**Jurnal Patriot**
E-ISSN: 2714-6596 P-ISSN: 2655-4984
Homepage: http://patriot.ppj.unp.ac.id/index.php/patriot
Vol. 7 (Issue 2), 2025, pp. 67-75

# The role of upper limb strength and power in predicting overhead serve performance among u-15 female volleyball athletes

**Wahyu Pudji Lestari Priyatmoko [1], Wiga Nurlatifa Romadhoni [1,*]**
[1] Department of Sport Coaching Education, Faculty of Sport Science, Universitas Negeri Semarang, INDONESIA.

**Article Information:**
Submitted: 4th June 2025; Accepted: 29th June 2025; Published: 30th June 2025

**ABSTRACT**

**Problems:** The study investigates the contribution of arm muscle strength and arm muscle power to the performance among u-15 female volleyball athletes Atlas Club in Semarang. **Purpose**: The purpose of this study was to determine the contribution of arm muscle strength and arm muscle power to the results of the upper serve on female athletes of the Semarang City Atlas Volleyball Club U-15. **Methods**: This study uses correlational research. The sample consisted of 15 female athletes aged 15 years who were taken using total sampling technique. The data collection technique uses a 60-second push-up test to measure arm muscle strength, 3 kg medicine ball throw (three attempts, the best results are taken) to measure arm muscle power, and the AAHPER volleyball top serve test (10 attempts) to measure the results of the top serve. Data analysis used descriptive statistics, normality test, correlation, and multiple linear regression. **Results**: The results of this study indicate that there is a very strong contribution between arm muscle strength, and arm muscle power to the results of the Atlas club female athletes obtained from r square of 0.965 (96.5%). However, when viewed based on the t test (partial) only arm muscle strength contributes 76.88% and is significant to the results of the upper serve with a significance value (Sig.) of 0.025 ($p < 0.05$). Meanwhile, arm muscle power contributed 19.61%, although it was not statistically significant at 0.221 ($p > 0.05$) to the results of the upper serve. **Conclusion**: these findings emphasize the primary role of arm muscle strength in optimizing serve outcomes. It is recomended that volleyball coaches prioritize training programs focused on developing arm muscle strength trougth resistance and plyometric exercises to improve upper serves.

**Keywords: arm muscle strength, arm muscle power, upper serve results, volleyball.**

https://doi.org/10.24036/ patriot.v%vi%i.1150

**Corresponding Author:**
Wahyu Pudji Lestari Priyatmoko
Department of Coaching, Faculty of Sport Science, Universitas Negeri Semarang, Indonesia.
Email: ayupriyatmoko@students.unnes.ac.id

## Introduction

Volleyball is one of the team sports that is very popular among the community (Priambodo et al., 2022). One of the sports of big ball games is a volleyball game that plays with each other to determine the outcome of the match, volleyball is included in the category of matches because it involves two teams (Alfais et al., 2024). The goal of the volleyball game itself is to attack each other into an empty field of space that cannot be reached by the opposing player. Volleyball sport has a high level of popularity in Indonesia, many teams have been formed in Indonesia, ranging from extracurricular teams, amateur clubs to professionals (Aprilianti et al., 2023). Volleyball is one of the sports that has developed very rapidly from the social environment, schools, private, universities and government agencies (Irlani et al., 2025). Basic skills of playing volleyball are a degree of ability to perform basic techniques of volleyball games effectively and efficiently which is determined by speed, accuracy, form, and the ability to adapt to the game (Helensi et al, 2022). In volleyball there are various types of basic serving techniques, and each serve has different techniques and levels of difficulty. Basically, the serve in volleyball is divided into two types, namely 1) underhand serve and 2). overhead serve (Listianto et al., 2023).

The serve is a ball hit from behind the field line with the aim of sending the ball over the net to the opponent's area. The purpose of the serve is to hit the ball from the back line of the field so that the ball passes the net and goes to the opponent's area which is empty or difficult to reach by the opponent, so that the opponent cannot receive the ball (Miftakhussurur et al., 2024). One of the most influential serves in a volleyball game is the top serve. The top serve requires a hitting technique, so it can be used as an attack method to score points, and of course it can also be used as an attack to stop the ball from the opponent's position (Lesmawan et al.,

2024). The ability to serve up is supported by coordination of wholebody movements that end in the form of swing movements supported by arm muscle strength so as to produce good accuracy. Good eye and hand coordination, it is also advantageous to be able to direct the ball stroke in the direction of the ball he wants (Sepriwandi, 2023). A good top serve must be supported by a good arm swing, not only the swing but the accuracy in hitting the target where the player wants also supports a good serve (Ghani et al., 2020)

