Journal of Coaching and Sports Science
Volume 4, Issue 1, 66-75.
e_ISSN: 2963-1483
https://www.journal.foundae.com/index.php/jcss/index
DOI: 10.58524/jcss.v4i1.601

Biomechanic Variables and Volleyball Serve Receiving Skills: The Role of Special Exercises

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Article Info

Article history:
Received: December 9, 2025
Revised: January 11, 2025
Accepted: February 20, 2025

Keywords:
Biomechanical variables;
Serve receiving;
Special exercises;
Volleyball.
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Abstract

Background of study: Volleyball is a highly dynamic sport in which serve reception plays a crucial role in determining a team's success. Ineffective serve reception can disrupt attack strategies. Therefore, developing training methods that improve reception accuracy and biomechanical efficiency is important.
Aims and scope of paper: Preparing special exercises to aid in some biomechanical variables and learning to receive a volleyball serve for players. As well as identify the effect of these exercises on the variables under study.
Methods: The experimental method was employed to address the research problem, utilizing a pre-test and post-test design with control and experimental groups. The samples comprised 20 players and were divided by a simple random method (lottery) into the experimental and control groups, each comprising 10 players.
Result: The results showed that the significance level values were significant for all research variables, which indicates the significance of the differences between the pre-and-and post-test and in favour of the post-test. It was below the significance level (0.05).
Conclusion: The exercises with the aids prepared by the researchers positively improved the values of the biomechanical variables (leg strength-maximum leg pressure-body angles-height, and speed of the ball at the moment of contact). Therefore, the researchers recommend using the exercises with the aids prepared by the researcher to learn and train serve-receiving skills in volleyball.

To cite this article: Jawad, M. K., Hussein, A. A. H., & Neama, N. S. (2025). Biomechanic variables and volleyball serve receiving skill: The role of special exercises. *Journal of Coaching and Sports Science, 4*(1), 66-75. https://doi.org/10.58524/jcss.v4i1.601

INTRODUCTION

Volleyball is a highly interconnected sport where each skill influences the success of others. Regardless of how strong a team's attack is, defensive capabilities must be equally, if not more, robust (Nascimento et al., 2024; Hussein & Hrebid, 2023; Li, 2025). Among the fundamental volleyball skills, serve reception plays a crucial role in shaping the team's performance (Saleem & Al-zuhairi, 2024). A well-executed serve reception allows the setter to distribute the ball effectively, creating multiple attack options and increasing the team's offensive efficiency (Adamec & Pridal, 2024). Research by Pridal et al. (2021) has shown that teams win rallies more frequently after receiving a serve than after serving, indicating that a strong serve reception supports a more effective attack strategy. Specifically, an accurate reception enables the setter to involve middle blockers and outside hitters in a faster, more unpredictable offensive play, reducing the opponent's chances to establish a solid defensive formation.

Team coaches strive to select players who are distinguished by a high level of integrated skill performance, and this cannot be achieved or reached except by developing players' levels from the early stages of their involvement in the game (Abdul & Hatem, 2024). For these skills to take root in them, use modern and innovative aids that develop skill performance, such as sensor-based tracking systems that analyze reception angles and reaction times (Salim et al., 2020), virtual reality (VR)--based training that simulates real serving scenarios for cognitive and motor adaptation (Jiang & Rekimoto, 2020) which provide controlled serving variations to increase player adaptability. This

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technology allows early volleyball players to experience more realistic playing conditions and improve their serve reception skills, which is crucial in building quality athletes for the national team (González-Silva et al., 2020).

Although the use of technology in training is growing, this approach is often still more focused on the technical aspects and game strategy (Ardha et al., 2024), while other approaches such as biomechanics help athletes optimize movement efficiency such as running speed (Pan et al., 2023), improve postural stability (Zemková & Zapletalová, 2022), and minimizing the risk of injury during training and competition (Hewett & Bates, 2017). The principles of biomechanics emphasize that players adjust their body angle, weight distribution, and reaction time to adapt to various types of serves from the opponent (Li et al., 2023). Most regular training programs still rely on repetitive experience-based training without considering crucial biomechanical factors such as body balance (Ryu et al., 2020), foot pressure distribution, and neuromuscular coordination (Merrigan et al., 2021), which all have an important role in creating a stable and accurate volley service reception. Therefore, a more specific approach is needed, namely special exercises designed based on biomechanical principles. These special exercises not only target muscle strengthening and body balance (Nema & Ismaeel, 2022) but also optimize the distribution of foot pressure, the angle of the body when receiving service (Al-Tamimi, 2023), as well as coordination of movements following the principles of efficient movement in volleyball (Idrees et al., 2022).

