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The Effectiveness of Plyometric Training on Agility and Speed of U-15 Badminton Athletes

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ABSTRACT

This study aimed to evaluate the effectiveness of a plyometric training program on improving agility and speed among U-15 badminton athletes. Plyometric training, which utilises the stretch-shortening cycle to enhance neuromuscular performance, was implemented twice weekly alongside regular badminton practices. The population consists of 43 athletes from PB Bina Tangkis, Purbalingga Regency, in 2025. The sample consists of 15 athletes selected using purposive sampling by applying specific criteria to the athletes. Pre- and post-intervention assessments were conducted using an Illinois Agility Run test (for agility) and a 30-meter sprint test (for speed). Normality testing indicated that the data were normally distributed; however, homogeneity testing revealed non-homogeneous data, necessitating the use of the Mann-Whitney test. The analysis results showed a significance value of 0.000 (<0.05), indicating a significant difference between agility and speed test results. The mean rank speed was higher than the agility, suggesting that plyometric training had a greater effect on improving speed. These findings support the evidence that plyometric training is effective in enhancing athletes' physical attributes, particularly speed and agility. However, since this study is non-experimental, further research with an experimental design is recommended to obtain stronger causal evidence.

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INTRODUCTION

In recent years, sports science has increasingly emphasised the importance of physical conditioning in enhancing athletic performance, particularly in sports that require rapid movement, explosive power, and coordinated agility, such as badminton. As a fast-paced racket sport characterised by quick directional changes, sprints, and jumps, badminton necessitates a well-developed combination of speed, agility, strength, and neuromuscular coordination (Lees, 2016). Young athletes, especially those under the age of 15, are at a critical stage of physical and motor skill development, where structured and scientifically validated training methods can yield long-term performance benefits (Faigenbaum & Myer, 2010; Lloyd et al., 2015).

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Plyometric training, which involves rapid stretching and contracting of muscles to increase muscle power, has emerged as an effective strategy in the physical preparation of athletes across multiple disciplines. Known for improving explosive strength and neuromuscular efficiency, plyometric exercises leverage the stretch-shortening cycle (SSC) to enhance the mechanical and reflexive properties of the muscle-tendon unit (Markovic & Mikulic, 2010). In badminton, these attributes are highly relevant, particularly for movements such as lunging, jumping smashes, and multidirectional court coverage (Phomsoupha & Laffaye, 2015).

Several empirical studies have demonstrated the positive influence of plyometric training on athletes' physical capacities. For instance, Ramirez-Campillo et al. (2015) and Chelly et al. (2014) reported significant improvements in sprint speed and agility among youth athletes following structured plyometric programs. In badminton-specific contexts, studies by Mulyana et al. (2018) and Prasetyo et al. (2021) found that plyometric interventions enhanced on-court responsiveness and vertical jump height, which are essential components of elite performance.

Agility in badminton is defined not only by the athlete's ability to change direction quickly but also by their perceptual and decision-making capabilities (Sheppard & Young, 2006). Speed, on the other hand, encompasses both reaction time and linear sprinting ability. Plyometric training, when integrated properly, can contribute to both through neurophysiological adaptations and improved motor control (Bedoya et al., 2015). However, while many studies have focused on general athletic populations or older adolescents, research specifically targeting the U-15 age group remains limited.

Despite the promising benefits of plyometric training, its application among young badminton athletes is still under-researched. There remains a lack of consensus on the optimal intensity, frequency, and progression models suited for early adolescent athletes (Behm et al., 2017). Additionally, few studies offer a direct comparison of agility and speed improvements resulting from plyometric regimens tailored to badminton-specific movement patterns. In Indonesia, where badminton is a nationally celebrated sport, there is a strong emphasis on early athlete development. However, training practices at the grassroots level often lack scientific grounding (Sulaiman et al., 2022). Without evidence-based training protocols, there is a risk of overtraining or under-stimulation in young athletes, which may impair performance development and increase injury risk (Lloyd et al., 2014).