Strength is one of the physical requirements that is useful for making a volleyball athlete have good technique, the strength of pulling and pushing arm muscles can be maximized by doing various training, one of which is by doing push up movements (Dixon, 2020). Arm muscle strength plays a crucial role in volleyball, especially in performing an effective overhead serve (Majstorović et al., 2020). Arm muscle strength has a contribution of 86.3% to the ability to serve up in volleyball games (Astriani et al., 2023). The role of arm muscle strength is very important in the success of volleyball serving because the strength of the arm muscles is the thrust of the advanced movement of the arm so that it can produce a strong ball hit (Utami et al., 2022). If arm muscle strength increases, the ability to serve will also increase. Vice versa, if the strength of the arm muscles is lower, the ability to serve will also be lower (Saptiani et al., 2019).

Power is a human physical condition when moving that uses a collection of muscles that contract in controlling the load with a combination of maximum strength and speed. The presence of power in the body helps muscle performance in performing basic volleyball techniques (Astriani et al., 2023). Arm muscle power is a person's ability to use maximum mobilized arm muscle power in the shortest possible time when serving in volleyball sports (Al Farisi et al., 2023). Arm muscle power in serving up is needed to produce maximum arm muscle contractions which are used to produce hard and maximum service stroke (Pratiwi et al., 2021). Physical conditions such as arm muscle power on the results of the upper serve in volleyball are important aspects that cannot be ignored in the development of athlete performance (Marpaung et al., 2020). Arm muscle power, which is the result of a combination of strength and speed of muscle contraction, determines the quality of an effective upper serve (Muhadi et al., 2024). A strong, fast, and accurate top serve will be greatly influenced by how much power the arm muscles can produce (Romadhonsyah, 2024). Research by (Kabul et al., 2013) showed that arm muscle power has a significant contribution to the success of the upper serve in volleyball. In his research, it was found that the greater the arm muscle power an athlete has, the better the service results that can be produced, both in terms of speed, height, and accuracy of ball direction. This shows that the development of arm muscle power not only has an impact on improving individual performance, but can also support the team's overall game strategy.

This shows that arm muscle strength and power play an important role in the upper serve program (Fahmir et al., 2024). Considering the limited research examining the simultaneous contribution of arm muscle strength and arme muscle ppower to overhead serve performance in female voleeyball athlete, this study focus on identifying which physical component has a more dominant influance on serve outcomes. The result are expected to provide practical benefits for coaches, managers and athletes in optimizing performance.

**Method**

This study uses a quantitative method with correlation, which aims to determine the contribution of arm muscle strength and arm muscle power to the results of the volleyball top serve in female athletes of the Atlas club in Semarang City, data collection was carried out on April 22$^{th}$, 2025. Correlational research was chosen because it is appropriate to determine the correlation between arm muscle strength and arm muscle power to the results of the upper serve.

The subjects of this study were 15-year-old female volleyball athletes at the Atlas Club in Semarang. The study population was 15 female volleyball athletes of Atlas club. The sampling technique in this study used total sampling, namely taking the entire population that met the criteria as a research subject.

The instrument used in this study consisted of three main measurment tools. Arm muscle strength was assessed using a 60-second push-up test, each participant was instructed to perform as many correct push-ups as possible within 60 second and this instrument with a validity value of 0.94 and a reliability of 0.93 (Faizin & Hariadi, 2019). Arm muscle power instrument using a 3 kg medicine ball was carried out 3 times and the best result was recorded as the final score, this instrument showed validity value of 0.77 and a reliability of 0.81 (Putu et al., 2022). The upper serve test instrument uses the AAHPER Volleyball Serve Test with a validity value of 0.76 and a reliability of 0.78 (Agus, 2021), measuring upper serve skills based on the ball landing zone in the field. Each athlete performed 10 times the upper serve and score was determined based on the accuracy and consistency of the serve.

The equipment used in this study includes medicine ball, stopwatch, standard volleyball, volleyball court, net, and assessment form push up test as much as possible with a time of 60 seconds, throwing a weight ball (medicine ball 3 kg) 3 times to measure arm power, and volleyball top service test 10 times.

The data analysis technique uses statistical analysis techniques, normality tests, correlations and multiple linear regression tests using the t test and f test. The results of the data analysis are then processed using the SPSS version 25 application, the data analysis results will be presented in the form of a table.

