Relationship between arm length, arm muscle strength and eye-hand coordination on the results of the upper service in the Garuda Jaya Sumatra volleyball team

Relación entre la longitud del brazo, la fuerza muscular del brazo y la coordinación ojo-mano en los resultados del servicio superior en el equipo de voleibol de Garuda Jaya Sumatra

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Abstract

Background: This study aims to determine the relationship between arm length, muscle strength, and eye-hand coordination with overhead service skills of male volleyball players of Garuda Jaya Sumatra.
Objective: This study aims to identify the relationship between arm length, arm muscle strength, and eye-hand coordination to the results of overhead serves in Garuda Jaya Sumatra volleyball players
Method: This study uses a quantitative descriptive research type with a correlational research method. This study took a sample of 14 male volleyball players aged 14-17 years who play at the Garuda Jaya Sumatra club. The method used is total sampling of male players aged 14-17 years. The instruments used to collect data are: Anthropometric Test to measure arm span. The arm muscle strength instrument uses the Camry-Electronic Hand-grip Dynamometer model EH101 ISO 9000 Certified by SGS (Societe Generale de Surveillance) with kilogram (Kg) units. Tennis Ball Throw-Catch Test to determine eye-hand coordination. Volleyball Overhead Service Test to assess overhead service skills. Data were analyzed through multiple regression and correlation tests with the help of SPSS version 27.
Research Results: The results of the study showed that there was a significant relationship between arm length, arm muscle strength, and eye-hand coordination on the results of the upper serve, as seen from the sig value of 0.02 <0.05. The results of this study can be implemented by volleyball coaches on athletes to identify Overhead serve skills. So that it can provide solutions in terms of improving athletes' upper serve skills.

Keywords

Arm length; strength; coordination; overhead serve.

Resumen

Antecedentes: Este estudio tiene como objetivo determinar la relación entre la longitud del brazo, la fuerza muscular y la coordinación ojo-mano con las habilidades de servicio por encima de la cabeza de los jugadores de voleibol masculinos de Garuda Jaya Sumatra.
Objetivo: Este estudio tiene como objetivo identificar la relación entre la longitud del brazo, la fuerza muscular del brazo y la coordinación ojo-mano con los resultados de los saques por encima de la cabeza en los jugadores de voleibol de Garuda Jaya Sumatra.
Método: Este estudio utiliza un tipo de investigación descriptiva cuantitativa con un método de investigación correlacional. Este estudio tomó una muestra de 14 jugadores de voleibol masculinos de 14 a 17 años que juegan en el club Garuda Jaya Sumatra. El método utilizado es un muestreo total de jugadores masculinos de 14 a 17 años. Los instrumentos utilizados para recopilar datos son: prueba antropométrica para medir la envergadura del brazo. El instrumento de fuerza muscular del brazo utiliza el dinamómetro de agarre manual electrónico Camry modelo EH101 ISO 9000 certificado por SGS (Société Générale des Surveillance) con unidades de kilogramos (Kg). Prueba de lanzamiento y recepción de pelota de tenis para determinar la coordinación ojo-mano. Prueba de servicio por encima de la cabeza de voleibol para evaluar las habilidades de servicio por encima de la cabeza. Los datos se analizaron mediante pruebas de regresión múltiple y correlación con la ayuda del SPSS versión 27.
Resultados de la investigación: Los resultados del estudio mostraron una relación significativa entre la longitud del brazo, la fuerza muscular del brazo y la coordinación ojo-mano con los resultados del saque superior, como se observa en el valor significativo de 0,02 <0,05. Los resultados de este estudio pueden ser aplicados por entrenadores de voleibol a atletas para identificar las habilidades del saque superior y así brindar soluciones para mejorar las habilidades del saque superior de los atletas.

Palabras clave

Longitud de los brazos; fuerza; coordinación; mejor saque.