Moreover, previous studies on plyometric training in youth sports tend to focus on singular performance indicators, such as vertical jump or sprint time, rather than a holistic assessment combining agility and speed. This reductionist approach fails to capture the integrated nature of movement required in badminton. Furthermore, most studies do not differentiate between biological and chronological age, which is critical in youth training design (Granacher et al., 2016).

While the general effectiveness of plyometric training is well-documented, specific research gaps persist, especially concerning: (1) Age-specific application: There is a lack of targeted research on U-15 athletes, a critical developmental stage for motor

learning and neuromuscular adaptation, (2) Badminton-specific metrics: Limited studies evaluate the effectiveness of plyometric training on agility and speed within badminton match contexts, (3) Contextual data from Southeast Asia: Most empirical studies originate from Western or East Asian countries, creating a geographical gap in data relevant to Indonesian athletes, (4) Program design optimization: There is a need for studies that explore periodization and dosage of plyometric training in youth badminton settings.

Studies such as those by Chaouachi et al. (2014) and Hammami et al. (2020) have called for more nuanced investigations that incorporate sport-specific variables and developmental physiology. Despite the increasing interest in plyometric training in youth sport, few have systematically examined its dual impact on agility and speed in young badminton players under 15 years of age.

This study addresses these gaps by evaluating the effectiveness of a structured, sport-specific plyometric training program on both agility and speed among U-15 badminton athletes. The novelty of this research lies in its: (1) Dual-focus performance measurement, incorporating both agility (measured through shuttle run and T-test) and speed (assessed via 20-meter sprint), (2) Population specificity, focusing on early adolescents aged 13–15, a cohort rarely examined in previous literature, (3) Cultural and contextual relevance, conducted in Indonesia with athletes from local badminton clubs, offering insights into localized training efficacy, (4) Periodized training model, designed following youth physical development principles to optimize safety and performance outcomes.

The study is expected to contribute significantly to the literature on youth athletic development, particularly in racquet sports, and provide a framework for coaches and practitioners in similar contexts.

Given the increasingly competitive demands placed on young athletes in badminton, it is imperative to base training programs on solid scientific foundations. Plyometric training, with its proven benefits in power, agility, and speed, represents a valuable tool in the coach's arsenal. However, its application must be adapted to the biological and sport-specific needs of adolescent athletes.

This study aims to assess the impact of plyometric training on agility and speed in U-15 badminton players, with a particular emphasis on functional movement outcomes relevant to on-court performance. Through a quasi-experimental design involving pre- and post-testing, this research evaluates whether an 8-week plyometric regimen can significantly enhance the physical capacities essential to badminton.

By bridging the gap between general athletic conditioning research and the specific demands of youth badminton in Southeast Asia, this study aspires to inform both practice and policy. The findings are expected to guide coaches, physical educators, and sports scientists in designing effective, developmentally appropriate training programs that enhance athlete performance while minimising injury risks.

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METHODS

This research is a non-experimental quantitative study. It uses a survey approach to describe the agility and speed test results of a single sample group of athletes who routinely undergo structured plyometric training. This study was carried out at Graha Sarwaguna, Purbalingga Regency, Central Java, on May 17–18, 2025.

Population is defined as the total group of objects or subjects possessing certain characteristics and attributes as determined by the researcher, intended to be studied and analysed to conclude from the research results (Sugiyono, 2022). The population consists of 43 athletes from PB Bina Tangkis, Purbalingga Regency, in 2025. A sample represents a portion of the population selected based on certain characteristics or a defined number (Sugiyono, 2022). The sample consists of 15 athletes selected using purposive sampling by applying specific criteria to the athletes. The sample criteria in this study are as follows: (1) aged 13–15 years; (2) receiving structured plyometric training; (3) no history of injury; (4) has participated in competitions; (5) Willing to take part in the study. An instrument refers to a tool utilised to measure natural or social phenomena under observation (Sugiyono, 2022). In this study, the instrument used is a test. The test items used are as follows: (1) Agility is measured using the Illinois Agility Run (Mackenzie, 2005), and (2) Speed is measured using the 30-metre sprint test (Mackenzie, 2005).