**Results**

The results of this study have been obtained and presented in tabular form with the following data calculations:

Table 1 Descriptive Statistics of Arm Muscle Strength Data, Arm Muscle Power and Volleyball Upper Serve

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Arm Muscle Strength | 15 | 22 | 40 | 31.00 | 5.412 |
| Arm Muscle Power | 15 | 3.8 | 6.0 | 4.933 | .6444 |
| Upper Serve Results | 15 | 26 | 35 | 30.40 | 3.112 |
| Valid N (listwise) | 15 | | | | |

Based on the results in table 1 descriptive data of female volleyball athletes Atlas club Semarang City. The arm muscle strength test shows a minimum score of 22, a maximum score of 40, an average score of 31.00 and a std deviation score of 5.412. The arm muscle power test shows a minimum score of 3.8, a maximum score of 6.0, an average score of 4.933 and a std deviation score of 6444. While the upper service test shows a minimum score of 26, a maximum score of 35, an average score of 30.40 and a score on the std deviation of 3,112.

Table 2. Normality Test of Arm Muscle Strength, Arm Muscle Power and Volleyball Upper Serve

| | Shapiro-Wilk | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| Arm Muscle Strength | .978 | 15 | .951 |
| Arm Muscle Power | .978 | 15 | .951 |
| Upper Serve Results | .932 | 15 | .297 |

Based on the results of the normality test in table 2 using the Shapiro-Wilk method, a sig value was obtained, in the strength test of 0.951, the arm muscle power test obtained a sig value of 0.951. Meanwhile, the upper service test obtained a sig value of 0.297. Based on the determining reference from the Shapiro-Wilk method because the three data each have a sig value greater than 0.05, it can be concluded that all test data are normally distributed.

Table 3. Correlation between arm muscle strength, arm muscle power and volleyball overhead serve

| | | Arm Muscle Strength | Arm Muscle Power | Upper Serve Results |
|---|---|---|---|---|
| Arm Muscle Strength | Pearson Correlation | 1 | .998** | .980** |
| | Sig. (2-tailed) | | .000 | .000 |
| | N | 15 | 15 | 15 |
| Arm Muscle Power | Pearson Correlation | .998** | 1 | .972** |
| | Sig. (2-tailed) | .000 | | .000 |
| | N | 15 | 15 | 15 |
| Upper Serve Results | Pearson Correlation | .980** | .972** | 1 |
| | Sig. (2-tailed) | .000 | .000 | |
| | N | 15 | 15 | 15 |

Based on the results of the analysis using the Pearson correlation test in table 3, it shows a very strong and significant relationship between arm muscle strength and the results of the upper serve in U-15 female volleyball athletes. The correlation coefficient between arm muscle strength and upper serve results is r count = 0.980 with a significance value of p = 0.000 (p < 0.05). This means that the higher the arm muscle strength of an athlete, the better the results of the upper serve produced. In addition, the correlation between arm muscle power and upper serve results also shows a very strong relationship, with a value of r count = 0.972 and p = 0.000 (p < 0.05). This shows that arm muscle power has a positive and significant relationship with the results of the upper serve, although the contribution is slightly lower than arm muscle strength.

Table 4. Test the coefficient of determination of arm muscle strength, arm muscle power and volleyball upper serve

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .982[a] | .965 | .959 | .631 |

Based on the results of multiple linear regression analysis in table 4, it shows that the coefficient of determination (R Square) value is 0.965, which indicates that 96.5% of the variation in the results of the upper serve can be explained by the variables of arm muscle strength and arm muscle power simultaneously. The correlation coefficient (R) value of 0.982 means that the relationship between the independent variable and the dependent variable is in the very strong category.

Table 5. Anova test results multiple linear regression

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 130.815 | 2 | 65.407 | 164.017 | .000[b] |
| | Residual | 4.785 | 12 | .399 | | |
| | Total | 135.600 | 14 | | | |

A. Dependent Variable: Hasil Servis Atas

B. Predictors: (Constant), Arm Muscle Power, Arm Muscle Strength

Based on the results of the multiple linear regression Anova test in table 5, the calculated F value is 164.017 with a significance value (Sig.) of 0.000. Because the significance value is smaller than 0.05 (p < 0.05), it can be concluded that the regression model is statistically significant. So, simultaneously, the variables of arm muscle strength and arm muscle power have a significant influence on the dependent variable, namely the results of the upper serve.

Table 6. Multiple Linear Regression Coefficient Analysis Results

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | 18.958 | 4.764 | | 3.980 | .002 |
| | Arm Muscle Strength | 1.135 | .444 | 1.974 | 2.559 | .025 |
| | Arm Muscle Power | -4.815 | 3.726 | -.997 | -1.292 | .221 |

a. Dependent Variable: Upper Serve Results

Based on the results of the multiple linear regression Anova test in table 6, it shows that arm muscle strength has a positive and significant contribution to the results of the upper serve on U-15 female volleyball athletes, showing a regression coefficient value of 1.135 with a t value of 2.559 and a significance value (Sig.) of 0.025. Because this significance value is smaller than 0.05 (p < 0.05), it can be concluded that partially, arm muscle strength has a contribution of 76.88% to the results of the upper serve on U-15 female volleyball athletes. This means that every one unit increase in arm muscle strength will increase the results of the upper serve.

