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Biomechanical Analysis and Optimization of Athlete Performance through Sepak Takraw Sports Movement Evaluation

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Abstract

Biomechanics is a very important field in sports because it provides in-depth insight into technique, movement efficiency, and athlete safety. In sepak takraw, which requires a combination of high speed, flexibility, agility, and accuracy, biomechanical evaluation plays a very crucial role in optimizing athlete performance while reducing the risk of injury. This study aims to evaluate and analyze movements in sepak takraw. This study uses the SLR method by systematically analyzing various scientific publications from national and international journals to find strategies for optimizing athlete performance based on biomechanical principles. The results of the study indicate that biomechanics can improve sepak takraw athlete performance through optimizing key movements, such as smash, serve, and block. Better technique not only improves movement efficiency but also helps prevent injuries due to excessive pressure on joints and muscles. These findings provide practical implications for coaches and athletes in designing more scientific, effective, and safe training programs. Understanding biomechanical principles allows for better technique improvement and injury prevention, which can improve performance in competition.

Keywords: *Biomechanics; Sepak Takraw; Performance; Movement Evaluation*

Introduction

Sepak takraw is one of the traditional sports in Southeast Asia that has developed into an international sport with an increasingly high level of competition. (Abdullah, 2023; Chen & Xiao, 2017). Sepak takraw combines elements of dexterity, agility, strength and body coordination, making it one of the most complex biomechanical sports. (Hanif et al., 2021; Padli et al., 2023; Rusli et al., 2023; Wiriawan & Nurdiansyah, 2020). Sepak takraw athletes are required to master various technical movements, such as smash (a hard kick towards the opponent at a certain angle), serve (an opening kick to start the game with high accuracy), and block (a block aimed at blocking the opponent's attack). These movements require not only high precision but also explosive strength and maximum flexibility, all of which involve the use of muscles, joints, and body coordination synergistically. (Anggraeni et al., 2023; Arifin, 2014; Arrazi & Hakim, 2021; Moungpool & Charoenpanich, 2022; Saputra & Dahrial, 2024; Sujae & Koh, 2008; Wulandari & Irsyada, 2019).

The challenge faced by sepak takraw athletes is maintaining consistent performance amidst heavy training and match loads. The high intensity and repetitive movements in sepak takraw often cause muscle fatigue and excessive stress on joints, potentially increasing the risk of injury. (Hakim et al., 2017; Khairunnisa & Pitriani, 2019; Supalak & Charoenpanich, 2023). Therefore, a science-based approach is needed to optimize movement and prevent injury. (Padli et al., 2023). Biomechanics plays an important role as one of the approaches to understanding and optimizing sepak takraw movements.

Biomechanics is the science that studies the forces and mechanics of the human body during physical activity, including sports. (Hakim et al., 2017; Rezaei et al., 2013). In sepak takraw, biomechanical analysis can help understand important parameters such as angle of movement, muscle strength, joint stability, and body weight distribution during the game. Biomechanical analysis can be used to improve smash technique by optimizing hip rotation and upper body coordination to produce more powerful and accurate shots. (Arifin, 2014). Research in similar sports, such as volleyball and basketball, has shown that modifying jumping and landing techniques can reduce stress on the knees. This finding is relevant for use in sepak takraw where high jumping is a key element of the sport. (Joseph et al., 2009).

Biomechanical research in sepak takraw is still relatively limited compared to other popular sports such as soccer, tennis, or basketball. This is partly due to the lack of global attention to sepak takraw as a traditional sport despite its potential to grow internationally. As a result, many unique aspects of sepak takraw biomechanics such as high jumps with rotational kicks or extreme flexibility in footwork have not been scientifically explored. (Bais et al., 2023). Therefore, this study was conducted to examine more deeply from a biomechanical perspective on sepak takraw sports.

This study uses a Systematic Literature Review (SLR) approach to evaluate the existing literature related to biomechanics in sepak takraw. This approach aims to answer two main questions: (1) How can biomechanical analysis help improve sepak takraw athletes' performance? and (2) What are effective biomechanics-based training strategies to reduce injury risk? Through a systematic literature analysis, this article is expected to provide evidence-based guidance for coaches, athletes, and academics in developing more effective and efficient training strategies.