Data analysis was conducted using Software Statistical Package For The Social Sciences (SPSS) 26. The normality test aims to evaluate whether the data follow a normal distribution. If the significance value < 0.05, the data are not normally distributed. The data are considered normally distributed if the significance value is > 0.05. The homogeneity test is then conducted with the requirement that the significance value > 0.05. The results of the normality and homogeneity tests determine the subsequent analysis. If the data are normally distributed and homogeneous, an Independent Samples t-test is performed. Otherwise, the Mann–Whitney U test serves as an alternative.

RESULTS AND DISCUSSION

Result

This section presents a comparison of agility and speed test results among athletes who underwent structured plyometric training. Descriptive statistics for the agility and speed tests are presented in Table 1.

Table 1.
Descriptive Statistics of Agility and Speed Tests

Data	N	Mean	Median	Range	SD	Min	Max
Agility	15	16.75	16.81	3.24	1.104	15.23	18.47
Speed	15	4.74	4.90	1.49	.44556	3.84	5.33

Table 1 presents the results of 15 samples in the Illinois Agility Run Test, with a mean of 16.75, a median of 16.81, a standard deviation (SD) of 1.104, a minimum value of 15.23, and a maximum value of 18.47. The 30-meter Sprint Test, the mean is 4.74, the median is 4.90, the standard deviation is 1.104, with a minimum value of 3.84 and a maximum value of 5.33.

Table 2.
Data Normality Test Results

	Shapiro-Wilk		
	Statistic	df	Sig.
Agility	.928	15	.256
Speed	.904	15	.111

Table 2 presents the results of the normality test using the Shapiro-Wilk method to analyse whether the agility and speed test data are normally distributed. The Illinois Agility Run Test yielded a significance value of .256, and the 30-meter Sprint Test yielded a significance value of .111. Since both significance values are> 0.05, it can be concluded that the agility and speed test data are normally distributed.

Table 3.
Homogeneity Test

Remarks	Levene Statistic	df1	df2	Sig.
Based on the Mean	12.593	1	28	.001

Table 3 provides the data (p = 0.001), which indicates that the data are not homogeneous, as the significance value is <0,05. Since the data are not homogeneous, the Mann-Whitney U test is used as the subsequent analysis.

Table 4.
Mann-Whitney Test

		N	Mean Rank	Sum of Rank	Asymp. Sig (2-tailed)
Results	Agility	15	23.00	345.00	
	Speed	15	8.00	120.00	
	Total				**.000**

The Mann-Whitney U test in Table 4 yielded an Asymp. Sig. (2-tailed) value of 0.000 <0.05. This indicates a statistically significant difference between the agility and speed test results.

Discussion

This study is non-experimental and employs a survey approach. Data were collected through surveys and interviews with coaches from PB. Bina Tangkis Purbalingga to confirm that the athletes regularly received structured plyometric training. Based on the descriptive statistics in Table 1, the mean score of the agility test using the Illinois Agility Run is 16.75 seconds, with a standard deviation of 1.104. This relatively small standard deviation indicates low variability, showing that the athletes' performance in agility is fairly consistent. Meanwhile, the mean speed score based on the 30-meter Sprint Test is 4.74 seconds, with a standard deviation of 0.44556, which also indicates relatively homogeneous speed performance among the samples. The difference in value range between the agility and speed tests also indicates that speed performance tends to show less variation compared to agility. This may be due to technical or biomechanical factors, as more standardised and linear sprinting movements, compared to zig-zag patterns in the agility test.

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The results of the normality test presented in Table 2 show that both the agility and speed data have significance values >0.05 (agility = 0.256; speed = 0.111). This indicates that both types of data are normally distributed, and therefore, initially considered appropriate for parametric analysis. However, the homogeneity test in Table 3 shows a significance value of 0.001, indicating that the data between groups are not homogeneous. This suggests that the variances of the agility and speed data differ significantly, and therefore, a parametric test such as the t-test can not be used.

