DOI 10.xxxx/xxxxx

ORIGINAL SCIENTIFIC PAPER

How Much Does Physical Condition Affect Volleyball Technique? A Case Study of High School Students in Padang City

Yogi Arnaldo Putra[1], Jannatul Khairoh[2], Andra Rizky Putra[3], Rully Effendi[3], Randi Kurniawan[4], Rudyanto[1]

[1] Faculty 1Department of Sport Coaching Education, Universitas Negeri Padang, Indonesia

[2]Doctoral in Sports Science, Universitas Negeri Padang, Padang, Indonesia

[3]Department of Sports Science, Sekolah Tinggi Olahraga dan Kesehatan Bina Guna, Medan, Indonesia

[4]Department of Sports Science, Universitas Negeri Medan, Medan, Indonesia

Corresponding Author: Yogi Arnaldo Putra, e-mail: yogi.ap@fik.unp.ac.id

Abstract

This study aims to identify the influence of physical condition on volleyball technique mastery among players at Padang State High School. The main objective of this study is to explore the relationship between various physical components such as leg muscle strength, arm muscle strength, agility, hand-eye coordination, flexibility, and aerobic endurance on basic volleyball techniques such as underhand passing, overhand passing, smashing, and overhand serving. Physical condition measurements were conducted using the vertical jump test, two-hand medicine ball put, Illinois Agility Test, tennis ball throw and catch test, flexibility test using a flexiometer, and the bleep test. The basic volleyball techniques measured included underhand passing, overhand passing, spiking (also known as smashing), and overhand serving. The research involved 30 volleyball players, selected using purposive sampling and analyzed using Structural Equation Modeling (SEM). The results showed significant correlations between physical conditions and volleyball techniques, particularly in underhand and overhand passing. However, physical conditions had a weaker influence on smashing and overhand serving. The SEM analysis revealed that flexibility, leg muscle power, and agility significantly contributed to better technique execution, with hand-eye coordination having a minor influence. The findings suggest that physical conditions, particularly leg muscle power, flexibility, and agility, play a significant role in mastering basic volleyball techniques. It is recommended that coaches develop training programs that integrate physical conditioning with technical skill development to optimize player performance.

Keywords: Physical, condition, volleyball, technique, agility.

DOI 10.xxxx/xxxxx

1. Introduction

Volleyball is one of the most popular and beloved sports among high school students (Ismailova, 2022). The popularity of this sport stems from its dynamic, competitive, and challenging nature, both physically and mentally (Furley, 2019; Martín-Rodríguez et al., 2024). To play well, a player must master various fundamental techniques, including underhand passing, overhand passing, serving, and smashing. These techniques form the foundation of volleyball, determining a team's success in both defense and attack (Deda, 2024).

However, mastering these basic techniques alone is insufficient without optimal physical condition (Stănciulescu, 2016). Good technical skills without adequate physical ability will make it difficult for players to maintain their performance throughout the game (Farley, Stein, Keogh, Woods, & Milne, 2020; Francesco Sgrò, Salvatore Bracco, Salvatore Pignato, & Mario Lipoma, 2018). In volleyball, physical aspects such as strength, speed, agility, flexibility, endurance, and coordination are crucial because the sport demands quick responses, agile position changes, and the ability to perform explosive movements repeatedly within a short time frame.

Observations at several schools, including a state high school in Padang City, reveal that many volleyball players experience a decline in technical performance, particularly towards the middle to end of the match. This often occurs due to physical fatigue, which leads to decreased serving accuracy, less synchronized movement coordination, and reduced jumping power for smashes or blocks. This phenomenon indicates that technical training alone is insufficient. A structured physical training program is necessary to maintain and optimally apply technical skills on the court.

Previous studies have confirmed that physical conditioning components significantly contribute to mastering basic volleyball techniques (Rebelo et al., 2025). For example, lower limb muscle power, measured through vertical jumps, is closely related to the ability to perform effective smashes and blocks (Berriel et al., 2021; Marpaung & Priyonoadi, 2019). Similarly, upper limb strength, assessed using the two-hand medicine ball throw, plays a crucial role in generating powerful serves and smashes (Pajar Juanda, Iyakrus, & Ahmad Richard Victorian, 2024). However, strength alone is insufficient without good eye-hand coordination (Mueangson et al., 2025; Setiawan & Mukarohim, 2024). This skill can be measured using the tennis ball catch-and-throw test and is essential for making precise movements and quick decisions on the court.

Additionally, agility, as measured by the Illinois Agility Test, is crucial for making lateral movements and executing position changes during both defense and attack (Söyler, 2022; Young, Dos'Santos, Harper, Jefferys, & Talpey, 2022). Flexibility, as measured by a flexometer, supports the range of body movement, enabling the performance of passing and ball return techniques more efficiently and safely (Bajić, Veljović, & Bulajić, 2023). Meanwhile, aerobic endurance, often overlooked, plays a crucial role in maintaining performance stability during matches, especially in high-intensity and long-duration matches (Hulton, Malone, Clarke, & MacLaren, 2022; Lv, Yang, Suo, & Han, 2025). This ability can be assessed through the bleep test.