Method

Literature Search

This study began with a literature search using credible academic databases such as Scopus, PubMed, and Google Scholar. The keywords used included biomechanics in sepak takraw, athlete performance optimization, and movement analysis. The combination of these keywords was optimized with Boolean operators such as "AND" and "OR" to increase the relevance of the search results. In addition, cross-references from relevant articles were also searched to ensure a more comprehensive research coverage.

Inclusion and Exclusion Criteria

Inclusion criteria were used to ensure that the selected articles were highly relevant to the research objectives. The selected articles were those published in the last 10 years (2014–2024), in English or Indonesian, and discussed biomechanics and movement evaluation in sepak takraw. Articles that focused on improving athlete performance and preventing injuries through a biomechanical approach were also included. Conversely, articles that did not provide full access, were not relevant to sepak takraw, or did not cover biomechanical aspects were excluded from the analysis.

Selection Process

Article selection was conducted in several stages to improve accuracy and effectiveness. The first stage involved screening titles and abstracts to assess initial suitability to the research topic. Articles that passed this stage were reviewed in-depth in full text to ensure relevance and eligibility. Articles that met all criteria were then classified into thematic categories, such as analysis of specific movements (smash, serve, block), injury prevention strategies, and use of biomechanics technology in movement evaluation.

Data Analysis

After selection, the selected articles were analyzed using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. This framework is used to ensure transparency, validity, and reliability of the SLR process. The article selection process in this study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. In the initial stage, a total of 29 articles were identified through database searches such as Scopus, PubMed, and Google Scholar.

After the identification process, screening was carried out to eliminate duplicate articles and evaluate relevance based on the research topic. A total of 4 duplicate articles were removed and 2 articles were removed because the full text was not available in Indonesian/English, leaving 23 articles for further review of the abstract and full text. At the eligibility stage, 13 articles were excluded because they did not meet the inclusion criteria. Of the excluded articles, 7 articles were not relevant to the research topic, while 4 articles did not contain sufficient empirical data for further analysis. As a final result, 12 articles were selected to be included in the analysis and became the basis for this study (Figure 1).

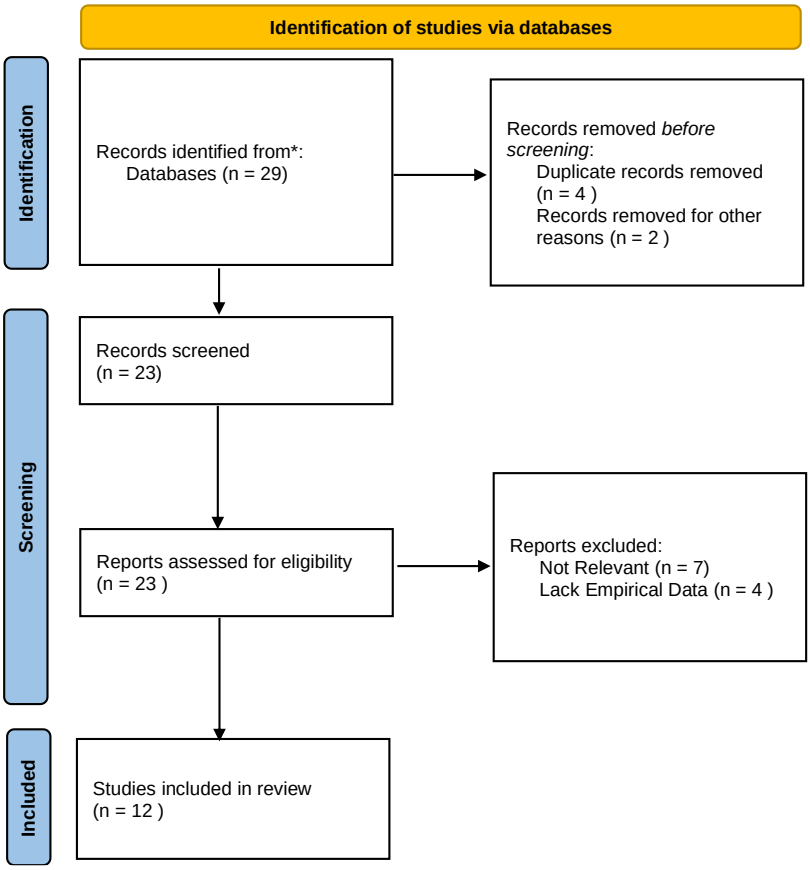

Figure 1. PRISM Flow Diagram

Each article was evaluated based on its methodology, research findings, and contribution to optimizing sepak takraw athlete performance. The data obtained were narratively synthesized to identify key patterns of findings and existing research gaps. Descriptive analysis techniques were used to visualize significant patterns of findings. This approach is expected to provide applicable guidance for coaches and athletes in developing data-driven strategies. These results are also expected to open up opportunities for further research in the field of sepak takraw biomechanics.