Introduction

Volleyball is a dynamic and multifaceted sport that demands a high level of technical proficiency and physical capability from its participants. (Assefa Berhanu, 2023; Karalić et al., 2023) highlight that the sport requires athletes to master various skills while exhibiting exceptional physical attributes (Marzano Felisatti et al., 2024). Among the myriad of technical skills essential for success in volleyball, the overhead serve stands out as a pivotal action, serving both as the first offensive maneuver in modern fast-paced volleyball and as a critical opportunity to score points (Almaliki & Khalaf, 2024; Romadhonsyah, 2024; Zhou & Saeed, 2022). The overhead serve is not just a routine action; it encapsulates the essence of strategic play, requiring players to engage in a series of biomechanical actions that rely on good technical, physical, and anthropometric abilities. A volleyball athlete must have a combination of these technical skills and anthropometric and physical characteristics.

Research indicates that factors such as arm length, arm muscle strength, and eye-hand coordination are instrumental in determining the efficacy of this skill (D'Isanto et al., 2018) the importance of these attributes cannot be overstated; they form the foundational elements that facilitate a powerful and accurate serve. For example, players with optimal arm length-to-height ratios tend to exhibit enhanced serving effectiveness, as noted by (Nuryastuti & Ismail, 2022) however, the concept of an "ideal" arm length remains ambiguous, with insufficient exploration into how variations in arm span may confer biomechanical advantages such as reach, leverage, or ball contact height.

In addition to anthropometric considerations, the role of muscular strength—particularly in the arms and shoulders—emerges as a critical factor in generating the power and control necessary for successful serves and spikes. Research by (Billy Yachsie et al., 2022; Suhadi, Guntur, Erwin Setyo Kriswanto, 2023). underscores the correlation between muscle strength and the ability to execute serves with both speed and precision. Strong arm and shoulder muscles facilitate a more forceful impact with the ball, ultimately influencing the trajectory and placement of the serve. Moreover, the explosive movements associated with jump serves and spikes are supported by the engagement of muscle groups in the abdomen and legs (Setiawan & Makorohim, 2024).This highlights the interconnectedness of various muscle groups and their collective contribution to performance in volleyball. Based on several research results, it shows that arm length greatly contributes to good upper serve, because the longer the arm in reaching the highest point when the ball is thrown upwards with the support of arm muscle strength, it will produce a good upper serve in terms of speed and accuracy of the service stroke.

Equally significant is the role of eye-hand coordination, which is paramount in a sport characterized by rapid exchanges and unpredictable play scenarios. Enhanced eye-hand coordination allows athletes to synchronize their movements, accurately time their joint actions, and swiftly adapt to the changing dynamics of the game. (Yusup et al., 2024) emphasize that improved eye-hand coordination translates into better execution of serves and receptions, particularly under pressure, while also contributing to increased agility and reaction time. This ability to respond adeptly to game situations is crucial for maintaining a competitive edge in volleyball.

Despite the wealth of research examining individual components of performance—such as arm span, muscle strength, and eye-hand coordination—there remains a conspicuous lack of integrated studies that explore how these elements interact synergistically to influence the execution of the overhead serve. Most existing literature tends to isolate one variable or focus exclusively on either technical or psychological aspects, thereby creating a gap in our understanding of how these physical and coordinative properties collectively impact this critical skill. This gap is particularly evident in the context of the Garuda Jaya Sumatra Volleyball Team in Ogan Ilir Regency, where skill assessments revealed that only 8 out of 14 players demonstrated proficiency in their overhead serves. This inconsistency underscores the necessity for a more comprehensive exploration of the core characteristics that influence performance.

Bridging this gap is of paramount importance, as it holds the potential to provide valuable insights that can inform evidence-based training programs. Understanding the physical qualities that impact overhead serve performance will empower coaches and practitioners to adopt a more targeted approach to training. This knowledge is essential for teams like Garuda Jaya Sumatra, as it aims to achieve more consistent performance outcomes and enhanced competitiveness in the sport.