Based on this background, a player's success in mastering basic volleyball techniques is determined not only by how often they practice the techniques but also by how well they develop their physical condition. Therefore, this study aims to empirically examine the extent to which physical components such as agility, muscle strength, coordination, flexibility, and aerobic endurance influence basic volleyball technique ability among high school students in Padang City. The results of this study are expected to provide tangible contributions to the field of coaching, particularly in designing training programs that not only focus on technical aspects but also consider physical aspects holistically and measurably, thereby producing competent, resilient, and high-performing student-athletes.

Based on the theoretical framework, physical condition is conceptualized as a latent construct comprising aerobic endurance, agility, muscle strength, flexibility, and hand-eye coordination, which are hypothesized to influence performance in volleyball technique.

2. Methods

This study involved 30 high school volleyball players selected through purposive sampling. The participants were aged 14-18 and were actively involved in regular volleyball training and school competitions. All participants had prior experience in organized volleyball activities. The participants were players who actively trained and regularly participated in school volleyball competitions. The inclusion criteria for participation in this study were students who were registered as regular players on the school volleyball team and who were willing to undergo a series of physical and technical tests. There were no specific exclusion criteria. Specifically, players who were injured at the time of data collection were excluded to maintain the validity of the results.

Although the sample size in this study was relatively small (n = 30), the use of Partial Least Squares Structural Equation Modeling (PLS-SEM) is considered appropriate. PLS-SEM is suitable for exploratory research and can be applied to small sample sizes, particularly when the research model is relatively simple and prediction-oriented. According to Hair et al. (2019), PLS-SEM can be used with small samples as long as the minimum sample size follows the "10-times rule," which states that the sample size should be at least ten times the maximum number of structural paths directed at any latent construct. In this study, the model meets this requirement. The model in this study is specified as a reflective measurement model, where all observed variables are assumed to reflect the underlying latent construct of physical condition.

This study used a quantitative approach with a correlational descriptive design. The purpose of this study was to investigate the impact of physical condition on the mastery of basic volleyball techniques. Data collection involved various physical condition tests and basic technique tests.

1. Physical condition tests:
   a. Vertical Jump Test to measure lower limb muscle power.
   b. Two-hand medicine Ball Throw to measure upper limb muscle power.
   c. Illinois Agility Test to measure agility.
   d. Tennis ball throw-catch test against a wall to measure hand-eye coordination.
   e. Flexometer to measure flexibility.

f. Bleep Test to measure aerobic endurance.

2. Basic volleyball technique tests:

a. Underhand pass

b. Overhand pass.

c. Smash.

d. Overhand serve.

These instruments were selected due to their relevance to measuring physical and technical abilities in the sport of volleyball. Data collection was conducted under controlled conditions in a school environment, supervised by coaches and researchers. Each participant took all tests in turn, and the results were recorded for further analysis.

The collected data were analyzed using Structural Equation Modelling (SEM) with the assistance of SmartPLS software. SEM was chosen because it can analyze complex relationships between physical condition variables and mastery of basic techniques simultaneously. The data analysis stages included:

1. Model Validity Test

This test was conducted using several indices, including the Chi-Square, Root Mean Square Error of Approximation (RMSEA), Goodness-of-Fit Index (GFI), and Comparative Fit Index (CFI). An RMSEA value below 0.08, along with GFI and CFI values above 0.90, indicates a good model.

2. Reliability and Construct Validity Test

Average Variance Extracted (AVE) is used to measure validity, where a value above 0.50 indicates adequate validity. Composite Reliability (CR) is used to measure construct reliability, with a value above 0.70 indicating good reliability.

3. Hypothesis Test

This test is conducted by examining path coefficients to assess the direct effects between variables. A T-statistic value above 1.96 at a 95% confidence level and a p-value below 0.05 indicate a significant relationship between variables.

4. Multicollinearity Evaluation

Multicollinearity among independent variables is evaluated using the Variance Inflation Factor (VIF), where a VIF value below 5 indicates no multicollinearity issues.

5. R-Square (R^2) and Adjusted R-Square

The R^2 value is used to measure the extent to which the independent variables (physical conditions) explain the variance in the dependent variable (volleyball technique). An R^2 value above 0.25 is considered adequate, while the adjusted R^2 is used to account for the number of variables used in the model.

6. Confidence Intervals:

Confidence intervals that do not include zero indicate a significant relationship between variables. Narrower intervals provide more precise estimates of the influence of variables.

By using this analysis, the study aims to provide a clear understanding of the relationship between physical condition and basic volleyball techniques, enabling coaches to design effective training programs for their players.

DOI 10.xxxx/xxxxx

3. Results

A correlation analysis was conducted to identify the relationships between physical condition components and basic volleyball skills. Physical condition variables consisted of aerobic endurance, agility, arm muscle power, flexibility, hand-eye coordination, and leg muscle power. Meanwhile, volleyball skill variables included lower passing, smash, upper passing, and upper serve. The correlation coefficient values for each variable indicator are presented in the following table 1.