Results and Discussion

ReviewA systematic review of 12 articles showed the relationship between physiological, technical, and training aspects on athlete performance. Balance factors, for example, were found to have a dominant influence on sepaktakraw serve ability, while leg muscle explosive power and hip flexibility were significantly related to kedeng smash ability. Paired wall passing training was also proven to be more effective than individual training in improving the ability to receive the first ball. On the biomechanical side, research shows the importance of the angle of contact in serving to achieve maximum ball speed. In addition, flexibility and foot-eye coordination have a major contribution to the basic skills of playing sepaktakraw, and differences in technique and physiology between players based on playing position (striker, server, feeder) also affect their performance. Several studies also revealed the influence of biomechanical techniques on the risk of injury, as well as the influence of specific training on jump height and serve ability. The smash movement is also a key element in sepak takraw. Biomechanical research identifies the smash as a movement that requires an optimal combination of leg muscle strength, hip flexibility, and upper body stability. The results of the literature analysis are presented in Table 1.

Table 1. Results of Literature Analysis

Author and Year	Research methods	Research purposes	Results	Journal Source
The film stars Tomoliyus and Endang Rini Sukamti.	Literature review using meta-analysis techniques (identification of articles from 2019–2023 using Google Scholar, Science Direct, and PubMed databases)	To know the influence of leg muscle strength, leg flexibility and balance on sepak takraw serving ability.	The balance factor has a large and most dominant influence on sepak takraw service ability compared to leg muscle strength and flexibility.	International Journal Of Multidisciplinary Research And Analysis Volume 06 Issue 07 July 2023, DOI: 10.47191/ijmra/v6-i7-15
Yudanto, Hari Yuliarto, Sudardiyono, Sujarwo, Syed Kamaruzaman Syed Ali, Manil Kara Kauki, Kukuh Wahyudin Pratama (2024)	Experiment with 2x2 design, involving 24 student athletes of PSTI Club, Sleman. Data collection instrument in the form of measurement test; analysis using two-way ANOVA	Determining the influence of individual and pair passing training methods and high and low coordination on the ability to receive the first ball in sepak takraw.	(1) Passing against the wall training in pairs is more effective than individually; (2) High coordination results in better ability to receive the first ball compared to low coordination; (3) There is a significant interaction between training method (individual/pair) and coordination level (high/low) on the ability to receive the first ball in sepak takraw.	Retos, number 55, 2024 (June), ISSN: 1579-1726 (print edition), 1988-2041
Rusli, Ruslan, Sarifin, Arimbi, Mariyal Qibtiyah (2023)	Descriptive quantitative using electromyogram (EMG) signals with the Trigno™ Wireless EMG System to measure the RMS (Root Mean Square) of medial head gastrocnemius muscle contractions.	Measuring the contraction strength of the medial head gastrocnemius muscle in the basic sepak takraw technique	The measurement results showed variations in muscle contraction strength between subjects. The third subject produced the highest EMG strength in the right medial head gastrocnemius muscle, while the smallest EMG signal was recorded in the left medial head gastrocnemius muscle.	COMPETITOR: Journal of Sports Coaching Education, Volume 15 Number 3 Year 2023, e-ISSN: 2657-0734, p-ISSN: 2085-5389
Sheng Chen, Rui Xiao (2017)	Descriptive-comparative; involving 30 Philippine college sepak takraw players, aged 18-22 years, using the 40 meter running test, time ruler, sargent vertical jump, 1 minute sit-up, and sit-and-	To identify the physiological profiles (speed, reaction time, lower extremity strength, muscular endurance, flexibility) of Philippine collegiate sepak takraw players and compare them based on playing position (striker, server, feeder)	There were no significant differences in speed, muscular endurance, and flexibility between positions. However, strikers had faster reaction times and greater lower extremity strength than servers and feeders.	Asia Pacific Journal of Education, Arts and Sciences, Vol. 4 No. 4, October 2017, P-ISSN: 2362-8022, E-ISSN: 2362-8030