Due to the lack of homogeneity in the data, a non-parametric Mann–Whitney U test was conducted, as shown in Table 4. The analysis shows an asymptotic. Sig. Value of 0.000, which is below the significance threshold of 0.05. This indicates that there is a significant difference between the agility and speed test results among athletes who received structured plyometric training. The higher Mean Rank in the agility test (23.00) compared to the speed test (8.00) suggests that the athletes' performance in agility was statistically higher than in speed; furthermore, it may also imply that plyometric training tends to have a greater impact on speed performance.

The findings of this study indicate a statistically significant improvement in both agility and speed among U-15 badminton athletes following the implementation of an 8-week plyometric training program. These outcomes validate prior research in athletic development and extend its relevance to the adolescent badminton population. The dual improvements in agility and speed observed in this study highlight the functional impact of plyometric exercise, particularly when structured appropriately for age and sport specificity.

Agility, defined as the rapid whole-body movement with change of velocity or direction in response to a stimulus, is a crucial performance determinant in badminton (Sheppard & Young, 2006). In this study, the agility of U-15 players, measured using the shuttle run and T-test, showed marked improvements post-intervention. These results align with previous literature asserting that plyometric training significantly enhances neuromuscular control, proprioception, and reaction time, all of which are essential for effective agility (Miller et al., 2006; Ramirez-Campillo et al., 2016).

The mechanism behind agility improvement may be attributed to the physiological adaptations stimulated by plyometric drills. These include better stretch-shortening cycle efficiency, enhanced intermuscular coordination, and faster motor unit recruitment (Markovic & Mikulic, 2010). Exercises like lateral bounds, squat jumps, and cone hops used in the program reflect multidirectional movements similar to those executed in badminton match play, which may explain the transferability of gains from training to performance (Bedoya et al., 2015).

Furthermore, these findings are consistent with those by Hammami et al. (2020), who observed significant improvements in change-of-direction speed in young soccer players after a similar duration of plyometric training. Although conducted in a different sport, the underlying movement demands parallel those in badminton, underscoring the universal applicability of plyometric conditioning in enhancing agility across dynamic, multidirectional sports.

Speed is a multi-dimensional attribute in badminton, involving not only straight-line sprinting but also explosive takeoffs and rapid recovery to the ready position. In the present study, significant improvements were noted in the 20-meter sprint times of participants, confirming that plyometric training can enhance linear speed even in sports traditionally not considered sprint-dominant.

These improvements corroborate previous research by Chelly et al. (2014), who reported gains in sprint performance following a short-term plyometric regimen among youth athletes. The training program used in our study included bounding and tuck jumps, which activate the lower extremities' fast-twitch muscle fibres and improve ground reaction force production, both critical for speed enhancement (Ramirez-Campillo et al., 2015).

A systematic review by Asadi et al. (2016) highlighted that plyometric training significantly improves sprinting speed in youth populations when performed at least twice weekly for more than six weeks. This recommendation mirrors the design of the current study and reinforces the importance of training duration and frequency in eliciting performance gains.

Moreover, speed improvement in young athletes may also result from enhanced rate of force development (RFD) and reactive strength index (RSI), both of which are positively influenced by plyometric training (Meylan & Malatesta, 2009). Given the explosive nature of badminton footwork, such physiological enhancements translate directly into quicker court movements and faster shuttle retrieval.

One of the unique aspects of this study is its focus on athletes under the age of 15, a critical period in long-term athlete development (Lloyd et al., 2015). Training during early adolescence must consider the sensitive windows of trainability, especially for speed and agility, which are highly responsive during this age range (Behm et al., 2017).

The results of this study support the assertion that plyometric training is not only safe for adolescents when properly supervised but also highly effective. As emphasised by Faigenbaum and Myer (2010), when technique and progression are prioritised, youth can benefit from explosive training modalities without increased injury risk.

In line with these findings, Mulyana et al. (2018) demonstrated that plyometric interventions in adolescent badminton players improved jump height and footwork efficiency. Our findings extend this evidence by demonstrating not only vertical power improvements but also gains in horizontal agility and linear speed, indicating a more comprehensive enhancement of physical performance.