Table 1. Outer Loadings (Matrix)

Variable	Physical Condition (X)	Volleyball Technique (Y)
Aerobic Endurance	0.690	
Agility	0.517	
Arm Muscle Explosiveness	0.594	
Flexibility	0.729	
Hand Eye Coordination	0.135	
Limb Muscle Explosiveness	0.617	
Lower Passing		0.735
Smash		0.442
Upper Passing		0.912
Upper Serve		0.075

From the outer loadings table 1, it can be seen that physical condition variables (X) have different contributions to volleyball techniques (Y). Outer loadings indicate the extent to which each indicator reflects its respective latent construct. In this study, most indicators of physical condition showed acceptable loadings (above 0.50), suggesting they adequately represent the underlying construct. Specifically, aerobic endurance (0.690), agility (0.517), arm muscle power (0.594), flexibility (0.729), and leg muscle power (0.617) demonstrate sufficient contributions as reflective indicators. However, hand-eye coordination shows a relatively low loading (0.135), suggesting it may not strongly reflect the physical condition construct in this model. This result

suggests that hand-eye coordination may function better as a separate construct rather than as a component of general physical condition.

Contributes significantly to volleyball technique with a path coefficient of 0.502, indicating a moderate relationship between physical condition and volleyball technique. Furthermore, the contribution of physical condition to several volleyball techniques, such as Lower Passing (0.735) and Upper Passing (0.912), is relatively high, indicating that basic passing ability in volleyball is highly dependent on the player's physical condition. However, the Smash (0.442) and Upper Serve (0.075) techniques have a weaker relationship with physical condition, which may indicate that these two techniques are influenced by factors other than physical condition, such as technical skills or playing experience.

Table 2. R-square – Summary

Volleyball Technique	R-square	Adjusted R-square
(Y)	0.252	0.225

In terms of R-square, the value for volleyball technique (Y) is 0.252, indicating that approximately 25.2% of the variance in volleyball technique can be explained by physical condition. This suggests a moderate level of explanatory power, meaning that other factors beyond physical condition also play a substantial role in influencing volleyball technique. The adjusted R-square value (0.225), which is slightly lower, further indicates that the model remains relatively simple and may be improved by incorporating additional relevant variables. Therefore, the findings should be interpreted with caution, considering the relatively limited explanatory power of the model.

Table 3. Multicollinearity Statistics (VIF) - Outer Model - List

Variable	VIF
Aerobic Endurance	1.468
Agility	1.246
Arm Muscle Explosiveness	1.317
Flexibility	1.610
Hand Eye Coordination	1.143
Limb Muscle Explosiveness	1.237
Lower Passing	1.269

Smash	1.081
Upper Passing	1.315
Upper Serve	1.011

In the VIF (Variance Inflation Factor), all variables have low values, well below the threshold of 5, indicating that there are no multicollinearity issues in this model. This means that the independent variables in physical condition do not significantly influence each other, and each contributes uniquely to the technical volleyball results.

Overall, this model provides insight into the importance of physical condition in supporting volleyball technique. However, it also suggests that many other factors may be more significant, particularly in techniques such as the smash and serve. This opens the door for further research to identify additional variables that could explain more variation in volleyball technique performance.

Table 4. Path Coefficients - Mean, STDEV, T-Values, P-Values

Variable	Original sample (O)	Sample average (M)	Standard deviation (STDEV)	T-statistics (O/STDEV)	P values
Physical Condition (X) - Volleyball Technique (Y)	0.502	0.633	0.143	3.513	0.000

From the results of the path coefficient between Physical Condition (X) and Volleyball Technique (Y), we see a coefficient value of 0.502. This indicates that physical condition has a significant influence on volleyball technique. With a T-statistic value of 3.513 and a highly significant p-value of 0.000, we can conclude that this influence is significant at a 95% confidence level. This means that physical condition indeed has a moderate relationship with influencing the quality of volleyball playing technique.

Table 5. Path Coefficients - Confidence Intervals

Path	Original Sample (O)	Sample Mean (M)	2.5%	97.5%
Physical Condition - Technique	0.520	0.057	-0.750	

The confidence interval provides a range of possible values for the path coefficient. In the case of Physical Condition → Volleyball Technique, the confidence interval of 2.5% to 97.5% is between

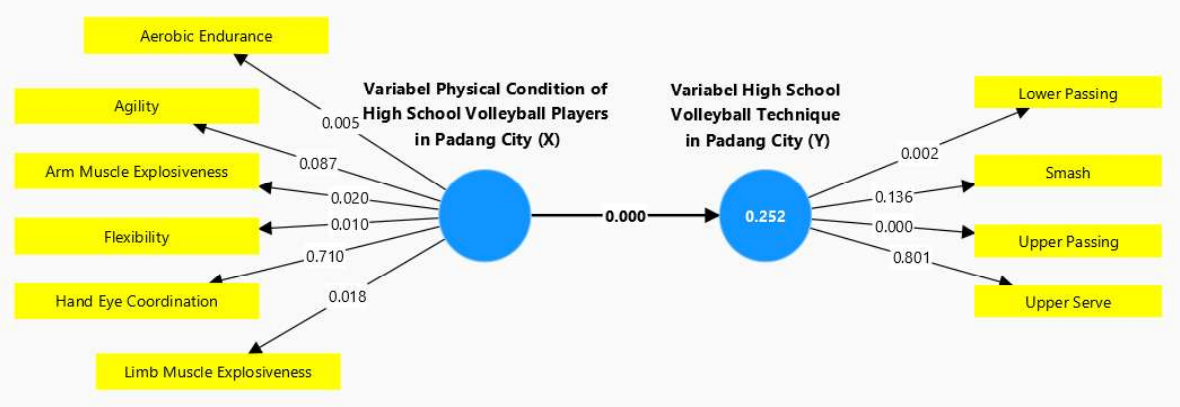
0.468 and 0.805, which does not include zero, thus confirming that this relationship is significant. This supports the previous conclusion that physical condition consistently affects volleyball technique.