	reach flexibility test.			
Professor of Medicine, Faculty of Medicine, and Graduate School ...	Quantitative-descriptive using video analysis with Kinovea Software on 5 male athletes at Sidoarjo State Sports High School	Analyzing the series of movements of the sepak takraw upper serve from a biomechanical perspective to produce effective movements and maximum results.	Effective support angle 124°-141°, swing angular angle 145°-157°, impact angle 156°-170°, impact height 125.29 cm-158.61 cm, average ball speed 9.73-2.21 m/s	Journal of Sports Achievement, Vol 4 No.2
M. Nur Rizky Saputra, Dahrial (2023)	Quantitative with data analysis techniques using Multiple Product Moment Correlation; sample of 12 Indragiri Sepak Takraw athletes	To find out the relationship between explosive power of leg muscles and hip flexibility with the ability of smashing kedeng in athletes from IST Tembilahan.	Significant relationships: - Explosive power of leg muscles with smash kedeng (r = 0.692 > rtable = 0.632) - Hip flexibility with smash kedeng (r = 0.729 > rtable = 0.632) - Combination of both (Fcount = 7.359 > Ftable = 4.26)	Indragiri Sports Journal Vol.8 No.2
Ian Harris Sujae, Michael Koh (2008)	Biomechanical analysis technique using seven ProReflex 1000 cameras (240 Hz) to record stance and stance technique in nine elite national players	Gain insight into sepak takraw serving, identify differences in technique, and determine factors that influence ball speed.	Horse technique has: - Longer and stiffer leg segments - Greater range of motion - Higher ball release velocity due to angular momentum and impulse-momentum relationships	Sports Biomechanics, Vol. 7(1): 72–87
Oce Wiriawan, Nurdiansyah (2020)	Descriptive research on 30 SMANOR students (15 males, 15 females)	Analyzing the physiological demands of sepak takraw sport based on gender differences	The physical performance of male athletes is higher than female athletes. Example data: - Flexibility: 23 cm (male) vs 22 cm (female)- Jump height: 60 cm vs 42 cm- VO_2 Max: 48.55 ml/kg/min vs 38.06 ml/kg/min- HRmax: 188 beats/min vs 185 beats/min	Scientific Sports Magazine (MAJORA), Vol. 26(1), 2020, 1-7, UNY
James Tangkudung (2020)	Research and development (R&D)	(1) Designing a ball conveyor machine (DBH 2MCS) for service training for beginner sepak takraw athletes. (2) Produces an effective machine for service practice.	The DBH 2MCS machine effectively improves the service ability of novice athletes. The assessment of material experts, coaches, and machine experts shows the category "Very Good" (84, 87, 89).	Journal of Sports Education, Jakarta State University.
Fakhruddin Arrazi, Abdul Aziz Hakim (2021)	Experiment, one group pretest-posttest design	To determine the effect of hanging ball smash training on the jump height of the Asam Jaya Club sepak takraw athletes before and after training.	Hanging ball smash training has a significant effect on jump height. The average posttest (2.6700) is higher than the pretest (2.6053). Significance 0.000 < 0.05.	Journal of Sports Health, Vol. 09, No. 01, March 2021, Pages 9-14.
Abdul Aziz Hakim, Mulyana, Sofyan Hanif (2017)	Path Analysis	To determine the influence of biomechanical knowledge, physical condition, and landing technique on the risk of ACL injury in sepak takraw athletes.	(1) Biomechanical knowledge, physical condition, and landing technique have a direct effect on the risk of ACL injury. (2) There is an indirect effect between biomechanical knowledge and physical condition on the risk of ACL injury.	Journal of Indonesian Physical Education and Sport, Vol. 3, no. 2, 2017, p. 151-161.
Syahril Bais, Padli, John Arwandhi, Iyakrus, Alforki Martha, Rudyanto, Ikhwanul Arifan (2023)	Quantitative with Correlational Approach	Looking at the contribution of flexibility and eye-foot coordination to the basic skills of playing sepak takraw.	(1) Flexibility contributes 19% to basic skills. (2) Eye-foot coordination contributes 22%. (3) Both contribute 44%.	Journal of Physical Education and Sport (JPES), Vol. 23, Issue 12, Art 382, pp. 3341-3348, December 2023.
Mahdi Rezaei, Raghad Mimar, Mohsen Paziraei, Sheida Latifian (2013)	Quantitative with ANOVA and Tukey's Post-hoc Test	Identifying talent identification indicators based on biomechanical parameters in elite male sepak takraw players.	(1) Significant differences in hip range of motion between the server and other players (spiker and feeder), and between the spiker and feeder. (2) Significant differences in vertical jump between the spiker and other players, but no differences were found between the feeder and server. (3) No significant differences in reaction time, speed, and acceleration time.	Middle-East Journal of Scientific Research, 16(7), 936-941, 2013. DOI: 10.5829/idosi.mejsr.2013.16.07.11290
H. Leonard Joseph, N. Roslizawati, MY Safrusahar, NMH Efri, S. Das, O. Baharudin, A. Pharmy (2009)	Cross-sectional study using a force platform to measure ground reaction forces, flight time, and contact time.	Examining the differences in lower body kinetics during a vertical jump task between early and late pubertal stages in Malaysian national level Sepak Takraw athletes.	(1) There was no significant decrease in peak ground reaction force in the post-pubertal group compared to the pre-pubertal group. (2) Flight time increased significantly in the post-pubertal group compared to the pre-pubertal group.	Clin Ter, 2009; 160(5): 403-407