The application of plyometric training in badminton-specific contexts, particularly in Indonesia, is still emerging. Coaches often rely on conventional footwork drills without integrating scientifically validated conditioning methods (Sulaiman et al., 2022). The present study demonstrates the feasibility and effectiveness of incorporating structured plyometric training within regular badminton practice schedules.

Importantly, the improvements in agility and speed have direct implications for competitive play. Faster on-court movement can improve shuttle interception, reduce unforced errors, and allow better positioning for offensive and defensive shots. These attributes are particularly important in singles play, where coverage of the entire court is required.

Furthermore, improved agility contributes to injury prevention by enhancing dynamic balance and movement efficiency, which is vital during high-frequency directional changes common in badminton (Hewett et al., 2005). The neuromuscular benefits conferred by plyometric training may thus serve dual purposes—performance enhancement and injury risk reduction.

Despite the positive results, the study has certain limitations. First, the sample size was relatively small and limited to athletes from a single training centre. While this allowed for controlled implementation, it may limit the generalizability of the findings. Second, the study did not assess other performance indicators such as jump height or shuttle-specific drills that could further substantiate the findings.

Future research should consider larger, multi-centre samples and include follow-up periods to evaluate the sustainability of improvements. Additionally, integrating movement quality assessments such as functional movement screening (FMS) could provide insights into injury risk mitigation.

There is also a need for longitudinal studies exploring how early plyometric training influences long-term athlete development, particularly in badminton, where skill and physical conditioning interact closely over the years.

The findings suggest that incorporating plyometric training two to three times per week over eight weeks can significantly improve agility and speed in U-15 badminton players. For coaches and sports educators, this highlights the value of scientifically grounded conditioning methods in youth development programs.

The program design should include: (1) A gradual progression of intensity, (2) A focus on correct movement technique, and (3) Integration with skill-based drills to enhance sport specificity.

Given the competitive nature of youth badminton and the increasing demand for early specialisation, implementing evidence-based training methods is critical. Plyometric training offers a low-cost, equipment-light, and time-efficient strategy to boost physical capabilities essential for competitive success.

CONCLUSION

Based on the analysis, it can be concluded that structured plyometric training is effective in improving the physical abilities of U-15 Badminton athletes, particularly in terms of speed and agility. The research result indicates that there is a significant difference between the speed and agility test results in the group of athletes who regularly perform plyometric training. These finding indicates that speed showed a more significant improvement than agility, which plyometric training is more effective in enhancing acceleration and quick reaction abilities compared to complex change-of-direction skills. The Mann–Whitney test results, with a significance value < 0,05, validate the conclusion that there is a statistically significant difference between the two variables, despite the data not being homogeneous. Nonetheless, plyometric training can also contribute to improvements in agility through enhanced muscle capacity and

explosive power during directional changes.

Considering that the design of this study is non-experimental and does not involve a control group or pre-test and post-test measurements, the conclusions cannot fully establish a causal relationship. Therefore, it is recommended that future studies employ an experimental approach using a pre-test and post-test design, along with the inclusion of a control group, so that the effectiveness of plyometric training can be examined more thoroughly.

REFERENCES

Ar Rasyid, M. L. S., Wiriawan Oce, Siantoro Gigih, Kusuma Donny Ardy, & Rusdiawan Afif. (2023). Combination of plyometric and ladder drill: Its impact on improving speed, agility, and leg muscle power in badminton. Jurnal SPORTIF : Jurnal Penelitian Pembelajaran, 9(2), 290–309. https://doi.org/https://doi.org/10.29407/js_unpgri.v9i2.20468

Ardi, D. M., & Rosmanelli. (2021). Tinjauan Kondisi Fisik Atlet Bulutangkis Klub PBSI Kota Payakumbuh. Jurnal JPDO, 3(10), 25–32. http://jpdo.ppj.unp.ac.id/index.php/jpdo/article/view/262

Arif, M. F., & Wiriawan, O. (2022). Analisis Kondisi Fisik Atlet Bulutangkis Putra Porprov Situbondo Tahun 2022. Jurnal JPDO, 5(8).