In light of these considerations, this study seeks to examine the interplay between arm span, muscle strength, and eye-hand coordination in relation to the performance of the overhead serve in volleyball. By adopting an integrated approach, this research aims to elucidate the complex relationships among these variables, providing a more nuanced understanding of how they collectively influence serving efficacy. Furthermore, the findings of this study may have significant implications for training methodologies, enabling coaches to tailor their programs to address the specific physical and technical needs of their athletes.

In conclusion, the overhead serve is a fundamental skill in volleyball that requires a confluence of technical ability and physical attributes. The interplay of anthropometric factors, muscular strength, and eye-hand coordination is crucial for optimizing performance in this skill. However, the existing literature has largely overlooked the integrated analysis of these components, resulting in a gap in our understanding of their collective impact. By addressing this gap, this research not only aims to advance the academic discourse surrounding volleyball performance but also seeks to provide practical applications that can enhance training practices for teams such as Garuda Jaya Sumatra. As the sport continues to evolve, the insights gleaned from this study may play a vital role in shaping the future of volleyball training and performance optimization.

Method

Participants

The sample in this study was Garuda Jaya Sumatra volleyball players totaling 14 male players with an age range of 14-17 years. The research sample was taken using the total sumption technique, where the purpose of the sample with the selection was based on the characteristics of the age of 14-17 years totaling 14 players who were involved in joint training since they first joined the team. These basics are so that the samples used have the same characteristics so that the research process can run well.

Procedure

This research method is carried out by means of correlation, which means there is a relationship between two or more variables (Sugiyono, 2023). This type of research is quantitative descriptive research, which is an approach that emphasises the analysis of numerical data (numbers) processed by statistical methods. Sampling was carried out using saturated sampling technique. Saturated sampling is a sampling technique when all members of the population are used as samples (Sugiyono, 2019).

Instrument

To measurements for the specified variables, the research scholar followed the following procedure: Arm length is measured from the tip of the shoulder (acromion) to the tip of the little finger. This measurement is crucial for anthropometric profiling in sports (Gayen et al., 2024), The arm muscle strength instrument uses the Camry-Electronic Hand-grip Dynamometer model EH101 ISO 9000 Certified by SGS (Societe Generale de Surveillance) with a measurement unit of kilograms (Kg). The hand grip dynamometer has a high validity coefficient of 0.880 and a reliability coefficient of 0.938 (Nathania et al., 2023) he subject holds the dynamometer in the hand to be tested, with the arm at right angles and the elbow by the side of the body. The handle of the dynamometer is adjusted if required - the base should rest on the first metacarpal (heel of palm), while the handle should rest on middle of the four fingers. When ready the subject squeezes the dynamometer with maximum isometric effort, which is maintained for about 5 seconds. No other body movement is allowed. The subject should be strongly encouraged to give a maximum effort. Hand-eye coordination test by throwing and catching the ball at the target (Ziagkas et al., 2017) This test evaluates hand-eye coordination. Participants stand a set distance from a wall and alternately throw and catch a tennis ball with both hands for a specified duration, typically 30 seconds. The test to measure the upper serve test is based on The AAHPERD (American Alliance for Health, Physical Education, Recreation and Dance) in (Rink et al., 2025) Implementation Steps: Starting Position: Participants stand in the service area behind the end line of the court according to the official volleyball rules. Instructions: Participants are asked to serve overhand 10 times to the opponent's court, with the aim of directing the ball to the designated zones. Scoring Zone: The opponent's court is divided into several scoring zones. For example: Center zone (main target zone)

= 3 points Right and left side zones (secondary zones) = 2 points Zone outside the line but still touching the court area = 1 point. The ball goes out of court or touches the net and does not enter = 0 points Implementation: Each participant serves one by one. The coach or examiner records the results of each serve and calculates the total score based on the target zone that has been achieved. Scoring: The maximum score is 30 points (if all 10 serves enter the main zone). The final score is used to measure the ability of each player to serve overhand. Note: Participants are allowed to warm up first. Any missteps (such as stepping on the line while serving) must be recorded and considered a failed service.