Several studies have shown that biomechanics is performed in volleyball during spike jumps (Gupta et al., 2021), biomechanics is performed to reduce volleyball injuries (Wu et al., 2022), to evaluate the biomechanics of receiving underhand serves in volleyball (Callupe et al., 2022), biomechanics related to jumping and physical fitness in female indoor volleyball players (Ahmadi et al., 2021), biomechanics has also been carried out on volleyball passes but specific training has not yet been carried out (Ozawa et al., 2021). However, although previous studies have explored various aspects of biomechanics in volleyball, no studies have specifically tested the effectiveness of biomechanics-based special exercises to improve volleyball serve reception skills. This study aims to create special exercises that help. The research hypothesis is that learning how to receive the serve and performing exercises with assisting devices positively impact some biomechanical variables for players.

METHOD

Design and Research Sample

This study employed an experimental design approach (Maruo, 2025; Mize & Manago, 2022). The research sample consisted of 20 Babylon University national team players selected using the comprehensive enumeration method. The players were randomly divided into groups—experimental and control, each with 10 players. The validity of this study was sample homogeneity tested based on key variables, such as height, weight, age, and technical performance in receiving service. In addition, equality between the two groups was verified before the intervention began, ensuring that both groups started on the same basis (Aulia & Yuliani, 2022; Wahyuningsih et al., 2024). The skill level of the players was also evaluated before the study to ensure uniformity between the two groups, thus minimizing potential differences that could affect the study results.

Data Collection and Analysis

This study used various methods and tools to collect and analyze data related to biomechanical variables in volleyball service reception. Data was collected from various reference sources, individual interviews, direct measurements, and tests designed to assess the players' technical abilities. The results of the tests were documented in a special form to ensure the accuracy and validity of the data collected. Various equipment was used to support this research, including a standard volleyball court, a 5-meter tape measure, 10 official volleyballs, and electronic scales to measure the players' body weight. In addition, two cameras were used to record movement during testing, which was then analyzed using a laptop with Kinova motion analysis software. The study also involved four RAM units with a capacity of 16GB each to support data processing, one tripod for camera stabilization during recording, and two Foot Scan devices used to measure the distribution of foot pressure and ground reaction force during service reception.

Research Variables

The biomechanical variables in this study were measured using the Kenova motion analysis program, which allows in-depth analysis of player movement. Some of the biomechanics variables measured include the angle of the knee joint when in contact with the ball (calculated based on the angle between the thigh and lower leg from the rear perspective), the angle of the hip joint (calculated based on the angle between the thigh and torso from the front perspective); and the angle of the shoulder joint (calculated from the angle between the upper arm and torso). In addition, this study also measures the horizontal distance between the two legs when in contact with the ball to assess the player's body balance.

Measurement of Service Reception Performance and Accuracy

The technical performance of the player in receiving the service is evaluated by assessing the technical performance, which aims to measure the skill of movement execution. Each player is given two chances to receive the service, with the best score being judged by a panel of judges using a 10-point scale. Meanwhile, service reception accuracy is measured using a special test designed to assess a player's ability to receive the ball with precision. In this test, each player is given 30 chances (15 in each session), and scoring is done using the following system, like 3 points if the ball lands in the predetermined target area; 2 points if the ball lands in an adjacent area but outside the main target; 1 point if the ball remains in the field but outside the target zone; 0 points if the ball does not fall into the previously mentioned categories. The maximum score a player can obtain in this test is 90 points.

Implementation of Special Training

Initial test of biomechanical variables and learning indicators in volleyball service reception skills. This test aims to measure the player's initial condition before a special training intervention. After collecting the initial data, the researchers developed exercises to improve biomechanical characteristics and learning indicators in service reception. These exercises focused on several key aspects, including improving postural stability and joint angles during the reception, optimizing foot pressure distribution for better balance, and improving neuromuscular coordination to speed up the reaction to the opponent's serve.

Table 1. Experimental and Control Group Training Methods

Groups		The method used	Dependent variable	
Experimental	**Pre-Test**	Special exercises	Biomechanical variables	**Post-test**
			Receiving accuracy	
Control		Vocabulary of the educational curriculum followed by the trainer	Biomechanical variables	
			Receiving accuracy	

Final Test and Data Analysis

The training program lasted for eight weeks, with a training frequency of three sessions per week, so 24 special training units were given to the experimental group. Meanwhile, the control group continued to undergo the standard training curriculum used by the coach without any additional specific biomechanical interventions. After the training, the researchers conducted another final test by applying the same procedures as the initial test to ensure consistency in shooting, testing, and measuring biomechanical variables and service reception accuracy. In this study, the paired t-test was used to analyze the difference between the pre-test and post-test results in the experimental group and the control group. This t-test aims to determine whether the specific training given to the experimental group significantly affects the biomechanical variables and the accuracy of service reception. The researchers used the latest statistical package (SPSS) version to analyze the research results. The following is a flowchart of the research for this study.