Table 6. Path Coefficients - Confidence Intervals

Path	Original Sample (O)	Sample Mean (M)	2.5%	97.5%
Physical Condition (X) - Volleyball Technique (Y)	0.502	0.633	0.468	0.805

From the more detailed graph, it can be seen that other independent variables, such as Aerobic Endurance (0.005), Flexibility (0.020), and Limb Muscle Explosiveness (0.018), also have low coefficient values related to physical condition. However, even though these values are low, they still have a positive contribution. Meanwhile, other factors, such as Hand-Eye Coordination, show smaller values (0.010), indicating that the role of hand-eye coordination is less significant in influencing physical condition.

In volleyball techniques, such as Lower Passing (0.002) and Upper Passing (0.136), there is a more significant influence of physical condition compared to other techniques, like Smash (0.801) and Upper Serve (0.136), which show a weaker relationship.



Overall, these results suggest that physical condition generally contributes significantly to improvements in volleyball playing techniques, particularly in basic skills such as passing. However, there are variations in the influence of each technique, suggesting that specific techniques may also be influenced by factors other than physical condition, such as technical skills, strategy, or playing experience.

This data also supports the assertion that the independent variables used do not exhibit multicollinearity issues based on the low VIF values, which indicates that each variable contributes independently to the dependent variable.

4. Discussion

The results of this study indicate that physical condition has a significant influence on the mastery of basic volleyball techniques among students at High school in Padang City. Good physical condition, including aerobic endurance, flexibility, and lower limb muscle power, is a fundamental factor in supporting players' performance when executing basic techniques, particularly underhand and overhand passes. These findings are consistent with previous studies, which indicate that physical components, particularly aerobic endurance and flexibility, are crucial for enhancing athletes' performance in sports that require rapid and reactive movements (Akbar et al., 2022; Nuzzo, 2020; X. Wang et al., 2023). Arm muscle strength is also a dominant factor influencing smash accuracy, followed by eye-hand coordination and body flexibility (Ardianto Rifki Purnama, Yopi Kusdinar, Kardjono Kardjono, & Mulyana, 2024).

Specific physical training for volleyball players can help improve performance in countries like Romania, where training levels are often lower compared to stronger championships (Martin, Gavra, & Martin-Hadmaș, 2024). Optimal physical ability enables players to maintain sufficient stamina throughout the match and possess the body flexibility necessary to execute more effective playing techniques (Cao, Liu, Wang, & Geok, 2024; Luo et al., 2023). Unique physical demands based on playing position and situational variables also influence performance, emphasizing the importance of position-specific physical training (Sarmento et al., 2024).

Good flexibility allows players to move more freely when receiving the ball, enhancing passing effectiveness (Ilahi & Rasvid, 2020). Flexibility also increases the range of motion, which is crucial in both defensive and offensive positions, especially during blocking or spiking (Cakici, Alpay, & Soylu, 2026; Soylu & Altundag, 2024). Other research indicates that volleyball players with high flexibility levels exhibit better performance in agility, acceleration speed, and vertical jumps compared to those with low flexibility levels. These measurements use the 6x10 m shuttle run test, the countermovement jump test with arm swing, and the 20 m sprint test from a standing position.

Lower limb muscle power is also crucial, especially for jumping higher, which helps players achieve an ideal position when performing overhead passes or blocks (Mercado-Palomino, Aragón-Royón, Richards, Benítez, & Ureña Espa, 2021). Muscle strength is crucial for ensuring effective jumps in controlling the ball, which ultimately impacts the improvement of techniques such as smashes and blocks (Esposito, Altavilla, Giardullo, Ceruso, & D'Isanto, 2024; Tariq Ismael, 2024).

Aerobic endurance plays a significant role in maintaining stamina throughout the match, especially in high-intensity sports like volleyball (Rafi Tri Indarwan & Adi S, 2025; Wu, 2023). Maintaining stamina allows players to sustain optimal performance from the start to the end of

the match (Hostrup & Bangsbo, 2023; Ranchordas, Dawson, & Russell, 2017). Previous studies also emphasize the importance of aerobic endurance in maintaining athletic performance during prolonged matches (Skorski et al., 2019; Spiering, Mujika, Sharp, & Foulis, 2021).

However, the influence of physical condition components varies across techniques. Eye-hand coordination, for example, showed a lower influence in this study, suggesting that technical skills or playing experience may play a greater role in improving basic volleyball technique performance (Addivinola, Cereda, & Aliberti, 2021). Research on teaching methods for eye-hand coordination in volleyball shows that a mixed approach (cognitive and dynamic ecological) is more effective in improving eye-hand coordination than a single approach (SAPARİA, DLIS, & HANIF, 2020).