Meanwhile, arm muscle power has a regression coefficient of -4.815, a t value of -1.292, and a significance value of 0.221 (p> 0.05), although the significance value is greater than 0.05, which means it is not statistically significant. However, arm muscle power still provides a contribution of 19.61% to the results of the volleyball top serve when viewed based on the calculation of the R square value. This shows that arm muscle power has a contribution in supporting the athlete's performance when serving up, especially in the aspects of speed and explosive power of the blow.

Based on the results of the multiple linear regression analysis displayed in the coefficient table, the partial effects of each independent variable on the dependent variable can be explained. Overall, these results indicate that out of the two variables studied, only arm muscle strength contributes to the overhand serve results in U-15 female volleyball athletes.

**Discussion**

Based on the results of the research that has been conducted, this study shows that arm muscle strength has a regression coefficient value with a significance (Sig.) value of 0.025. Since this significance value is less than 0.05 ($p < 0.05$), it can be concluded that arm muscle strength contributes 76.88% to the service results. This means that every one-unit increase in arm muscle strength will improve the service results. Meanwhile, arm muscle power has a regression coefficient with a significance value of 0.221. Since this significance value is greater than 0.05 ($p > 0.05$), it can be concluded that arm muscle power only contributes 19.61% to the upper service results in U-15 female volleyball athletes, although it is not statistically significant.

This research reinforces that arm muscle strength is the main physical factor supporting an athlete's ability to perform an effective overhand serve. These findings are consistent with previous studies that show that upper arm muscle strength contributes to improved serving performance in volleyball (Myers et al., 2015). A person's physical strength plays a significant role in how well they perform in sports, and in volleyball, one of the important components that greatly affects performance is arm muscle strength (Dimi et al., 2023). Muscle strength is an essential biomotor element for enhancing muscle endurance in coping with loads during sports activities (Novita Oktaviana et al., 2024). The arm muscles play one of the most important roles in performing a volleyball serve, as the arm muscles are the central point of power, so the strength of the arm muscles will support the strength of other parts of the body (La Kamadi, 2020). At the moment a player serves, maximum muscle strength is required so that the resulting hit is strong and hard, therefore, muscle strength is very important for a volleyball player (Devi et al., 2022). The explosive strength of the arm muscles is very important for initiating strong and fast movements during serves. Stronger arm muscles generate higher racket head speed (in volleyball, hand speed), which contributes to ball power and control (Musa et al., 2023).

Although the power of the arm muscles only contributes 19.61% to the overhead serve outcome, in practice, the power of the arm muscles is a supporting factor in the context of on-field performance, especially in generating movement speed and hitting strength in the overhead serve. Volleyball also requires excellent physical condition, meaning that when playing volleyball, in addition to technique, good physical fitness is also needed, where wrist flexibility plays an important role in the game of volleyball (Sistiasih et al., 2024). Physical condition is a factor that greatly influences a person's performance; without good physical condition, techniques and tactics cannot function perfectly during training or matches, and good physical condition is a requirement that must be possessed by an athlete (Pujowigoro et al., 2023).

Power is very important for sports branches that require explosiveness; power is the ability of an athlete's muscles to overcome resistance with maximum strength and speed in a single complete movement (Solihin et al., 2024). The capacity of muscles to exert their full strength in a short period of time is called power. As mentioned earlier, power is very important in volleyball (Novita et al., 2022). The better the explosive strength of an athlete's arm muscles, the better their overhead serve ability (Nila Firmasari, 2019). The ability to have good arm muscle power possessed by a volleyball player will make it easier for the player to perform a high-quality overhand serve, such as the speed of the ball making it difficult for the opponent to receive the serve. In addition to affecting the speed of the serve, having good arm muscle power allows a player to easily direct the hit to a specific point that is difficult for the opponent to reach (Ramawan et al., 2020).

There are several factors that characterize a team with good service. First is the determination of the right serve for each player. Next, to perform an effective serve, the server must have an aggressive mindset and strong hand contact (Suharjana et al., 2020). The key to successfully executing an overhand serve in volleyball is the strength of the arm muscles; the ball is hit hard and strong due to the push from the follow-through arm movement (Kuncoro, 2021). The strength of the arm muscles is the driving force that produces a stronger hit against the ball. Based on this, it is clear that the strength of the arm muscles has a close relationship with the success of executing a volleyball serve (Darumoyo et al., 2024). Arm strength is an important aspect of volleyball, and there are several theories that explain why it is important. One theory states that the

explosiveness of the arm muscles is crucial for successful serves in volleyball (Oktariana & Hardiyono, 2020). Athletes with good arm muscle strength have a positive impact on the use of power in executing punches (Destriana et al., 2024).