Research by Emayanti Anggraeni et al. (2023) used meta-analysis to assess the effect of leg muscle strength, flexibility, and balance on sepaktakraw serving ability. The results showed that balance had a more dominant effect compared to muscle strength and flexibility on sepaktakraw serving ability. Meanwhile, Yudanto et al. (2024) in a 2x2 experiment found that pair passing training was more effective than individual training in improving the ability to receive the first ball, and high coordination gave better results than low coordination.

Rusli et al.'s (2023) research used electromyogram (EMG) signals to measure the strength of gastrocnemius muscle contractions in basic sepak takraw techniques, and showed variations in contraction strength between subjects. Sheng Chen and Rui Xiao (2017) in a comparative study found that there were no significant differences in physiological aspects such as speed and endurance between positions in a team, but strikers had better reaction times and lower limb strength compared to servers and feeders. On the other hand, Dyah Ayu Retno Wulandari (2023) analyzed the sepak takraw upper service movement biomechanically, finding that the angles of support and effective contact greatly influenced the speed of the ball produced.

Research by M. Nur Rizky Saputra and Dahrial (2023) showed a significant relationship between leg muscle explosive power and hip flexibility with kedeng smash ability. Ian Harris Sujae and Michael Koh (2008) found that the horse technique in sepak takraw resulted in a higher ball release speed, thanks to longer leg segmentation and greater range of motion. Meanwhile, Oce Wiriawan and Nurdiansyah (2020) showed that male athletes had better physical performance than female athletes in terms of flexibility, jump height, and VO_2 Max.

Research by Dadang Budi Hermawan et al. (2020) successfully designed an effective ball conveyor machine for service training for beginner athletes, while Fakhruddin Arrazi and Abdul Aziz Hakim (2021) found that hanging ball smash training had a significant effect on increasing the jump height of sepak takraw athletes. Research by Abdul Aziz Hakim et al. (2017) used path analysis to show that biomechanical knowledge, physical condition, and landing technique have a direct effect on the risk of ACL injury.

Research by Syahril Bais et al. (2023) showed that flexibility and foot-eye coordination contribute significantly to basic sepak takraw skills, with the combination of the two contributing the most. Mahdi Rezaei et al. (2013) and H. Leonard Joseph et al. (2009) respectively examined differences in talent indicators in elite sepak takraw players and differences in lower body kinetics between sepak takraw athletes at early and late puberty stages, which showed significant differences in several physical parameters.

Based on the research results that have been obtained, it can be concluded that biomechanical factors such as balance, flexibility, muscle strength, and coordination, as well as technical factors and structured training play a very significant role in improving the performance of sepak takraw athletes. In this discussion, we will further analyze the contribution of these factors to key movements in sepak takraw and their implications for the development of more effective training programs.

Balance and Flexibility in Basic Movements

The results of research by Anggraeni et al. (2023) show that balance is the main factor that influences service ability in sepak takraw. Good balance helps athletes to remain stable when performing service movements, which require proper body positioning to maximize the power and accuracy of the ball.(Male et al., 2024). In this context, balance is considered very important because almost every movement in sepak takraw, be it serving, smashing, or passing, requires optimal body control. Poor balance can cause uncoordinated movements, which directly impacts the quality of the techniques executed.