Although eye-hand coordination is important in catching and controlling the ball, its influence on overall volleyball performance is lower than that of muscle strength or agility (Ngadiyana, 2020). Another study also found that while eye-hand coordination is important, its impact on technical performance in volleyball is not as significant as other physical components (Jariono et al., 2023). Eye-hand coordination is a skill that can be improved through various training methods, such as the use of the FitLight Trainer and distance manipulation exercises. This coordination is critical in serving, passing, and smashing techniques in volleyball (Waryanti, Umar, Rifki, & Masrun, 2025). Concerning basic techniques, passing ability is highly dependent on physical condition (B. Wang et al., 2024). Underhand and overhand passing are significantly influenced by leg and arm muscle strength, as well as the agility required to move quickly to the correct position (Uly, Hudain, Adil, Kamaruddin, & Fahrizal, 2025). Studies indicate that upper body and arm muscle strength play a significant role in enhancing ball speed and accuracy during passing (Finlay, Bridge, Greig, & Page, 2022). Training focused on improving these muscle strengths can help players perform passing more effectively and consistently (Suchomel, Nimphius, Bellon, & Stone, 2018).

Passing requires high precision, and good physical strength helps players control and direct the ball better (Rein, Raabe, & Memmert, 2017). On the other hand, techniques such as smashes and overheads reveal a weaker relationship with physical condition, suggesting that technical skills, including ball control and hand speed, play a greater role in the execution of these techniques (Li, Li, Zhang, & Shan, 2023). This finding supports the notion that technical complexity influences the degree to which physical condition contributes to performance outcomes. Some studies also support these findings, showing that technical experience and ball control play a larger role in the success of smashes and overhead serves (Ramasamy et al., 2023).

The R-squared value from this analysis indicates that approximately a quarter of the variation in volleyball technique mastery can be explained by physical condition. This suggests that, in addition to physical condition, other factors such as playing experience, strategy, and motivation also play important roles in enhancing a player's technical ability (Wiemeyer, Nacke, Moser, & 'Floyd' Mueller, 2016). This study is consistent with findings stating that experience and technical skills are equally important as physical condition in determining athletic performance (Koopmann, Faber, Baker, & Schorer, 2020).

Low multicollinearity among physical condition variables indicates that each component contributes uniquely to the volleyball technique without interfering with one another (Musa et al., 2023). Physical conditions such as agility and aerobic endurance have a significant influence on improving overall player performance (Komarudin, Suharjana, Yudanto, & Kusuma, 2022). These variables function independently and make significant contributions to each technique, ensuring that no single variable dominates (Musall, Kaufman, Juavinett, Gluf, & Churchland, 2019).

Overall, this study demonstrates that physical condition plays a crucial role in supporting the mastery of basic volleyball techniques, particularly in passing techniques. Techniques such as smashes and overhead serves are more influenced by other factors like technical skills and playing experience. This study also opens opportunities for further exploration of non-physical factors that may influence volleyball technique performance, such as psychological aspects, strategy, or team dynamics.

Each physical component contributes differently to each technique in volleyball, and coaches need to understand the specific role of each variable to design more effective training programs. Thus, this study contributes not only to the development of volleyball performance at the student level but also to the scientific literature on the influence of physical condition on technical performance in the sport of volleyball.

5. Conclusions

This study concludes that physical condition has a moderate but significant influence on volleyball technique performance, particularly in passing skills. However, the relatively low explanatory power suggests that factors beyond physical condition also play a substantial role. Therefore, training programs should integrate both physical conditioning and technical skill development to achieve optimal performance.

Therefore, it is recommended that volleyball training programs not only focus on developing technical skills but also integrate physical training specifically designed to enhance relevant physical components. This is important for achieving optimal performance in volleyball matches, especially for techniques that require strength, flexibility, and high speed. Further research is needed to explore other factors that may influence volleyball techniques, such as psychological aspects, team dynamics, or tactical strategies, which can contribute to a player's success on the court.

Conflict of Interest

The authors declare that they have no conflicts interests.

References

1. Addivinola, S., Cereda, F., & Aliberti, S. (2021). Teaching method to improve eye-hand coordination in volleyball serve. *Journal of Human Sport and Exercise - 2021 - Spring Conferences of Sports Science*. Universidad de Alicante. https://doi.org/10.14198/jhse.2021.16.Proc4.18
2. Akbar, S., Soh, K. G., Jazaily Mohd Nasiruddin, N., Bashir, M., Cao, S., & Soh, K. L. (2022). Effects of neuromuscular training on athletes physical fitness in sports: A systematic review. *Frontiers in Physiology*, *13*. https://doi.org/10.3389/fphys.2022.939042
3. Ardianto Rifki Purnama, Yopi Kusdinar, Kardjono Kardjono, & Mulyana. (2024). The Relationship Between Wrist Flexibility and Arm Muscle Strength with the Accuracy and Speed of Smash for Badminton Athletes Universitas Pendidikan Indonesia (UPI). *Journal of Physical Education Health and Sport*, *11*(2), 75–78. https://doi.org/10.15294/jpehs.v11i2.18563
4. Bajić, S., Veljović, D., & Bulajić, B. Đ. (2023). Impact of Physical Fitness on Emergency Response: A Case Study of Factors That Influence Individual Responses to Emergencies among University Students. *Healthcare*, *11*(14), 2061. https://doi.org/10.3390/healthcare11142061
5. Berriel, G. P., Schons, P., Costa, R. R., Oses, V. H. S., Fischer, G., Pantoja, P. D., … Peyré-Tartaruga, L. A. (2021). Correlations Between Jump Performance in Block and Attack and the Performance in Official Games, Squat Jumps, and Countermovement Jumps of Professional Volleyball Players. *Journal of Strength and Conditioning Research*, *35*(12S), S64–S69. https://doi.org/10.1519/JSC.0000000000003858
6. Cakici, A. P., Alpay, N., & Soylu, C. (2026). Effects of an eight-week neuro-athletic training program on passing accuracy, shooting precision, flexibility, and isokinetic knee strength in male soccer players: A randomized controlled trial. *Journal of Science and Medicine in Sport*. https://doi.org/10.1016/j.jsams.2026.01.013
7. Cao, S., Liu, J., Wang, Z., & Geok, S. K. (2024). The effects of functional training on physical fitness and skill-related performance among basketball players: a systematic review. *Frontiers in Physiology*, *15*. https://doi.org/10.3389/fphys.2024.1391394
8. Deda, N. (2024). The Study of Technical-Tactical and Physical Parameters of Modern Volleyball Through Specific Models in the Defense Element. *Interdisciplinary Journal of Research and Development*, *11*(2), 44. https://doi.org/10.56345/ijrdv11n206
9. Esposito, G., Altavilla, G., Giardullo, G., Ceruso, R., & D'Isanto, T. (2024). The Effects of the Use of Plyometric Exercises with and without the Ball in the Development of Explosive Strength in Volleyball. *Journal of Functional Morphology and Kinesiology*, *9*(3), 126. https://doi.org/10.3390/jfmk9030126
10. Farley, J. B., Stein, J., Keogh, J. W. L., Woods, C. T., & Milne, N. (2020). The Relationship Between Physical Fitness Qualities and Sport-Specific Technical Skills in Female, Team-Based Ball Players: A Systematic Review. *Sports Medicine - Open*, *6*(1), 18. https://doi.org/10.1186/s40798-020-00245-y