To improve arm muscle strength, proper exercises, such as upper extremity plyometric exercises, are highly recommended. Plyometric exercises can help strengthen the arm muscles and enhance muscle strength in volleyball players, resulting in stronger and more accurate serves (Turgut et al., 2019). Plyometric is a training method to develop or enhance explosiveness and strength, which are important components of most sports achievements or performances (Betna, Yanse et al., 2020). With optimal arm muscle strength, volleyball athletes will be able to achieve higher accuracy in performing overhand serves (Haqmal et al., 2023). In addition, arm strength development exercises can also improve performance in other techniques such as passing and smashing.

One way to optimize performance in the overhand serve, volleyball players need to develop a training program that focuses not only on arm muscle strength but also on other aspects such as leg, back, and hand muscle strength, which also play a significant role in supporting this sport. With a combination of strength from the entire body, athletes will achieve optimal results in matches (Yusup et al., 2024). Therefore, it is important for coaches to emphasize the development of arm muscle strength through a structured training program, which not only involves strength training but also explosive and plyometric exercises to maximize overhand serve performance and other techniques in volleyball.

## Conclusion

The results of this study emphasize the importance of developing arm muscle strength in physical training programs for volleyball athletes, especially in the adolescent age group. Therefore, coaches and sports trainers are advised to design training programs that specifically emphasize the improvement of arm muscle strength, whether through weight training, resistance training, or structured plyometric exercises. Strengthening the arm muscles will not only improve the quality of the overhead serve but can also support other basic technical skills such as passing and smashing.

Based on the findings and limitations of this study, future research is recommended to include additional variables such as basic techniques, coordination, and body flexibility, as these factors have not to overhead serve performance. Incorporating these variables may offer a more comprehensive understanding of the key determinants of serve effectiveness. Furthermore, future studies could involve large sample size, different age groups, and using an experimental approach through intervention training programs to directly measure the effectiveness of the training. These, the results of this research are expected to serve as a foundation for the development of more effective volleyball training methods.

## References

Al Farisi, M. Y., & Daharis, D. (2023). Kontribusi Power Otot Lengan dan Koordinasi Mata dan Tangan Terhadap Servis Atas Bola Voli Siswa Ekstrakurikuler SMAN 1 XIII Koto Kampar. *ANTHOR: Education and Learning Journal*, *2*(2), 267–271. https://doi.org/10.31004/anthor.v2i2.126

Alfais, M. A., Yudhistira, D., & Alfais, M. A. (2024). Pengembangan strategi menyerang dan bertahan cabang olahraga bola voli : konstruk validity. *MULTILATERAL: Jurnal Pendidikan Jasmani Dan Olahraga*, *23*(3), 186–196. https://doi.org/http://dx.doi.org/10.20527/multilateral.v23i3.19571 Alamat

Amelia Aprilianti, B., Rusdiana, A., Imanudin, I., Hardwis, S., Hartono, T., Aprilianti, A., & Ikhwan Hidayat, I. (2023). Kinematics Analysis Volley Ball Jump Smash : Pendekatan Dua Dimensi Gerak. *Jurnal Ilmu Keolahragaan*, *4*(1), 2023. https://doi.org/http://dx.doi.org/10.26418/jilo.v6i2.69333 KINEMATICS

Astriani, F., Tuti Ariani, N. L. P., & Happy Kardiawan, I. K. (2023). Hubungan Kekuatan Otot Perut Dan Power Otot Lengan Dengan Ketepatan Servis Atas Pada Atlet Putri Club Satrya Kelana Wuryantoro. *Jurnal Pendidikan Kepelatihan Olahraga Undiksha*, *12*(1), 24–29. https://doi.org/10.23887/jjpko.v12i1.61952

Betna, Yanse, A., Wahyudi, A., & Nasuka, &. (2020). The Effect of Plyometric Exercise and Arm Muscle Strength on Smash Ability of Pervoba Volleyball Athletes. *Journal of Physical Education and Sports*, *9*(2), 138–144. https://journal.unnes.ac.id/sju/index.php/jpes/article/view/33991

Darumoyo, K., Nugroho, G. S., & Wahyudi, A. N. (2024). Hubungan kekuatan otot lengan terhadap ketepatan servis atas. *Jurnal Porkes*, *7*(1), 84–95. https://doi.org/10.29408/porkes.v7i1.22774

Destriana, D., Muslimin, M., Yusfi, H., & Anggraini, P. (2024). Relationship between strength, coordination, and balance to underhand service in amateur volleyball players' teenage. *Jurnal SPORTIF : Jurnal Penelitian Pembelajaran*, *10*(2), 230–244.