In addition to balance, flexibility also plays a major role in improving athlete performance. Research by Syahril et al. (2023) states that body flexibility, especially in the legs, contributes 19% to athletes' basic skills in sepak takraw. The body's ability to move with a wider range of motion allows athletes to perform movements more efficiently and reduce the risk of injury. For example, in serving and passing movements, hip and ankle flexibility allows players to adjust the angle of the body better, resulting in more accurate and powerful balls.

Eye-Foot Coordination and Service Technique

Eye-foot coordination is another biomechanical factor that has a major influence on the quality of the game. In a study by Syahril et al. (2023), it was found that eye-foot coordination contributed 22% to the basic skills of sepak takraw players, with a total contribution of 44% together with flexibility. Good coordination between vision and foot movement is very important in the game, considering that the sepak takraw ball moves at high speed and often requires quick and precise reactions.

The service technique in sepak takraw is greatly influenced by the athlete's ability to manipulate his body to produce efficient and effective movements. Research by Wulandari and Irsyada (2023) shows that the optimal ball contact angle ranges from 156° to 170°, which is produced with a support angle of around 124° to 141°. This correct angle produces higher ball speeds, with a speed range of 9.73 to 12.21 m/s, which allows for more effective serves. This shows that not only muscle strength is important, but also a good biomechanical understanding of how body position and ball contact angle can affect the final outcome of the service movement.

Muscle Explosive Power and Smash Kedeng

The explosive power of the leg muscles has also been shown to play an important role in increasing the strength and effectiveness of the smash movement.(Aji & Yudhistira, 2023). Research by Saputra and Dahrial (2023) showed a significant relationship between leg muscle strength and hip flexibility on smash kedeng ability in sepak takraw athletes. In this case, leg muscle strength is very important in providing the thrust needed to produce speed and power in smashes, while hip flexibility allows players to achieve optimal attack angles. Increasing leg muscle explosive power through plyometric training and strength training can improve athletes' performance in smashes, which are one of the main attack techniques in sepak takraw.(Sahabuddin, 2020).

Practice and Its Effect on Basic Skills

In addition to biomechanical and physiological factors, training factors also play a very important role in improving athlete performance. Research by Yudanto et al. (2024) revealed that pair-based wall passing training is more effective in improving the ability to receive the first ball compared to individual training. Pair training requires athletes to communicate and work together in controlling the ball, which can improve team coordination and increase situational awareness during the match. This reflects the importance of social aspects and teamwork in training, which of course can improve individual and team performance as a whole.(Yudanto et al., 2024).

Well-structured and programmed training that includes biomechanical aspects, such as balance, flexibility, coordination and strength, can help athletes optimize their basic techniques, such as serving, passing and smashing.(Baidhowi, 2022). A training program that includes these elements must be balanced with proper supervision and regular evaluation of the athlete's progress. In this case, the role of the coach is vital to ensure that the training is carried out correctly and leads to significant improvements.

Injury Prevention and Performance Optimization

It is important to note that biomechanical knowledge also has a major impact on injury prevention, especially injuries that often occur in sepak takraw athletes, such as knee and ankle ligament injuries. Research by Hakim et al. (2017) shows that understanding the biomechanics of movement, especially in landing techniques, can reduce the risk of injury. Using the correct landing technique, taking into account the angle and force of the fall, can help prevent injuries that could potentially harm an athlete's career.

Training that focuses on muscle strength and flexibility, as well as a good understanding of biomechanics, can help athletes reduce the risk of injury when performing explosive movements such as smashes or serves.(Hermawan, 2019). Therefore, injury prevention should be an important part of an athlete's training program and should be considered at every stage of technical skill development.

Implications for Training Program Development

Based on the results of this study, it can be concluded that to optimize the performance of sepak takraw athletes, training must include a combination of strengthening biomechanical factors, such as balance, flexibility, coordination, and muscle explosive power, as well as developing proper techniques. In addition, training that focuses on basic techniques, such as serving, passing, and smashing, must be balanced with training that hones aspects of coordination and teamwork. This integrated training program will help athletes achieve optimal performance, reduce the risk of injury, and improve their abilities in competitive matches.(Safei et al., 2024).