11. Finlay, M. J., Bridge, C. A., Greig, M., & Page, R. M. (2022). Upper-Body Post-activation Performance Enhancement for Athletic Performance: A Systematic Review with Meta-analysis and Recommendations for Future Research. *Sports Medicine*, *52*(4), 847–871. https://doi.org/10.1007/s40279-021-01598-4
12. Francesco Sgrò, Salvatore Bracco, Salvatore Pignato, & Mario Lipoma. (2018). Small-Sided Games and Technical Skills in Soccer Training: Systematic Review and Implications for Sport and Physical Education Practitioners. *Journal of Sports Science*, *6*(1). https://doi.org/10.17265/2332-7839/2018.01.002
13. Furley, P. (2019). What Modern Sports Competitions Can Tell Us About Human Nature. *Perspectives on Psychological Science*, *14*(2), 138–155. https://doi.org/10.1177/1745691618794912
14. Hostrup, M., & Bangsbo, J. (2023). Performance Adaptations to Intensified Training in Top-Level Football. *Sports Medicine*, *53*(3), 577–594. https://doi.org/10.1007/s40279-022-01791-z
15. Hulton, A. T., Malone, J. J., Clarke, N. D., & MacLaren, D. P. M. (2022). Energy Requirements and Nutritional Strategies for Male Soccer Players: A Review and Suggestions for Practice. *Nutrients*, *14*(3), 657. https://doi.org/10.3390/nu14030657
16. Ilahi, R., & Rasvid, W. (2020). The Effect of Limb Muscle Explosive Power, Flexibility, and Confidence Toward Long Passing Ability of Football Players. *Proceedings of the 1st International Conference of Physical Education (ICPE 2019)*. Paris, France: Atlantis Press. https://doi.org/10.2991/assehr.k.200805.048
17. Ismailova, A. (2022). Volleyball is a popular game in many countries around the world. *ACADEMICIA: An International Multidisciplinary Research Journal*, *12*(10), 75–85. https://doi.org/10.5958/2249-7137.2022.00809.6
18. Jariono, G., Nurhidayat, Sudarmanto, E., Nugroho, H., Maslikah, U., & Budiman, I. A. (2023). Basic Volleyball Technical Skills for Students: Validity and Reliability. *Physical Education Theory and Methodology*, *23*(5), 747–753. https://doi.org/10.17309/tmfv.2023.5.13
19. Komarudin, K., Suharjana, S., Yudanto, Y., & Kusuma, M. N. H. (2022). The different influence of speed, agility and aerobic capacity toward soccer skills of youth player. *Pedagogy of Physical Culture and Sports*, *26*(6), 381–390. https://doi.org/10.15561/26649837.2022.0604
20. Koopmann, T., Faber, I., Baker, J., & Schorer, J. (2020). Assessing Technical Skills in Talented Youth Athletes: A Systematic Review. *Sports Medicine*, *50*(9), 1593–1611. https://doi.org/10.1007/s40279-020-01299-4
21. Li, F., Li, S., Zhang, X., & Shan, G. (2023). Biomechanical Insights for Developing Evidence-Based Training Programs: Unveiling the Kinematic Secrets of the Overhead Forehand Smash in Badminton through Novice-Skilled Player Comparison. *Applied Sciences*, *13*(22), 12488. https://doi.org/10.3390/app132212488
22. Luo, S., Soh, K. G., Zhang, L., Zhai, X., Sunardi, J., Gao, Y., & Sun, H. (2023). Effect of core training on skill-related physical fitness performance among soccer players: A