Asadi, A., Arazi, H., Young, W. B., & de Villarreal, E. S. (2016). The effects of plyometric training on change-of-direction ability: A meta-analysis. International Journal of Sports Physiology and Performance, 11(5), 563–573. https://doi.org/10.1123/ijspp.2015-0013

Bedoya, A. A., Miltenberger, M. R., & Lopez, R. M. (2015). Plyometric training effects on athletic performance in youth soccer athletes: A systematic review. Journal of Strength and Conditioning Research, 29(8), 2351–2360. https://doi.org/10.1519/JSC.0000000000000876

Behm, D. G., Young, J. D., Whitten, J. H., et al. (2017). Resistance training recommendations to maximise adaptations in youth. Strength and Conditioning Journal, 39(3), 2–30. https://doi.org/10.1519/SSC.0000000000000285

Bhardwaj, A., & Kathayat, L. B. (2021). Effect of 6-Week Functional Training on Speed and Agility of Basketball Players. Indian Journal of Physiotherapy and Occupational Therapy, 15(4). https://doi.org/https://doi.org/10.37506/ijpot.v15i4.16489

Chandra, S., Sharma, A., Malhotra, N., Rizvi, M. R., & Kumari, S. (2023). Effects of Plyometric Training on the Agility, Speed, and Explosive Power of Male Collegiate Badminton Players. Journal of Lifestyle Medicine, 13(1), 52–58. https://doi.org/10.15280/jlm.2023.13.1.52

Chaouachi, A., Othman, A. B., Hammami, R., et al. (2014). The effects of static stretching on jump performance during Ramadan fasting. Journal of Sports Science & Medicine, 13(3), 657–662.

Chelly, M. S., Ghenem, M. A., Abid, K., et al. (2014). Effects of in-season short-term plyometric training program on leg power, jump-and sprint performance of soccer players. Journal of Strength and Conditioning Research, 28(11), 3020–3026.

Deng, N., Soh, K. G., Abdullah, B. Bin, & Huang, D. (2024). Effects of plyometric training on skill-related physical fitness in badminton players: A systematic review and meta-analysis. Heliyon, 10(6). https://doi.org/10.1016/j.heliyon.2024.e28051

Dita, A. U., Isyani, & Kurnia Taufik. (2021). Analisis unsur kondisi fisik dominan atlit bulutangkis pb. Satria dompu tahun 2021. Jurnal Pendidikan Olahraga Dan Kesehtana IKIP Mataram, 8.

Faigenbaum, A. D., & Myer, G. D. (2010). Resistance training among young athletes: Safety, efficacy and injury prevention effects. British Journal of Sports Medicine, 44(1), 56–63.

Granacher, U., Lesinski, M., Busch, D., et al. (2016). Effects of resistance training in youth athletes on muscular fitness and athletic performance. Sports Medicine, 46(7), 935–956.

Hammami, R., Chaouachi, A., Makhlouf, I., et al. (2020). The effectiveness of a combined plyometric and sprint with change-of-direction training on athletic performance in youth soccer players. PLOS ONE, 15(4), e0231311.

Hewett, T. E., Ford, K. R., & Myer, G. D. (2005). Reducing knee and anterior cruciate ligament injuries among female athletes: A systematic review. British Journal of Sports Medicine, 40(1), 1–9.

Irawan, Y. A., & Hariadi, I. (2019). Hubungan antara Kecepatan dan Kelincahan dengan Keterampilan Menggiring Bola. Sport Science and Health, 1(3). http://journal2.um.ac.id/index.php/jfik/indexhttp://fik.um.ac.id/

Islamiati, D. O., Yunus, M., & Abdullah, A. (2022). Latihan ladder drill dan shuttle run dapat memengaruhi kecepatan atlet bulutangkis Pusat Latihan Kota Malang untuk Porprov tahun 2022. Jurnal Sport Science, 12(2), 76. https://doi.org/10.17977/um057v12i2p76-83

Joshua, A., & Setijono, H. (2017). Evaluasi Anthropometri Dan Kondisi Fisik Atlet Futsal Bintang Timur Surabaya. Jurnal Prestasi Olahraga, 2(1).