https://doi.org/10.29407/js_unpgri.v10i2.22673

Devi, N. K. A. T., Parwata, I. M. Y., & Permadi, A. W. (2022). The Relationship between Arm Muscle Strength and Lower Serve Accuracy in Volleyball Players at SMA Negeri 1 Kediri. *Jurnal Kesehatan, Sains, Dan Teknologi (JAKASAKTI)*, *1*(2), 83–90. https://doi.org/10.36002/js.v1i2.2316

Dimi, S., Sutoro, S., Putra, M. F. P., Wandik, Y., Womsiwor, D., & Sinaga, E. (2023). Tinggi badan, kekuatan otot lengan, dan keterampilan servis atas bola voli: sebuah tinjaun singkat. *Multilateral : Jurnal Pendidikan Jasmani Dan Olahraga*, *22*(4), 256. https://doi.org/10.20527/multilateral.v22i4.16475

Dixon. (2020). Pengaruh Latihan Push-Up Terhadap Peningkatan Kekuatan Otot Lengan. *Ciencias: Jurnal Penelitian Dan Pengembangan Pendidikan*, 93–101.

Elif Turgut, Ozge Cinar-Medeni, F. Çolakoğlu, G. B. (2019). "Ballistic Six" Upper-Extremity Plyometric Training for the Pediatric Volleyball Players. *Journal of Strength and Conditioning Research*, *33*(5), 1305–1310. https://doi.org/10.1519/JSC.0000000000002060

Faizin, A., & Hariadi, I. (2019). Hubungan Antara Panjang Lengan Dan Kekuatan Otot Lengan Terhadap. *Indonesia Performance Journal*, *3*(2), 101–107. https://doi.org/10.17977/im077v3i22019p101-107

Ghani, M. Al, Parlindungan, D., & Yulianingsih, I. (2020). Hubungan Power Otot Lengan Koordinasi Mata Tangan dan Rentang Tangan dengan Hasil Servis Atas Pada Pemain Bola Voli Universitas Muhammadiyah Jakarta. *Riyadhoh : Jurnal Pendidikan Olahraga*, *3*(2), 47. https://doi.org/10.31602/rjpo.v3i2.3718

Haqmal, P. S., Nurlatifa, R. W., Wicaksono, A., Rani, D. C. A., & Nizar, P. E. (2023). Leg Power, Arm Strength, and Smash Accuracy in Female Volleyball Athletes: A Correlational Study. *In: Proceedings of International Conference on Physical Education, Health and Sport*, *3*, 453–462.

Hermawan Listianto, N. (2023). Pengaruh Latihan Push Up Normal Dan Tangan Menumpu Bangku Terhadap Kemampuan Servis Atas Bola Voli Putri Club Perdana Wonosobo Tahun 2021. *Unnes Journal of Sport Sciences*, *7*(1), 15–19. https://journal.unnes.ac.id/sju/index.php/ujss/index Volume

Irlani, R., & Azizah, A. R. (2025). Pengaruh Latihan Push Up terhadap Ketrampilan Servis Atas Pada Kegiatan Ekstrakurikuler Bola Voli SMK Tamtama Karanganyar. *Jurnal Pendidikan Tambusai*, *9*, 7580–7585.

Kabul, N., Sugiharto, & Waluyo, M. (2013). Sumbangan Power Lengan, Togok Dan Tungkai Terhadap Kemampuan Servis Atas Bola Voli. *Journal of Sport Sciences and Fitness*, *2*(2), 44–48. https://doi.org/doi.org/10.15294/jssf.v2i2.2552

Kadek Ramawan, Syarif Hidayat, G. E. B. D. (2020). Hubungan Tinggi Badan, Power Otot Tungkai Dan Power Otot Lengan Terhadap Kemampuan Smash Pada Club Bola Voli Citroen Pedawa Tahun 2020. *Jurnal Pendidikan Kepelatihan Olahraga Undiksha*, *11*(3), 30–36. https://doi.org/10.23887/jjpko.v11i3.27782

Kuncoro, A. D. (2021). Hubungan Kekuatan Otot Lengan Dan Panjang Lengan Dengan Hasil Servis Atas Bola Voli. *Jurnal Porkes*, *4*(2), 118–125. https://doi.org/10.29408/porkes.v4i2.4661

La Kamadi. (2020). Kontribusi Kondisi Fisik Terhadap Kemampuan Servis Bawah Dalam Permainan Bolavoli. *Journal Coaching Education Sports*, *1*(2), 151–60. https://doi.org/doi: 10.31599/jces.v1i2.369

Leo Agus. (2021). Pengaruh Latihan Menggunakan Metode Jarak Bertahap Terhadap Ketepatan Servis Atas Bola Voli. *Prosiding Seminar Nasional Pendidikan Universitas Subang (SENDINUSA)*, *3*(1), 49–59.