Overall, this study provides a clear picture of how biomechanical, physiological and technical aspects can complement each other to improve the performance of sepak takraw athletes.(Roszani et al., 2023). The application of the results of this study in training programs can produce athletes who are more skilled, stronger, and better prepared to face the challenges of competition, and can reduce the risk of injury that often occurs in this sport.

Conclusion

Based on the results of this study, it can be concluded that biomechanical analysis plays a very important role in improving the performance of sepak takraw athletes. Factors such as balance, flexibility, muscle strength, and body coordination have been shown to affect basic technical abilities, such as serving, passing, and smashing, which are important elements in sepak takraw. Structured training with a focus on strengthening biomechanical and technical aspects has been shown to improve athlete performance, both in individual and team aspects. In addition, optimizing proper techniques, such as the angle of contact with the ball in service and correct landing ability, can prevent injuries and increase the effectiveness of movements. Therefore, it is important for coaches and athletes to understand the principles of biomechanics and implement training programs that include a combination of physical strengthening and technical development. The implications of this study also show that a good understanding of biomechanics can reduce the risk of injury, improve basic skills, and maximize athletes' potential in competition. Thus, this study provides a strong foundation for the development of more effective and efficient training programs in sepak takraw.

Reference

Abdullah, KH (2023). A Bibliometric and Scoping Retrospective of Sepak Takraw. Asian Journal of Arts, Culture and Tourism. https://doi.org/10.55057/ajact.2022.4.4.3.

Aji, T., & Yudhistira, D. (2023). The Effect of Hanging Ball Training Method to Improve Kedeng Smash Skill of Sepak Takraw Athletes in Panca Event Games. In Proceedings of the Unima International Conference on Social Sciences and Humanities (UNICSSH 2022) (pp. 1023–1029). Atlantis Press SARL. https://doi.org/10.2991/978-2-494069-35-0_123.

Anggraeni, E., Tomoliyus, & Rini Sukamti, E. (2023). The Effect of Leg Muscle Strength, Leg Flexibility and Balance on the Ability to Service Sepaktakraw: Literature Review. International Journal Of Multidisciplinary Research And Analysis, 6(7). https://doi.org/10.47191/ijmra/v6-i7-15.

Arifin, Z. (2014). Analysis of Upper Service Movement in Sepak Takraw Game Based on Biomechanics Concept. Journal of Sports Education, 3.

Arrazi, F., & Hakim, AA (2021). The Effect of Hanging Ball Smash Training on the Jump Height of Sepak Takraw Athletes at the Asam Jaya Club. Journal of Sports Health, 9.

Baidhowi, MM (2022). The Effect of Hanging Ball Training on Sepak Takraw Service Results in Double Event Numbers of Athletes at the Regional Student Sports Education and Training Center (PPLOPD) Sepak Takraw, Kendal Regency. VII National Indonesian Seminar, 1645–1650.

Bais, S., Padli, Arwandi, J., Iyakrus, Martha, A., Rudyanto, & Arifan, I. (2023). The contribution of flexibility and eye-to-foot coordination to the basic skills of sepak takraw. Journal of Physical Education and Sport, 23(12), 3341–3348. https://doi.org/10.7752/jpes.2023.12382.

Chen, S., & Xiao, R. (2017). Physiological Profile of Filipino Sepak Takraw College Players. Asia Pacific Journal of Education, Arts and Sciences, 4(4), 69–74.

Hakim, AA, Mulyana, & Hanif, S. (2017). The Effect Of Biomechanical Knowledge, Physical Condition, And Landing Technique On ACL Injury Risk Of Sepak Takraw Athletes. JIPES Journal of Indonesian Physical Education and Sport, 3(2), 151–161. http://pps.unj.ac.id/journal/Jipes.

Hermawan, DB (2019). Developing Machine Training (DBH 2MCS) To Improve Beginner Athlete Service in Sepak Takraw in Sumedang Regency. Journal of Education, Health and Sport, 9, 42–54.

Joseph, H.L., Roslizawati, N., Safrusahar, M.Y., Efri, N.M.H., Das, S., Baharudin, O., & Pharmy, A. (2009). Effect of pubertal developmental stages and lower limb kinetics during vertical jump task in Sepak Takraw Sport. In Physiotherapy Program, Faculty of Allied Health Sciences (Vol. 160, Issue 5). Jalan Raja Muda Abdul Aziz.