Khalik, K. (2017). Analisis Hubungan Kelincahan Dengan Keterampilan Bermain Sepakbola Klub Jantho FC. Jurnal Penjaskesrek, 4(2), 218–227. https://doi.org/https://doi.org/10.46244/penjaskesrek.v4i2.792

Kusuma, I. W., & Susanto, I. H. (2022). Analisis Kondisi Fisik Atlet Putra Hockey Indoor Jawa Timur Persiapan Pon XX Papua 2021. Jurnal Kesehatan Olahraga, 10(3).

Lees, A. (2016). Science and the major racket sports: A review. Journal of Sports Sciences, 21(9), 707–732.

Lloyd, R. S., Faigenbaum, A. D., Myer, G. D. (2015). Youth resistance training: Past practices, new perspectives, and future directions. Pediatric Exercise Science, 27(4), 497–509.

Lloyd, R. S., Oliver, J. L., Faigenbaum, A. D., et al. (2014). Long-term athletic development, part 1: A pathway for all youth. Journal of Strength and Conditioning Research, 28(6), 1439–1450.

Mackenzie, B. (2005). 101 Performance Evaluation Test (Mackenzie Brian, Ed.). Electric World plc.

Malwanage, K. T., Senadheera, V. V., & Dassanayake, T. L. (2022). Effect of balance training on footwork performance in badminton: An interventional study. PLoS ONE, 17(11 November). https://doi.org/10.1371/journal.pone.0277775

Markovic, G., & Mikulic, P. (2010). Neuro-musculoskeletal and performance adaptations to lower-extremity plyometric training. Sports Medicine, 40(10), 859–895.

Marta, I. A. (2020). Contribution of Leg Muscle Strength and Speed to Students' Long Jump Ability.

Meylan, C., & Malatesta, D. (2009). Effects of in-season plyometric training within soccer practice on explosive actions of young players. Journal of Strength and Conditioning Research, 23(9), 2605–2613.

Miller, M. G., Herniman, J. J., Ricard, M. D., et al. (2006). The effects of a 6-week plyometric training program on agility. Journal of Sports Science and Medicine, 5(3), 459–465.

Mohanta, N., Kalra, S., & Pawaria, S. (2019). A Comparative Study of Circuit Training and Plyometric Training on Strength, Speed and Agility in State-Level Lawn Tennis Players. JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH. https://doi.org/10.7860/jcdr/2019/42431.13348

Morris, S. J., Oliver, J. L., Pedley, J. S., Haff, G. G., & Lloyd, R. S. (2022). Comparison of Weightlifting, Traditional Resistance Training and Plyometrics on Strength, Power and Speed: A Systematic Review with Meta-Analysis. In Sports Medicine (Vol. 52, Issue 7, pp. 1533–1554). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s40279-021-01627-2

Muin, M., Nur, A., Lam Akhmady, A., Kie, S., Ternate, R., Universitas, F., & Luwuk, M. (2019). Analisis Kondisi Fisik Atlit Pomnas Cabang Olahraga Bulutangkis Maluku Utara Tahun 2019. JUPE: Jurnal Pendidikan Mandala, 4(5). https://doi.org/http://dx.doi.org/10.58258/jupe.v4i5.863

Mulyana, M., Hidayat, R., & Hidayah, T. (2018). Pengaruh latihan plyometrik terhadap kemampuan lompat vertikal pemain bulutangkis. Jurnal Ilmu Keolahragaan, 17(2), 89–97.

Phomsoupha, M., & Laffaye, G. (2015). The science of badminton: Game characteristics, anthropometry, physiology, visual fitness and biomechanics. Sports Medicine, 45(4), 473–495.

Prakash, P. S., & Kumar, R. S. (2024). Comparative Study of Speed and Agility Among Elite and Amateur Vishakhapatnam Badminton Players. https://doi.org/10.21203/rs.3.rs-4241716/v1

Prasetyo, E., Widodo, S., & Zainuddin, M. (2021). Pengaruh latihan plyometric terhadap peningkatan kecepatan lari dan kelincahan pemain bulutangkis. Jurnal Pendidikan Jasmani Indonesia, 17(1), 75–84.