Lesmawan, H., Nugraha, J. S., Ariyadi, N., Fajariyanto, G., Atas, K. S., District, B., Regency, W., & Regency, L. (2024). Kontribusi Kekuatan Otot Lengan Dan Kelentukan Pergelangan Tangan Terhadap Ketepatan Melakukan Servis Atas Dalam Olahraga Bola Voli. *JURNAL LOCUS : Penelitian & Pengabdian*, *3*(11), 898–907. https://doi.org/10.58344/locus.v3i11.3289

Majstorović, N., Dopsaj, M., Grbić, V., Savić, Z., Vićentijević, A., Aničić, Z., Zadražnik, M., Toskić, L., & Nešić, G. (2020). Isometric strength in volleyball players of different age: A multidimensional model. *Applied Sciences (Switzerland)*, *10*(12), 1–12. https://doi.org/10.3390/APP10124107

Marpaung, H. I., & Priyonoadi, B. (2020). The Correlation between Leg-arm Muscle Power and Volleyball Players' Open Smash Ability. *Proceedings of the 3rd Yogyakarta International Seminar on Health, Physical Education, and Sport Science in Conjunction with the 2nd Conference on Interdisciplinary Approach in Sports.*, 379–385. https://doi.org/10.5220/0009786803790385

Miftakhussurur, M., & Nuryadi, A. (2024). The Influence Of Push-Ups On The Accuracy Of Underhand Serves In The Women ' s Volleyball Team Of Universitas PGRI Adi Buana Surabaya. *Jurnal Ilmiah ADIRAGA*, *10*(2), 58–68. https://doi.org/https://doi.org/10.36456/adiraga

Mohamad Fahmir, M. Syahrun Effendi, M. S. (2024). Servis Atas Pada Peserta Ekstrakurikuler Bola Voli

Smp Negeri 5 Model Lubuklinggau. *YLIP (Yayasan Linggau Inda Pena) South Sumatera, Indonesia*, *4*(1), 1–10. https://doi.org/doi.org/10.55526/sjs.v2i1.192

Muhadi, & Saitya, I. (2024). Contribution of Medicine Ball Throw Training and Arm Muscle Power to Smash Ability in STKIP Harapan Bima Volleyball UKM. *Jurnal Ilmiah Mandala Education (JIME)*, *10*(1), 2656–5862. https://doi.org/10.58258/jisip.v7i1.6808/http

Muhamad Ahyar, Akhmad Olih Solihin, B. S. (2024). Hubungan Kekuatan Otot Lengan Dan Power Tungkai Terhadap Ketepatan Smash Dalam Permainan Bulutangkis. *Ilmiah, Jurnal Pendidikan, Wahana*, *10*(10), 1067–1079. https://doi.org/10.5281/zenodo.11627937

Muhamad Yusup, Ahmad Alwi Nurudin, B. B. (2024). Hubungan Kekuatan Otot Lengan, Panjang Lengan dan Koordinasi Mata- Tangan terhadap Hasil Servis Atas Bola Voli pada Siswa Ekstrakurikuler SMP Islam Fatahillah Kota Sukabumi Tahun Pelajaran 2023/2024. *Jurnal Bintang Pendidikan Indonesia*, *2*(4), 312–322. https://doi.org/10.55606/jubpi.v2i4.3304

Muslimin, Helensi, P. (2022). Pengaruh Metode Latihan Variasi tehadap Ketrampilan Passing Bawah dalam Permainan Bola Voli pada Siswa SMP Negeri 59 Palembang. *Journal on Teacher Education*, *4*, 628–639.

Natalie L Myers, Aaron D Sciascia, Philip M Westgate, William B Kibler, T. L. U. (2015). Increasing Ball Velocity in the Overhead Athlete: A Meta-analysis of Randomized Controlled Trials. *J Strength Cond Res.*, *29*(10), 64–79. https://doi.org/doi: 10.1519/JSC.0000000000000931.