Data analysis

The data collection techniques used in this study include tests and measurements This study will use SPSS version 27 to use simple regression and correlation test analysis techniques. Regression testing is a statistical technique for estimating the relationship between dependent variables and one or more independent variables The correlation technique used is Pearson's product moment correlation, which determines the simple correlation, namely the relationship between two or more independent variables used in testing with one or more dependent variables (Sugiyono, 2023). Before performing regression and correlation analyses, assumptions like normality, linearity, and multicollinearity were verified with the suitable statistical tests. The linear interdependence of the independent variables (overhead serve skills, arm length, arm muscle strength, and eye-hand coordination) and the dependent variable was evaluated through the Pearson correlation coefficient.

Results

The results of the correlation test and measurement of arm length, arm strength and hand eye coordination are shown in this study measured arm length with the following results.

Table 1. Description of arm length data

No	Data Description	Result
1	Mean	45
2	Median	46
3	Modus	51
4	Maximum value	51
5	Minimum value	33
6	Range	18
7	standard deviation	4,64713

The description of the table above shows that the overall data on the participants' Arm Length has a mean value of 45.00, median value of 46.00, mode value of 51.00, maximum value of 51.00, minimum value of 33.00, range of 18.00, and standard deviation of 4.64713.

Table 2. Description of arm muscle strength

No	Data Description	Result
1	Mean	3
2	Median	4
3	Modus	3
4	Maximum value	4
5	Minimum value	2
6	Range	2
7	standard deviation	0,61914

The description of the table above shows that the overall data on muscle elasticity is 3.00, the median value is 4.00, the modulus value is 3.00, the maximum value is 4.00, the minimum value is 2.00, the range is 2.00 and the standard deviation is 0.61914.

Table 3. Description of eye-hand coordination

No	Data Description	Result
1	Mean	4
2	Median	5
3	Modus	5
4	Maximum value	5
5	Minimum value	3
6	Range	2
7	standard deviation	0,62915

The description of the table above shows that the overall data of eye-hand coordination is 4.00, the median value is 5.00, the modulus value is 5.00, the maximum value is 5.00, the minimum value is 3.00, the range is 2.00 and the standard deviation is 0.62915.

Table 4. Regression Test Results of Arm Length and Overhead Servis

ANOVAa					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	200,236	1	200,236	16,806	.001b
Residual	142,978	12	11,915		
Total	343,214	13			

a. Dependent variable: top service

b. Predictors: (constant), arm legth

Based on table 4, the results obtained have a significance value of 0.001 which means it is smaller than α = 0.05, meaning that there is a relationship between arm length and overhead serve in volleyball games in the Garuda Jaya Sumatra volleyball team.

Table 5. Results of Correlation Test of Arm Length and Top Serve

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0,764a	0,583	0,549	3,452	0,583	16,806	1	12	0,001

a. Predictors: (constant), arm legth

The regression test results in table 5 show the coefficient of determination R = 0.764 which means that arm length is strong related to volleyball serving. The conclusion is that arm length is significantly and completely correlated with the ability to serve the volleyball game.

Table 6. Regression Test Results of Arm Muscle Strength and Top Serve

ANOVAa					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	214,888	1	214,888	20,095	.001b
Residual	128,326	12	10,694		
Total	343,214	13			

a. Dependent variable: Top serve

b. Predictors: (constant), arm muscle strength

The significance value of the calculation results in table 6 is 0.001, indicating that the value is smaller than α = 0.05, which means that there is a relationship between arm muscle strength and volleyball serving.

Table 7. Correlation Test Results of Arm Muscle Strength and overhead Serve

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.791a	0,626	0,595	3,270	0,626	20,095	1	12	0,001

a. Predictors: (constant), arm muscle stregth

Judging from the results of the regression test in table 7, the coefficient of determination R = 0.791 is obtained, which shows that arm muscle strength has a strong relationship with volleyball serving. In conclusion, arm muscle strength has a significant relationship with back serve and has strong correlation according to relationship guidelines.