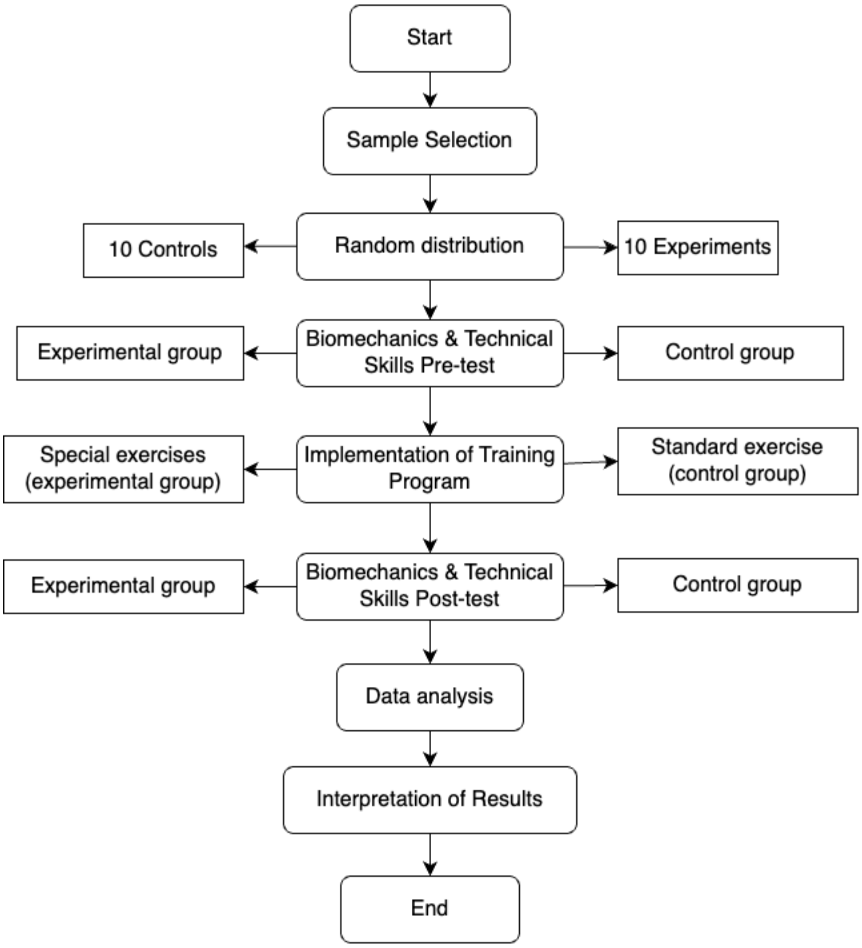

Figure 1. Research Flowchart

RESULTS AND DISCUSSION

Results

This study analyzed the impact of specific biomechanical exercises on volleyball service reception by comparing pre-test and post-test results in the control and experimental groups. Paired t-tests for correlated samples were used to evaluate differences within groups between pre-test and post-test measurements, while independent t-tests were used to compare post-test results between the two groups. The findings of this study are presented and analyzed as follows.

The Results of the Tests of Biomechanical Variables and Learning Indicators for the Control Group for the Pre- and Post-Measurement

Table 2 presents the analysis of the control group's performance before and after the training period. It shows the mean value, standard deviation, t-value, and significance level for each measured variable.

Table 2. Biomechanical Variables and Learning Indicators for the Control Group for the Pre- and Post-Measurement

Variables		Pre- Test		Post -Test		T Calculated value	Sig level	sig type
		Mean	Std. Deviation	Mean	Std. Deviation			
Biomechanical variables	Knee joint angle	96.66	2.591	90	0.866	10.055	0.000	Sig
	Hip joint angle	90.33	1.671	87.74	1.317	7.412	0.000	Sig
	Shoulder joint angle	71.07	5.417	58.5	2.486	4.855	0.001	Sig
	Distance between Legs	116.24	3.226	106.14	7.511	4.207	0.000	Sig
	Right Leg	25.800	5.266	30.700	6.165	8.963	0.000	Sig

Variables		Pre- Test		Post -Test		T Calculated value	Sig level	sig type
		Mean	Std. Deviation	Mean	Std. Deviation			
Maximum pressure	Left Leg	30.400	7.321	35.000	7.055	13.532	0.000	Sig
Technical performance		6.6	0.966	7.9	0.737	8.51	0.000	Sig
Receiving accuracy		60.3	10.467	71.9	6.935	8.104	0.000	Sig

The arithmetic means standard deviations, calculated t-values, significance level for the biomechanical variables and learning indicators pre-and post-tests for the control group are shown in table 2. To assess the validity of these differences and their statistical significance, the researchers used the (t-test for correlated samples. Furthermore, according to the findings, all research variables showed substantial significance level values, highlighting the significance of the differences between the pre-and-and post-measurements that favoured the post-measurement.

