the paired sample t-test.

Table 5. The results of the delta values for speed, agility, leg muscle power, and the paired sample t-test

Group	Variable	Δ (mean ± SD)	p-value (Sig. (2-tailed))
TR	Speed (sec)	-0.396 ± 0.144	0.000
	Agility (sec)	-0.656 ± 0.337	0.000
	Leg muscle power (watt)	126.83 ± 72.01	0.000
SH	Speed	-0.302 ± 0.118	0.000
	Agility	-0.542 ± 0.177	0.000
	Leg muscle power (watt)	105.39 ± 54.18	0.000
C	Speed	-0.108 ± 0.085	0.001
	Agility	-0.244 ± 0.260	0.008
	Leg muscle power (watt)	41.05 ± 36.76	0.003

P-value <0.05 is a significant effect.

The results of the paired sample t-test found that all three groups could increase leg muscle speed, agility, and power (p<0.05). The differences between the three groups can be seen through the Manova and post hoc tests. The results of the Manova test can be seen in Table 6, namely the between-subject test below.

Table 6. Manova test results from the test of between-subjects effects

Variable	Sig. (2-tailed)
Speed	0.000
Agility	0.002
Leg muscle power	0.002

P<0.05 indicates a significant difference.

The results of the Manova test presented in Table 6 above show that the three groups have significant differences simultaneously in the variables of speed, agility, and leg muscle power (p<0.05).

After conducting the manova test, it showed that there were differences between the three groups in speed, agility, and leg muscle power. The results of the LSD post hoc test are presented in Table 7 below.

Table 7. Post Hoc LSD test

Variable	Group		P (sig.)
Speed	TR	SH	0.059
		C	0.000*
	SH	C	0.000*
Agility	TR	SH	0.301
		C	0.001*
	SH	C	0.010*
Leg Muscle Power	TR	SH	0.357
		C	0.001*
	SH	C	0.008*

*P<0.05 indicates a significant difference.

The results showed that there was a significant difference between the group given the treatment (Group TR and SH) and the conventional training group (Group C) (P<0.05). However, there was no significant difference between the TR and SH groups in increasing speed, agility, and leg muscle power (P>0.05).

DISCUSSION

This study aims to determine the effect of a combination of plyometric and ladder drill exercises in increasing speed, agility, and leg muscle power. The study results show that the combination of plyometric exercises and ladder drills (Group TR and SH) can increase speed, agility, and leg muscle power in badminton better than conventional exercises (Group C). The results of the paired sample t-test showed that the group that was given the

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treatment (Group TR and SH) and the conventional training group (Group C) could increase speed, agility, and leg muscle power ($p<0.05$). These results align with previous research, which found that plyometric training can increase speed, including sprint distances of 30 meters (Arianda et al., 2021). Not only that, research by Tottori & Fujita (2019) found that plyometric exercises can increase sprint speed at distances of 20-30 meters, 30-40 meters, and 40-50 meters, as well as stride lengths of 0-10 meters, 20-30 meters, and 30 – 40 meters. Ladder drill training is also known to increase speed or performance of speed significantly (Nuryadi & Firmansyah, 2018; Short et al., 2022). Ladder drills can also significantly improve speed performance in badminton players (Chandrakumar & Ramesh, 2015).

Plyometrics is a training method that can be used to improve agility and other motor skills (Čaprić et al., 2022). A compelling adaptation transfer will occur if training is performed as needed (such as competition, sparring, or try-out) (Čaprić et al., 2022). Meanwhile, plyometric movements such as jumping, hopping, and bounding, which are performed quickly and explosively, have a relationship with increased agility components (Cappa & Behm, 2013; Silva et al., 2019). Specifically in badminton, plyometric training progressively in badminton players for six weeks can significantly increase agility (Irawan, 2017). Adolescent badminton athletes also experience increased agility after being given plyometric training interventions (Ozmen & Aydoğmuş, 2017). Agility can occur due to explosive force (Kosni et al., 2022) and depends on muscle strength, speed, coordination, and dynamic balance (Heang et al., 2012). In addition, ladder drills can also be used to increase agility and speed (Dhanaraj, 2014). The ladder drill exercise uses a fitness tool in the form of a ladder that is placed on a floor/ground surface, where a person will run, jump, and jump by moving his feet quickly on the tool to develop the speed and agility of the person using it (Kusuma & Kardiawan, 2017). Another study revealed a significant increase in agility in badminton players after the intervention of ladder drill exercises (Chandrakumar & Ramesh, 2015).