Table 8. Regression Test Results of Eye-hand Coordination and Upper Serve

ANOVAa					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	222,807	1	222,807	22,205	.001b
Residual	120,408	12	10,034		
Total	343,214	13			

a. Dependent variable: top serve
b. Predictors: (constant), Eye-hand Coordination

The significance value of the calculation results in table 8 of 0.001 is smaller than α = 0.05 which shows that there is a relationship between hand-eye coordination with the peak of the serve in volleyball games.

Table 9. Correlation Test Results of Eye-hand Coordination and Overhead Serve

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.806a	0,649	0,620	3,168	0,649	22,205	1	12	0,001

a. Predictors: (constant), Eye-hand Coordination

Judging from the results of the regression test in table 8, the coefficient of determination R = 0.806 is obtained, which shows that hand-eye coordination has a strong relationship with volleyball serving. In conclusion, hand-eye coordination is significantly related to back serve and has a strong correlation according to the relationship criteria.

Table 10. Correlation Test Results of Arm Length, Arm Muscle Strength and Eye-hand Coordination and overhead

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.943a	0,899	0,862	2,357	0,889	32,118	3	12	0,000

a. Predictors: (constant), Arm Length, Arm Muscle Strength and Eye-hand Coordination

The results obtained from the calculation of SPSS 27 sig. F value Changel is 0.000, indicating a value that is smaller than α = 0.05, which means there is a relationship between arm length, arm muscle strength and eye-hand coordination to the overhead service in volleyball.

To observe the level of relationship between arm length, arm muscle strength and hand eye coordination on the overhead serve in volleyball by looking at the R value obtained R = 0.943, then the value is compared with the guideline for the degree of relationship. Based on the correlation degree guidelines, it can be concluded that the value of R = 0.943 is included in the perfect correlation relationship.

Discussion

The results of the study based on the results of data analysis can be presented in the following discussion that after a simple regression test was conducted, it showed that the independent variable Regression analysis unveiled potent correlation between arm length and overhand serve execution performance (R= 0.764, p = 0.001) serving as a reference point to explain 58.3% variance on performance serve. This means that overhand serve executing endurance wouldn't be a challenge for long-dominant armed athletes since they seem to have anatomical benefits during mechanical leverage and force application during a serve. Supporting this fact, (Hidayatullah et al., 2023) indicated positive impacts on offending

spike back attack ability of junior volleyball athletes attributing the results to increased arm length due to anatomical advantages like reach and leverage beyond other age-eligible athletes. (Chatterjee et al., 2023; Musa et al., 2023) also mentioned high-performance volleyball players is from anthropometric variables like length arm, which serves as a spin on the importance. The results of the research study (Agustiningsih, 2019) stated that there was a relationship between arm muscle strength and arm length with volleyball top serve results. Furthermore, research conducte (Arfiani, 2023) stated that there was a relationship between arm muscle strength and hand-eye coordination with volleyball top serve skills. This implies importance of arm length concerning different techniques of serve skill such as overhand serves among others. On a wider scope, one more analysis added to full understanding of the subject claiming to understand the serve arm span velocity relation, (Fett et al., 2020) The study pointed out exercise specific anthropometric measurement underscore arms span as a focal point among other relevant factors concerning serve velocity, and (Ridlo & Saifulloh, 2019) which states that there is a contribution of arm muscle strength to the results of the lower serve in volleyball games. Performing a longer arm lever bolavoli top serve movement will provide more advantages when hitting the ball (Kuncoro, 2021) by directing all the energy possessed, especially in the arm which must be coordinated with arm movements to support the ability to play the ball by trying to bounce the ball using the arm as much as possible by coordinating the ability to see and hit the ball so that it can determine and direct the ball to be served. Physical condition and risk of falls in a group of elderly people from the medical service of a public University (Carrillo et al., 2024) Correlation between Hand-Eye Coordination and Wrist Flexibility on Short Service Ability in the PB Avanti Makassar Badminton Game (Nurafiati et al., 2023). Collectively, these studies affirm that arm length is a critical anthropometric factor influencing overhand serve performance in volleyball. Longer arms provide biomechanical advantages that enhance reach, leverage, and force application, leading to improved serve velocity and accuracy. These insights are valuable for talent identification and training program development, emphasizing the need to consider individual anthropometric profiles in athletic performance optimization.