The Results of the Tests of Biomechanical Variables and Learning Indicators for the Experimental Group

During service reception, the experimental group underwent special biomechanical training designed to optimize postural balance, foot pressure distribution, and neuromuscular coordination. The impact of this training was evaluated using paired t-tests, with the results shown in table 3.

Table 3. Experimental Group's Pre- and Post-Test Arithmetic Means, Standard Deviations, Computed T-Values, and Significance Level

Variables		Pre- Test		Post -Test		T Calculated value	Sig level	sig type
		Mean	Std. Deviation	Mean	Std. Deviation			
Biomechanical variables	Knee joint angle	95.86	2.796	86.86	1.825	9.745	0.000	Sig
	Hip joint angle	88.37	1.32	83.14	1.653	8.741	0.000	Sig
	Shoulder joint angle	68.57	5.828	53.54	1.914	6.134	0.000	Sig
	Distance between Legs	112.44	2.626	100.04	1.374	12.45	0.000	Sig
Maximum pressure	Right Leg	26.800	5.223	32.700	5.696	8.004	0.000	Sig
	Left Leg	31.100	7.519	40.300	4.398	6.866	0.000	Sig
Technical performance		6.8	0.788	8.3	0.674	9	0.000	Sig
Receiving accuracy		60.7	9.58	81.1	2.132	6.732	0.000	Sig

The arithmetic means, standard deviations, computed (t) values, significance level for the biomechanical variables and learning indicators pre-and post-tests for the experimental group are displayed in table 3. To assess the validity of these differences and their statistical significance, the researchers used the t-test for correlated samples. Additionally, the results showed that every research variable had values at the significance level, highlighting the significance of the differences between the pre-and-and post-measurements that favoured the post-measurement.

The Results of the Post-tests for the Control and Experimental Groups, Biomechanical Variables, and Learning Indicators

Table 4. The Biomechanical Variables and Learning Indicators in the Post-Test

Variables		Control		Experimental		T Calculated value	Sig Level	Sig Type
		Mean	Std. Deviation	Mean	Std. Deviation			
Biomechanical variables	Knee joint angle	90	0.866	86.86	1.825	4.913	0.000	Sig
	Hip joint angle	87.74	1.317	83.14	1.653	6.772	0.000	Sig
	Shoulder joint angle	58.5	2.486	53.54	1.914	4.998	0.000	Sig
	Distance between Legs	106.14	7.511	100.04	1.374	2.526	0.021	Sig

Maximum pressure	Right Leg	30.700	6.165	32.700	5.696	3.251	0.004	Sig
	Left Leg	35.000	7.055	40.300	4.398	3.180	0.005	Sig
Technical performance		7.9	0.737	8.3	0.674	1.265	0.222	Non Sig
Receiving accuracy		71.1	6.935	81.1	2.131	4.01	0.001	Sig

Table 4 shows the post-test results for the biomechanical variables and learning indicators, including the arithmetic means, standard deviations, calculated t, and significant levels between the control and experimental groups. The findings showed that the significance level value was significant, except for the technical performance variable, which showed non-significant changes.

This study showed that biomechanics-based special training significantly improved movement efficiency and accuracy of serve reception in volleyball, as shown in the post-test comparison between the experimental and control groups table 4. These findings support the research hypothesis that receiving serves and practising with assistive devices favourably impact several biomechanical variables for players.

The main aspects validated in this study were the differences in knee joint angle and hip joint angle between the pre-test and post-test in the experimental group. These differences indicate that the training with the assistive devices used in this study effectively developed and adjusted the joint angles to an ideal range in serve reception. These adjustments allow players to better absorb the ball's momentum, improve stability, and optimize body balance when receiving hard serves from opponents (Ali & Shaalan, 2021). Meanwhile, knee angle adjustment allows for better energy absorption upon contact with the ball, which reduces impact force and improves ball control in serve reception. This contributes to a more effective technique than a less optimal reception technique, where players who do not have proper joint angles tend to lose balance or make less stable contact with the ball. As Mahardika et al. (2024) asserted, the downward elastic rebound motion that occurs during hard ball reception allows players to better manage the ball's momentum, which explains the significant improvement in serve reception accuracy in the experimental group.