systematic review. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.1046456

23. Lv, X., Yang, J., Suo, L., & Han, W. (2025). The role and application of internal and external load indicators in monitoring fatigue in rugby players—a narrative review. *Frontiers in Sports and Active Living*, *7*. https://doi.org/10.3389/fspor.2025.1654577
24. Marpaung, H. I., & Priyonoadi, B. (2019). The Correlation between Leg-arm Muscle Power and Volleyball Players' Open Smash Ability. *Proceedings of the 3rd Yogyakarta International Seminar on Health, Physical Education, and Sport Science in Conjunction with the 2nd Conference on Interdisciplinary Approach in Sports*, 379–385. SCITEPRESS - Science and Technology Publications. https://doi.org/10.5220/0009786803790385
25. Martin, Ștefan A., Gavra, M. G., & Martin-Hadmaș, R. M. (2024). Analyzing Targeted Muscle Strength: Impact on Speed, Endurance, and Performance in Female Volleyball. *Applied Sciences*, *14*(23), 10951. https://doi.org/10.3390/app142310951
26. Martín-Rodríguez, A., Gostian-Ropotin, L. A., Beltrán-Velasco, A. I., Belando-Pedreño, N., Simón, J. A., López-Mora, C., … Clemente-Suárez, V. J. (2024). Sporting Mind: The Interplay of Physical Activity and Psychological Health. *Sports*, *12*(1), 37. https://doi.org/10.3390/sports12010037
27. Mercado-Palomino, E., Aragón-Royón, F., Richards, J., Benítez, J. M., & Ureña Espa, A. (2021). The influence of limb role, direction of movement and limb dominance on movement strategies during block jump-landings in volleyball. *Scientific Reports*, *11*(1), 23668. https://doi.org/10.1038/s41598-021-03106-0
28. Mueangson, O., Keawmai, W., Pabbumnan, R., Chukaithai, A., Thongdonmuean, P., & Vongvaivanichakul, P. (2025). The Effects of Eye Exercises on Eye-Hand Coordination, Cognitive Functions and Balance Ability of the Elderly: A Randomized Controlled Trial. *International Journal of Environmental Research and Public Health*, *22*(10), 1564. https://doi.org/10.3390/ijerph22101564
29. Musa, R. M., Abdul Majeed, A. P. P., Suhaimi, M. Z., Abdullah, M. R., Mohd Razman, M. A., Abdelhakim, D., & Abu Osman, N. A. (2023). Identification of high-performance volleyball players from anthropometric variables and psychological readiness: A machine-learning approach. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, *237*(4), 317–324. https://doi.org/10.1177/17543371211045451
30. Musall, S., Kaufman, M. T., Juavinett, A. L., Gluf, S., & Churchland, A. K. (2019). Single-trial neural dynamics are dominated by richly varied movements. *Nature Neuroscience*, *22*(10), 1677–1686. https://doi.org/10.1038/s41593-019-0502-4
31. Ngadiyana, H. (2020). The Effect of Eye-Hand Coordination Training on Accuracy of Service in Volleyball Players. *Proceedings of the 1st South Borneo International Conference on Sport Science and Education (SBICSSE 2019)*. Paris, France: Atlantis Press. https://doi.org/10.2991/assehr.k.200219.040
32. Nuzzo, J. L. (2020). The Case for Retiring Flexibility as a Major Component of Physical Fitness. *Sports Medicine*, *50*(5), 853–870. https://doi.org/10.1007/s40279-019-01248-w

33. Pajar Juanda, Iyakrus, & Ahmad Richard Victorian. (2024). The Relationship Between Arm Length and Arm Muscle Power with the Chest Pass Ability. *ACTIVE: Journal of Physical Education, Sport, Health and Recreation*, *13*(2), 390–396. https://doi.org/10.15294/peshr.v13i2.4910
34. Rafi Tri Indarwan, & Adi S. (2025). Analysis of Endurance Training in Volleyball: A Systematic Literature Review. *Indonesian Journal for Physical Education and Sport*, *6*(2), 56–66. https://doi.org/10.15294/inapes.v6i2.27083
35. Ramasamy, Y., Usman, J., Razman, R., Wei, Y. M., Towler, H., & King, M. (2023). A Systematic Review of the Biomechanical Studies on Shoulder Kinematics in Overhead Sporting Motions: Types of Analysis and Approaches. *Applied Sciences*, *13*(16), 9463. https://doi.org/10.3390/app13169463
36. Ranchordas, M. K., Dawson, J. T., & Russell, M. (2017). Practical nutritional recovery strategies for elite soccer players when limited time separates repeated matches. *Journal of the International Society of Sports Nutrition*, *14*(1). https://doi.org/10.1186/s12970-017-0193-8
37. Rebelo, A., Valente-dos-Santos, J., Pires, I. G., Arrais, I., Pereira, J. R., & Turner, A. N. (2025). Strength and Conditioning for Volleyball: A Review. *Strength & Conditioning Journal*, *47*(5), 499–517. https://doi.org/10.1519/SSC.0000000000000895
38. Rein, R., Raabe, D., & Memmert, D. (2017). "Which pass is better?" Novel approaches to assess passing effectiveness in elite soccer. *Human Movement Science*, *55*, 172–181. https://doi.org/10.1016/j.humov.2017.07.010
39. SAPARİA, A., DLIS, F., & HANIF, A. S. (2020). Plyometric Training Methods and Hand Eye Coordination on Volleyball Smash Skills in Sport Education Students, Tadulako University. *International E-Journal of Educational Studies*, *4*(8), 167–175. https://doi.org/10.31458/iejes.709841
40. Sarmento, H., Martinho, D. V., Gouveia, É. R., Afonso, J., Chmura, P., Field, A., … Clemente, F. M. (2024). The Influence of Playing Position on Physical, Physiological, and Technical Demands in Adult Male Soccer Matches: A Systematic Scoping Review with Evidence Gap Map. *Sports Medicine*, *54*(11), 2841–2864. https://doi.org/10.1007/s40279-024-02088-z
41. Setiawan, H., & Mukarohim, F. (2024). Contribution of Arm Muscle Strength and Hand Eye Coordination to the Lower Service Results of the Mts S Muaro Sijunjung Volleyball Extracurricular Team. *Eduvest - Journal of Universal Studies*, *4*(10), 9699–9714. https://doi.org/10.59188/eduvest.v4i10.43685
42. Skorski, S., Mujika, I., Bosquet, L., Meeusen, R., Coutts, A. J., & Meyer, T. (2019). The Temporal Relationship Between Exercise, Recovery Processes, and Changes in Performance. *International Journal of Sports Physiology and Performance*, *14*(8), 1015–1021. https://doi.org/10.1123/ijspp.2018-0668
43. Söyler, M. (2022). Examination of the effects of reactive agility and planned change of direction skills on Self Defense techniques in private security and protection program students. *Sportis. Scientific Journal of School Sport, Physical Education and Psychomotricity*, *8*(3), 309–328. https://doi.org/10.17979/sportis.2022.8.3.9008