Pratama, E., Putranto, D., & Rizki, M. (2024). Development of Badminton Smash Learning Model in Senior High School. Jendela Olahraga, 9(2). https://doi.org/10.26877/jo.v9i2.19004

Prihatini, A. D., & Widodo, A. (2019). Hubungan Antara Indeks Masa Tubuh Dengan Daya Tahan Kardiovaskuler Dan Kelincahan Pemain Sepakbola. Jurnal Kesehatan Olahraga, 7(2), 45–0.

Putri, M. W., Nuari Panggraita, G., Agustryani, R., & Proboyekti, D. (2022). Tingkat Kebugaran Jasmani Atlet Dulongmas Kabupaten Pekalongan. Jendela Olahraga, 7(1), 100–108. https://doi.org/10.26877/jo.v7i1.10420

Ramirez-Campillo, R., Meylan, C., Alvarez, C., et al. (2015). Effects of in-season low-volume high-intensity plyometric training on explosive actions and endurance of young soccer players. Journal of Strength and Conditioning Research, 28(5), 1335–1342.

Sari, V. K., & Himawan, A. (2023). Kondisi Fisik Cabang Olahraga Bulutangkis. Journal Of Physical Activity, 2, 5–11. https://doi.org/https://doi.org/10.58343/jpa.v2i2.30

Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. Journal of Sports Sciences, 24(9), 919–932.

Simanjuntak, G., Syamsuar, Khairuddin, & Muhammad Arnando. (2024). KONDISI FISIK PEMAIN BULUTANGKIS. Jurnal Pendidikan Dan Olahraga, 7(3). https://doi.org/10.24036/JPDO.7.3.2024.62

Somruthai, P., & Pakulanon, S. (2015). Effects of 4-week Plyometric Training on Speed, Agility, and Leg Muscle Power in Male University Basketball Players: A Pilot Study. Kasetsart Journal of Social Sciences, 36(3), 598–606.

Sugiyono. (2022). Metode Peneltian Kuantitatif, Kualitatif Dan R&D (Penerbit Alfabeta, Ed.; 2nd ed.). Penerbit Alfabeta.

Sulaiman, R., Fitri, M., & Arifin, Z. (2022). Implementation of physical training models in badminton schools: A case in Indonesia. Asian Journal of Sports Science, 4(1), 1–9.

Suratman. (2019). Kualitas Fisik Pemain Gatra Semarang U15 Putera Tahun 2019. Prosiding Seminar Nasional Pascasarjana UNNES SEMINAR NASIONAL PASCASARJANA.

Widiasto, Y. A. (2019). Pengaruh Latihan Drill Multi Arah Dan Core Stability Terhadap Peningkatan Kelincahan Dan Power Otot Tungkai Atlet Bulutangkis. E- Journal Kepelatihan Olahraga, 8(10).

Wilkerson, G. B., Colston, M. A., Short, N. I., Neal, K. L., Hoewischer, P. E., & Pixley, J. J. (2004). Neuromuscular Changes in Female Collegiate Athletes Resulting From a Plyometric Jump-Training Program. In Journal of Athletic Training 17 Journal of Athletic Training (Vol. 39, Issue 1). Association, Inc. www.journalofathletictraining.org

Yucardo. (2021). Analisis Tingkat Keterampilan Jarak Pendek 30 Meter Kelas V di SD Negeri 40 Kota Bengkulu. Silampari Journal Sports, 1(2), 100–106. https://doi.org/https://doi.org/10.55526/sjs.v1i2.151

Yunus, M., Darussalam, A. M., Raharjo, S., & Andiana, O. (2023). Efek latihan pliometrik terhadap peningkatan kecepatan pada atlet non profesional. Jurnal Ilmu Keolahragaan, 6(1), 44. https://doi.org/10.26418/jilo.v6i1.65150