The biomechanical mechanism of "absorbing the momentum" of the ball's ineffective serve reception differs from less efficient reception techniques; this study aligns with Ikeda & Mori's (2024) parameters on ball bounce and biomechanical interaction of absorbing ball momentum. In receiving a more effective serve, players tend to adjust their body position to the optimal angle, pull their arms back, and use their bodies to distribute the impact force evenly. This research aligns with research by Rasmussen & Zee (2021), which shows how many badminton athletes are in the range of 10-30 degrees. Conversely, in less effective techniques, players may be too rigid or less flexible in absorbing the force of the ball hit, which causes the ball to bounce uncontrollably or be difficult to control. The distance between the feet in this study also showed significant changes in the experimental group. This increase in distance allows players to lower their centre of gravity and increase body stability, which is a key principle in postural balance when receiving a hard serve. Previous studies (Dayekh, 2002) also confirmed that effective serve reception requires a wider support base to ensure players remain stable when receiving serves at high speeds.

This study supports the biomechanical theory in volleyball serve reception, especially in postural stability and optimization of pressure distribution during play. As described by Hussein (2025), a link in the kinematic chain of the human body between the knee joint and the hip joint plays an important role in improving players' response to hard serves. This study offers a more specific approach to developing serve reception techniques through biomechanics-based interventions than previous studies. In contrast, other studies have focused more on technical factors or general game strategies. For example, Al-Jubouri & Hussein's (2022) study highlighted the importance of knee angle in serve reception but did not include specific biomechanics-based exercises as the main intervention method. This suggests that this study reinforces existing biomechanical theories and expands insights into how specific exercises can optimize the serve reception technique more effectively. This study confirms that biomechanics-based specific exercises focusing on joint angles, foot pressure distribution, and postural balance can improve the effectiveness of serve reception. Coaches can implement this approach in their training programs to improve players' ability to deal with fast and powerful serves from opponents. This study also contributes to developing evidence-based training strategies that can be adopted to train youth and professional athletes. Coaches can design more efficient drills to improve player performance in competitive situations by understanding how biomechanical factors can be optimised.

Research Contributions

This study contributes to evaluating the impact of biomechanics-based training in volleyball, specifically in optimizing serve reception technique. It bridges the gap between traditional training and modern biomechanical approaches by highlighting how adjustments to joint angles, foot pressure distribution, and postural balance can improve the effectiveness of serve reception.

Limitations

Although this study provides new insights into biomechanics in volleyball, there are some limitations. For example, it was conducted on a limited number of samples (only 20 players), which may affect the generalizability of the results. This study focused more on biomechanical analysis without considering psychological factors or tactical strategies in serve reception. Factors such as mental stress, decision-making, and reaction to the opponent also affect the success of serve reception.

Suggestions

Future research needs to involve larger and more diverse samples to ensure the external validity of these findings. Advanced technologies such as real-time movement sensors and virtual reality could be applied in future studies to develop more adaptive and interactive training programs. Future research could also compare the effectiveness of biomechanics-based training with other training methods, such as video feedback-based training or artificial intelligence (AI) systems in service reception technique analysis. This will provide greater insight into the most effective approaches to improve athlete performance in volleyball.

CONCLUSION

This study supports the hypothesis that biomechanics-based specialized training can improve the effectiveness of the serve reception technique in volleyball. By comparing the experimental and control groups, this study proved that adjustments to joint angles, leg pressure distribution, and body balance directly impact the stability and accuracy of serve reception. The experimental group showed greater improvement than the control group on various biomechanical variables, such as knee angle ($p < 0.001$), hip angle ($p < 0.001$), maximum pressure on the right and left legs ($p < 0.001$), and serve reception accuracy ($p < 0.01$). These findings confirm that biomechanics-based training is more effective than conventional training methods. Technical performance and accuracy of volleyball serve-receiving skills were positively influenced by exercises performed using contemporary aids. Future research could explore how combining biomechanical training and cognitive aspects could result in a more holistic approach to volleyball training.

ACKNOWLEDGMENT

The authors thank the Faculty of Physical Education and Sports Science / University of Babylon, Iraq, for supporting their scientific work.

AUTHOR CONTRIBUTION STATEMENT

Research Design: MKJ, AAH. Statistical analysis: AAH, NSN. Preparation of the article: MKJ, AAH,NSN. Data Collection- Performed by MKJ, NSN.

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