Khairunnisa, A., & Pitriani, P. (2019). Sepaktakraw Players Injuries Event. JUARA: Sports Journal, 5(1), 1–7. https://doi.org/10.33222/juara.v5i1.624.

Male, S., Kadir, S., Duhe, EDP, & Haryanto, AI (2024). Effectiveness of Upper Service Accuracy Training with Kick Pad vs Sepak Takraw Hanging Ball. Journal of Sports Science and Health, 9(1), 74–86. https://doi.org/10.5614/jskk.2024.9.1.7.

Moungpool, B., & Charoenpanich, N. (2022). Kinematic Analysis of Back Foot Serve in Male Sepak Takraw Players. Journal of Sports Science and Health, 23(2).

Padli, Kiram, Y., Haryanto, J., Desman, MA, Soniawan, V., & Sembiring, NS (2023). Coaching and Education of Sepak Takraw Sports: an Evaluation Study. Journal of Education and Teaching, 56(1), 183–193. https://doi.org/10.23887/jpp.v56i1.50721.

Rezaei, M., Mimar, R., Paziraei, M., & Latifian, S. (2013). Talent identification indicators in sepaktakraw male elite players on the basis of some biomechanical parameters. Middle East Journal of Scientific Research, 16(7), 936–941. https://doi.org/10.5829/idosi.mejsr.2013.16.07.11290.

Roszani, MAA, Zainuddin, NF, Aznan, EAM, Jamaludin, M., Ismail, Z., & Miswan, MS (2023). Analysis of Spiking Technique towards Point Distribution Succession in Sepak Takraw League (STL) Champions Cup 2021. Journal of Human Centered Technology, 2(1), 68–72. https://doi.org/10.11113/humentech.v2n1.43.

Rusli, RU, Ruslan, R., G., S., Arimbi, A., & Qibtiyah, M. (2023). Measurement of Medial Head Gastrocnemius Muscle Contraction Strength in Basic Sepak Takraw Techniques Using Electromyogram Signals. COMPETITOR: Journal of Sports Coaching Education, 15(3), 683. https://doi.org/10.26858/cjpko.v15i3.53403.

Safei, I., Nabillah, AA, Mulyawan, R., & Harun. (2024). Anthropometric Profile and Physiological Characteristics of Lampung Sepak Takraw Athletes. PLYOMETRIC: Journal of Science and Sports Education, 4(2), 11–22.

Sahabuddin. (2020). The Effect of Hanging Ball and Bounce Ball Smash Training on Smash Ability in Sepaktakraw Games. SPORTIVE: Journal of Physical Education, Sport and Recreation, 3.

Saputra, MNR, & Dahrial. (2024). Relationship between Leg Muscle Explosive Power and Hip Flexibility with Sepak Takraw Kedeng Smash Results in Indragiri Sepak Takraw Athletes. Indragiri Sports Journal, 8(2). https://ejournal-fkip.unisi.ac.id/joi.

Hanif, AS, Basyiruddin, B., Gani, A., Azis Hakim, A., & Aji, T. (2021). Asean Sepak Takraw Course. Proceedings of the 2021 National Community Service Seminar, 2021, 2021. http://journal.unj.ac.id/unj/index.php/snppm.

Sujae, I. H., & Koh, M. (2008). Technique analysis of the horse and sila serves in sepaktakraw. Sports Biomechanics, 7(1), 72–87. https://doi.org/10.1080/14763140701687552.

Supalak, R., & Charoenpanich, N. (2023). A Comparison of Vertical Ground Reaction Force and Knee Joint Motion During Landing Between Half-Roll and Sunback Spikes in Female Sepak Takraw Players. Journal of Sports Science and Health, 24(1).

Wiriawan, O., & Nurdiansyah. (2020). Physiological Demands of Sepak Takraw Sports for High School Athletes. Scientific Sports Magazine (MAJORA), 26(1), 1–7.

Wulandari, DAR, & Irsyada, M. (2019). Analysis of Sepak Takraw Upper Service Motion in Male Athletes at Sidoarjo State Sports High School. Journal of Sports Achievement, 2(4).

Yudanto, Yuliarto, H., Sudardiyono, Sujarwo, Ali, SKS, Kauki, MK, & Pratama, KW (2024). The Effect of Training Method and Coordination on First Ball Receiving Skills in Sepaktakraw. Retos, 55, 596–602. https://recyt.fecyt.es/index.php/retos/index.