Ni Komang Indah Pradnya Utami, I Made Yoga Parwata, A. W. P. (2022). The Relationship between Arm Muscle Strength and Upper Serve Ability in Portenang Club Volleyball Players. *Jurnal Kesehatan, Sains, Dan Teknologi*, *1*(1), 113–120. https://doi.org/10.36002/js.v1i1.1949

Nila Firmasari, A. A. (2019). Explosive Power Otot Lengan Dan Kelentukan Pinggang Berpengaruh terhadap Kemampuan Servis Atas Bolavoli. *Jurnal Patriot*, 1–23. https://doi.org/10.24036/PATRIOT.V1I3.436

Novita, N., Oka Harahap, P., Sahputera Sagala, R., & Natas Pasaribu, A. M. (2022). Effect of plyometric exercises on limb muscle power in volleyball players. *Jurnal SPORTIF : Jurnal Penelitian Pembelajaran*, *8*(1), 131–144. https://doi.org/10.29407/js_unpgri.v8i1.17810

Novita Oktaviana, Wiga Nurlatifa Romadhoni, Hadi Hadi, P. S. P. (2024). The Contribution of Leg Muscle Strength and Power to the Front Kick Results of PSHT Semarang Tengah Male Adolescent Pencak Silat Athletes. *Unnes Journal of Sport Sciences*, *8*(1), 11–17. https://doi.org/10.15294/ujoss.v8i1.26091

Oktariana, D., & Hardiyono, B. (2020). Pengaruh Daya Ledak Otot Lengan, Daya Ledak Otot Tungkai Dan Kekuatan Otot Perut Terhadap Hasil Smash Bola Voli Pada Siswa SMK Negeri 3 Palembang. *Journal Coaching Education Sports*, *1*(1), 13–24. https://doi.org/10.31599/jces.v1i1.82

Pratiwi, W. E. S., & Asmuddin. (2021). Hubungan Power Otot Lengan Dengan Kemampuan Servis Atas Permainan Bola Voli Pada Siswa Sma Negeri 1 Wawonii. *JOKER (JURNAL ILMU KEOLAHRAGAAN)*, *2*(1), 50–55.

Priambodo, E. N., Nasuka, N., Wicaksono, A., Romadhoni, W. N., & Yudhistira, D. (2022). Pelatihan digitalisasi sistem pertandingan bola voli untuk meningkatkan kompetensi wasit. *Medikora*, *21*(2), 162–169. https://doi.org/10.21831/medikora.v21i2.51984

Pujowigoro, Y., Sukarmin, Y., Nasrulloh, A., Nugroho, S., Guntur, Guntur, & Manihuruk, F. (2023). The Influence of Plyometrics and Weight Training Exercises on Limbs Muscle Power in View of Limbs Muscle Endurance in Volleyball Players Aged 16-18 Years. *International Journal of Multidisciplinary Research and Analysis*, *06*(06), 2726–2735. https://doi.org/10.47191/ijmra/v6-i6-71

Putu, I., Widhi Andika, H., Agama, S., & Singaraja, H. (2022). Pengaruh Metode Pelatihan Beban Medicine Ball Throw dan Panjang Lengan terhadap Power Otot Lengan Atlet Cricket Buleleng. *Jurnal Pendidikan Kesehatan Rekreasi*, *8*(1), 1–15. https://ojs.mahadewa.ac.id/index.php/jpkr/article/view/1365

R. Musa, A. A. Abdul Majeed, Muhammad Zuhaili Suhaimi, M. Abdullah, M. A. Mohd Razman, Deboucha Abdelhakim, N. A. A. O. (2023). Identification of high-performance volleyball players from anthropometric variables and psychological readiness: A machine-learning approach. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, *237*(4), 317–324. https://doi.org/10.1177/17543371211045451

Romadhonsyah, A. (2024). Contribution of Arm Muscle Power and Body Flexibility Regarding Volleyball Services for Athletes. *Multidisciplinary Journal of Tourism, Hospitality, Sport and Physical Education*, *1*(1), 1–5. https://doi.org/10.37251/jthpe.v1i1.1032

Saptiani, D., Sugiyanto, S., & Syafrial, S. (2019). Hubungan Kekuatan Otot Lengan Dan Koordinasi Mata

Tangan Terhadap Akurasi Servis Atas Bola Voli Pada Peserta Putri Ekstrakurikuler Di Sman 2 Seluma. *Kinestetik*, *3*(1), 42–50. https://doi.org/10.33369/jk.v3i1.8810

Sepriwandi, R. (2023). Hubungan Kekuatan Otot Lengan Terhadap Kemampuan Servies Atas Bola Voli Di Sma Negeri 5 Pinggir. *Jurnal Inovasi Olahraga*, *1978*, 207–212. https://doi.org/10.53905/jiojournal.v2i03.44

Sistiasih, V. S., Nurrohman, D., & Rumpoko, S. S. (2024). The Relationship Between Wrist Flexion And Leg Muscle Explosive Power Against Volleyball Smash Ability. *Journal Coaching Education Sports*, *5*(1), 97–108. https://doi.org/10.31599/jces.v5i1.3670

Suharjana, Priyanto, E., & Ndayisenga, J. (2020). Contribution of leg power, arm power, stomach muscle power, and back muscle power on jumping services. *International Journal of Human Movement and Sports Sciences*, *8*(5), 240–248. https://doi.org/10.13189/saj.2020.080512