44. Soylu, C., & Altundag, E. (2024). Rewiring for Victory: Neuro-Athletic Training Enhances Flexibility, Serve Speed, and Upper Limb Performance in Elite Volleyball Players—A Randomized Controlled Trial. *Applied Sciences*, *14*(23), 11102. https://doi.org/10.3390/app142311102
45. Spiering, B. A., Mujika, I., Sharp, M. A., & Foulis, S. A. (2021). Maintaining Physical Performance: The Minimal Dose of Exercise Needed to Preserve Endurance and Strength Over Time. *Journal of Strength & Conditioning Research*, *35*(5), 1449–1458. https://doi.org/10.1519/JSC.0000000000003964
46. Stănciulescu, R. (2016). Development of Basic Physical Qualities, Essential Condition for Creating a Competitive Physical Capacity. *Scientific Bulletin*, *21*(1), 54–60. https://doi.org/10.1515/bsaft-2016-0037
47. Suchomel, T. J., Nimphius, S., Bellon, C. R., & Stone, M. H. (2018). The Importance of Muscular Strength: Training Considerations. *Sports Medicine*, *48*(4), 765–785. https://doi.org/10.1007/s40279-018-0862-z
48. Tariq Ismael, A. (2024). Analysis of the Relationship between Certain Biokinematic and Goniometric Variables of the Linear Smash with Explosive Force Upwards, Forwards, and in Volleyball Shooting. *Ascarya: Journal of Islamic Science, Culture, and Social Studies*, *4*(1), 55–65. https://doi.org/10.53754/iscs.v4i1.667
49. Uly, A., Hudain, Muh. A., Adil, A., Kamaruddin, I., & Fahrizal, F. (2025). The Effect of Drill Training on Underhand Passing Ability in High School Students. *ETDC: Indonesian Journal of Research and Educational Review*, *4*(2), 420–432. https://doi.org/10.51574/ijrer.v4i2.3172
50. Wang, B., Wan, B., Chen, S., Zhang, Y., Bai, X., Xiao, W., … Long, B. (2024). A Systematic review of the factors that affect soccer players' short-passing ability—based on the Loughborough Soccer Passing Test. *BMC Sports Science, Medicine and Rehabilitation*, *16*(1), 96. https://doi.org/10.1186/s13102-024-00880-y
51. Wang, X., Soh, K. G., Samsudin, S., Deng, N., Liu, X., Zhao, Y., & Akbar, S. (2023). Effects of high-intensity functional training on physical fitness and sport-specific performance among the athletes: A systematic review with meta-analysis. *PLOS ONE*, *18*(12), e0295531. https://doi.org/10.1371/journal.pone.0295531
52. Waryanti, D., Umar, U., Rifki, M. S., & Masrun, M. (2025). LEARNING STRATEGIES INVOLVING PLAY AND COORDINATION: A PATHWAY TO IMPROVING MOTOR SKILLS. *Prima Magistra: Jurnal Ilmiah Kependidikan*, *6*(3), 355–362. https://doi.org/10.37478/jpm.v6i3.5053
53. Wiemeyer, J., Nacke, L., Moser, C., & 'Floyd' Mueller, F. (2016). Player Experience. In *Serious Games* (pp. 243–271). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-40612-1_9
54. Wu, X. (2023). HIGH-INTENSITY INTERVAL TRAINING IMPACTS ON ENDURANCE OF VOLLEYBALL PLAYERS. *Revista Brasileira de Medicina Do Esporte*, *29*. https://doi.org/10.1590/1517-8692202329012023_0047

55. Young, W., Dos'Santos, T., Harper, D., Jefferys, I., & Talpey, S. (2022). Agility in Invasion Sports: Position Stand of the IUSCA. *International Journal of Strength and Conditioning*, *2*(1). https://doi.org/10.47206/ijsc.v2i1.126