Fort the next variable the analysis showed a strong correlation between arm muscle strength and overhead serve ability (R = 0.791, p = 0.001), with a contribution of 62.6% that arm muscle strength is an important contributor to the execution of overhead serves in volleyball (Keoliya et al., 2024) . (Martin et al., 2024) shown upper body strength was strongly correlated with performance metrics, showing significant relationships with points score Several studies have reported a high relationship of arm muscle strength (AMS) and serving performance, suggesting that higher strength of upper limbs tends to correlate to better serving performance For, eg,a study by (Nazirah, 2024) on junior high school students reported strong correlation (r = 0.902) between arm muscle strength and floating serve effectiveness (contribution rate (81.36%) of serve performance. This indicates that developing arm strength in growing sports persons may aid in serve skills. In another study, (Rizky et al., 2024)) observing a class of first semester students taking Physical Education, found that the serving ability in volleyball was significantly related to the strength of the arm and back muscles with a correlation r = 0.82. This emphasizes the impact of upper limb strength on serve performance.

This is further supported by findings of (Kumar, 2023) who performed a comparative study on the impact of strength and plyometric training on volleyball performance, in research (Destriana et al., 2024) states that there is a relationship between strength, Visualization of techniques in volleyball is important to produce a volleyball game (López-serrano, 2025). Effects of plyometric training on explosive strength in pubescent girls volleyball players (Vilela & Caniuqueo-Vargas, 2021) It was observed that participants who underwent strength training could open hand serve and spike the volleyball better than participants not subjected to strength training, indicating the positive impact of strength training on volleyball performance .

Resting hand and eye coordination is essential while executing overhead serves. Recent studies show that a strong relationship exixts between hand eye coordination and set serving with a relationship of R= 0.806 (p = 0.001) marking 64.9% of variance in serve efficiency which is quite high. In more recent times, The results showed that both training techniques and hand coordination levels do affect serve performance and better with high coordination. (Özbay & Ulupınar, 2022)(Ngadiyana, 2020) also studied the impact of hand coordination in addition to shoulder strength on a group of college male volleyball players serving abilities. It turned out that both have a measurable impact on serving and therefore serve performance. It was found, as expected, that coordination as well as physical power positively influences serve, coordination and balance on the lower serve in adolescents, then research

(Mardiah et al., 2023) states that there is a relationship between arm muscle explosiveness and hand-eye coordination on the upper serve on female extracurricular participants at Tembilahan Hulu.

Based on the results of this study, there is a relationship between eye-hand coordination and the results of the top serve of the Garuda Jaya Sumatra volleyball game. In a different study, (Arfiani, 2023) stated that there was a relationship between arm muscle strength and hand-eye coordination with volleyball top serve skills, this study is in line with research (Karmila et al., 2024). which states that there is a contribution of arm muscle strength, eye-hand coordination, and abdominal muscle strength to the ability to serve over volleyball in UPT SPF 29 Bulukumba students, as well as research (Addivinola et al., 2021) teaching method is a training effort that can improve hand-eye coordination which is very useful in volleyball serving, the outcomes showed that important hand-eye coordination and serve accuracy which highlighted the role of coordination on accurate serve execution. (Destriana et al., 2024) examined the role arm muscles, e hand-eye coordination, an assessment on underhand serving for junior high school volleyball players. The studies highlighted above confirm that the coordination of hands and eyes is one of the main factors determining the effectiveness of overhead serves in volleyball. Therefore, for optimum performance, training programs designed to improve serving skills should include exercises such as reaction drills and ball-handling that are targeted at improving coordination.