In general, plyometric exercises have been implemented in all sports to help increase muscle strength and power, where plyometric exercises consist of eccentric movements followed by concentric contractions of the same muscle group (Irawan, 2017). Plyometrics are designed to improve jumping performance abilities which are used to increase power output and explosiveness by training the muscles to work more in a short time (Bhosale et al., 2020). This plyometric training method increases strength, acceleration, and power (Váczi et al., 2011). According to research on 90 badminton athletes, there is an increase in the achievement of faster sprint times and better jumping abilities (Panda et al., 2022). The ability to jump in badminton is closely related to leg muscle power (Wea & Samri, 2022). Plyometrics also significantly improves jumping smash skills in badminton games (Wea & Samri, 2022). Even plyometric training is a training method that can improve forehand smashes in badminton (Sholeh et al., 2020). Not only plyometric exercises, ladder drill exercises also can significantly increase the leg muscle power component (Kusuma & Kardiawan, 2017). In addition, ladder drill exercises are effective and significant in developing speed, agility, and power (Sethu, 2014).

The group that did conventional exercises or the group that was not given treatment (group C) could increase speed, agility, and leg muscle power in badminton players because badminton is a sport that has benefits in increasing physical fitness in adolescents, including: increasing muscle endurance, strength, power, flexibility, and cardiorespiratory fitness (Fernandez-Fernandez et al., 2013; Lee et al., 2021; Mohammed, 2020; Stovba et al., 2019). One's involvement in badminton can improve all aspects of physical health, particularly heart and lung function and basic physical capacities (Cabello-Manrique et al., 2022).

The Manova test results showed significant differences between the three groups' increasing speed, agility, and leg muscle power in badminton players ($p<0.05$). However, the results of the post hoc test showed that there was a significant difference between the group given the combination treatment of plyometric and ladder drill exercises (Group TR and SH) and

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the conventional training group (Group C) ($p<0.05$). If the two groups that were given treatment were compared to each other, namely between the TR and SH groups, they showed no significant difference in increasing speed, agility, and leg muscle power in badminton players. According to previous research, the most effective plyometric training program can be carried out routinely, lasting 6 to 8 weeks (Fernandez-Fernandez et al., 2016; Filipas et al., 2023; Guo et al., 2021; Lu et al., 2022; Ozbar et al., 2014), as well as the ladder drill training program. The results of this study which stated that there were no significant differences in the TR (tuck jump-double leg run) and SH (squat jump-double leg hop) groups, were in line with several previous studies, even though the plyometric tuck jump and squat jump exercises were both can improve the performance of the physical condition of leg muscle power, but there is no known significant difference between the two (Ashari et al., 2019; Falah & Pranatahadi, 2019; Ratno & Darmawan, 2019). The previous study also revealed that the average value of increasing leg muscle power was more significant in the group that was given the plyometric tuck jump exercise intervention compared to the plyometric squat jump, although the significance value proved that there was no significant difference (Ashari et al., 2019; Falah & Pranatahadi, 2019; Ratno & Darmawan, 2019). This is because the motion in doing the plyometric tuck jump and ladder drill double leg run requires more explosive movements compared to the plyometric squat jump and ladder drill double leg hop.

This research provides results and novelty in the form of a positive impact from a combination of plyometric and ladder drill exercises on badminton players in increasing speed, agility, and leg muscle power. As we know that badminton is one of the most popular sports in the world (Phomsoupha & Laffaye, 2015) and is the fastest racquet sport in the world (Stovba et al., 2020) because the speed of the shuttlecock can reach more than 250 km/hour in matches at the elite level (Malwanage et al., 2022). This is due to the demands of modern sports, which require athletes to be faster and stronger (Polglaze & Hoppe, 2019), including in badminton.

Badminton needs speed and leg muscle power, especially when attacking (Liu & Wang, 2023). In addition, the ability of fast and accurate footwork techniques on the athlete's field must have good lower leg strength and agility (Jianping, 2021). This study's results will positively contribute to badminton sports coaching if coaches or practitioners implement them on their athletes in the training process. The limitations of this study are that the research subjects used are still not at the sub-elite or elite level, and the gender or sex of the research subjects is only male. Therefore, the recommendation for further research is to use sub-elite or elite athletes and women as research subjects. Thus, the combined plyometric and ladder training results from elite, sub-elite, amateur, and novice athletes can be compared. In addition, there will be comparisons between male and female badminton athletes. In addition, the weakness of this study is that the research subjects used were in their teens, and the number was small. Thus, gaps for future research could use research subjects in adulthood or the golden age who are at the peak performance stage and a larger number of research subjects.

CONCLUSION

From the results of the research and discussion above, the conclusions of this study are: (1) the combination of plyometric and ladder drill exercises can increase the speed, agility, and leg muscle power, and (2) there is no significant difference between the two groups given the treatment, namely TR (tuck jump-double leg run) and SH (squat jump-double leg hop) in increasing speed, agility, and leg muscle power. This research implies that the combination of plyometric and ladder drill training methods can be implemented and used in the training process in badminton. So that it can increase speed, agility, and leg muscle power, which can help improve the performance of badminton athletes.

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