Overhead serving in volleyball is a complex motor skill that requires the integration of various physical and neuromuscular attributes. Recent research indicates that arm length, arm muscle strength, and hand-eye coordination collectively have a strong correlation with overhead serve performance, with a multiple correlation coefficient of $R = 0.869$ ($p = 0.002$), explaining 75.5% of the variance in performance. This suggests that these three variables are critical determinants of effective serving. With regard to servicing, having long arms offers a mechanical advantage. With longer arms, there comes the ability to generate higher angular velocities alongside an elevated contact point, making it easier to hit the ball harder and with a downward direction. Although there are not many studies concentrating purely on the importance of arm length, biomechanics as a field does support the notion of its importance in serving performance. The biomechanical principle of angular velocity indicates that increasing the distance from the axis of rotation (i.e., having longer arms) can lead to higher linear velocity at the point of contact, assuming the same angular speed. This means that players with longer arms can generate greater ball speed during a serve. A study by (Liu et al., 2024) found that arm swing speed significantly contributes to angular momentum in the volleyball jump serve, which is crucial for serve performance. Additionally, research by (Kumar, 2023) demonstrated a significant relationship between arm length and serve velocity, indicating that players with longer arms tend to have faster serves.

Arm length provides a mechanical advantage during the overhead serve by increasing the range of motion and leverage. A longer arm allows for a higher contact point, potentially increasing the velocity and downward angle of the serve. This biomechanical leverage facilitates greater angular momentum, which is critical for powerful and precise serves (Kuncoro, 2021). Explosive strength of the arm muscles is essential for initiating forceful and rapid movement during the serve. Stronger arm muscles generate higher racket head speed (in volleyball, hand velocity), which contributes to both the power and control of the ball. These findings align with the understanding that longer limbs can enhance the effectiveness of the kinetic chain during serving, leading to improved performance (Saptiani et al., 2019). The proper execution of a powerful service requires strength in the arms to create the required force. According to a study (Fadhil & Alficandra, 2024) Arm muscle explosive power greatly enhances the precision of serving, serving as 6.45% of the variance of serving accuracy, and Eye-hand coordination refers to the synchronized control of eye movement with hand movement, a skill crucial for timing, ball tracking, and accurate contact in overhead serves. This coordination enables the player to adjust dynamically to the ball toss and apply precise force during the serve (Sari et al., 2024). It is clearly evident that with this degree of variance, strength training is essential for improving serve performance. Coordination between the eyes and hand is vital for the serve to be accurate and timely. Conclusively, this coordinates training programs accordingly and meets all the requirements in order for optimal performance to be achieved. Hand-eye coordination was reported to have a contribution to serving accuracy according to the same scholar that emphasized the importance of combined effort. The overhead serve in volleyball is influenced significantly by a combination of anthropometric and motor coordination variables. Arm length contributes to leverage and contact height, muscle strength supplies the necessary power, and eye-hand coordination ensures timing and directional accuracy. Together, these elements form the

foundation for a biomechanically efficient and tactically effective serve. Coaches and practitioners should thus incorporate targeted training interventions that develop these attributes to optimize performance outcomes.

The combination of factors like arm span, the strength of the muscles in arm, as well as the coordination of eyes and hands is fundamental for determining the efficiency of overhead serves in volleyball. Coaches and athletes need to embrace a multi-faceted training approach that optimally develops these attributes at the same time to maximize serving capabilities.

Conclusions

Based on the research findings, there is a relationship between arm length on the overhead serve, there is a relationship between arm muscle strength on the overhead serve, there is a relationship between eye-hand coordination on the overhead serve, and there is a relationship between arm length, arm muscle strength, and eye-hand coordination on the results of the upper serve. The findings of this study can be used as a reference for further research to increase the number of this study with a larger population and sample and use more sophisticated tools, so that it is expected to increase arm muscle and hand-eye coordination as it relates to the upper serve of Garuda Jaya Sumatra volleyball players.

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