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THE EFFECT OF RESISTANCE BAND ON ARM MUSCLE STRENGTH IN OVERHEAD SERVICE TRAINING IN CITRA CLUB VOLLEYBALL PLAYERS

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ABSTRACT

The overhead serve is an important technique in volleyball that initiates attacks and creates scoring opportunities. The effectiveness of this technique is influenced by several physical factors, particularly upper-limb muscle strength. Resistance band training was selected for this study because it provides elastic resistance, allowing more flexible, safe, and sport-specific movement patterns than many conventional strength-training methods, making it suitable for youth athletes. This study aimed to examine the effect of overhead serve training using resistance-band media on arm muscle strength in volleyball players at Citra Club. This research employed a quantitative, pre-experimental design with a one-group pretest–posttest. The sample consisted of 16 volleyball players aged 10–18 years, selected purposively. Arm muscle strength was measured using a handgrip dynamometer as an indicator of general upper-limb muscular strength during physical fitness assessment. The training program consisted of 10 sessions over five weeks. The results showed that the average arm muscle strength increased from the pretest to the posttest. The normality test using the Normal Probability–Probability Plot (P–P Plot) indicated that the residuals were normally distributed, as the points followed a diagonal pattern. In addition, the Normalized Gain (N-Gain) analysis yielded an average value of 0.0604, indicating that the training program produced a moderate improvement in players' arm muscle strength. These findings indicate that overhead serve training using resistance band media can improve arm muscle strength in youth volleyball athletes and can serve as an alternative training method in volleyball coaching programs.

Keyword: Resistance band training, overhead serve, arm muscle strength, volleyball athletes, training methods.

INTRODUCTION

Volleyball is a fast-growing team sport with high-level play at both recreational and professional levels. In Indonesia, volleyball is played widely in schools and communities and is also an important part of sports programs for children and teens. Volleyball is played by two teams of six players on a court that is 18 by 9 meters, separated by a net (Irwanto, 2021). To perform well in matches, players need to master basic skills like serving, passing, smashing, and blocking. These skills are connected and help score points during rallies (Leon, Candra, Danardani, & Hidayat, 2023)(Andriyati, 2022).

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Among these techniques, the serve plays a strategic role because it marks the beginning of play and can function as the first attacking opportunity. An effective serve not only initiates a rally but can also disrupt the opponent's reception pattern and create direct scoring opportunities. In modern volleyball, the overhead serve is one of the most frequently used techniques because it can produce higher ball velocity and sharper trajectories, making it more difficult for opponents to control the ball during reception (Fatah Firmansyah, Fauzi, & Saiin, 2022). (Maria Surty Plisa Geni, 2025) also emphasizes that an overhead serve, when performed with adequate power and accuracy, can be an effective attacking strategy and significantly influence the momentum of a volleyball match.

From a biomechanical perspective, the overhead serve involves a coordinated kinetic chain movement. This begins with trunk rotation, followed by shoulder internal rotation and elbow extension. These actions accelerate the arm and generate ball velocity. Research in sports biomechanics indicates that shoulder internal rotation plays a dominant role in producing arm acceleration during overhead athletic movements. It also enables efficient transfer of mechanical energy from the upper body to the ball (Escamilla, RF, & Andrews, 2009). In addition, effective overhead performance requires adequate neuromuscular coordination and joint stability within the shoulder complex. This coordination maintains movement efficiency and reduces the risk of injury (Mohammadian, M., Sadeghi, H., Khaleghi Tazji, M., & Maloney, 2022). These biomechanical characteristics show that the development of upper-limb strength is essential for powerful, controlled overhead serve movements.

The successful execution of an overhead serve is influenced by several physical components. Arm muscle strength and explosive power are especially important. Muscle strength is the basis for developing explosive power. Adequate muscular strength enables athletes to generate greater force in less time. (Williams, SM, & Lacy, 2018) define muscle strength as the ability of a muscle or group of muscles to produce maximum tension during a single contraction. Explosive power refers to the ability of muscles to generate maximal force in a short period (Pasaribu, 2020). Successful volleyball players must also possess physical abilities such as agility, endurance, coordination, and injury-prevention skills (Muhammad Ishak, Ahmad Adil, 2025). Continuous and structured training is important for improving motor skills and technical performance. Systematic practice enhances motor learning and movement efficiency (Sudirjo & Sudrazat, 2024).

However, preliminary observations conducted at Citra Club in Citembong Hilir Hamlet, Cikeusi Village, Darmaraja District, Sumedang Regency revealed several practical problems related to the overhead serve performance of adolescent volleyball players aged 10–18 years. Based on observations and interviews with coaches, many players were unable to produce strong and consistent overhead serves. In several situations, the ball failed to cross the net or lacked sufficient speed, making it easier for opponents to receive the ball. These findings indicate that the arm muscle strength of several players has not yet developed optimally, which consequently affects the quality of their serve performance. In addition, motivation to practice also plays an important role in the development of sports skills, because motivated athletes tend to engage more actively in the training process and strive to improve their performance (Susilawati, 2017).

Several previous studies have aimed to enhance arm muscle strength using different training methods. (Firdaus, Sudirman, & Arini, 2021) established a strong link between arm muscle strength and overhead serve accuracy in volleyball players. Other researchers have used pull-up exercises established a strong link between arm muscle strength and overhead serve accuracy in volleyball players. Other researchers have used pull-up exercises (Izzuddin, Gemael, & Pratiwi, 2022), resistance training with sand-filled bottles (Rika Widianita, 2023), and burpee exercises (P Pitri, D Donie, Y Setiawan, 2024). While these methods produced positive outcomes, most rely on conventional approaches that do not accurately reflect the movement patterns required for the overhead serve. Thus, alternative methods offering more functional and adaptable resistance are necessary to better develop arm muscle strength in volleyball athletes.

One training method with considerable potential to address this need is elastic resistance training with resistance bands. Resistance bands provide progressive elastic resistance, meaning

that the resistance increases as the band is stretched, allowing muscles to work throughout the full range of motion. This characteristic enables resistance bands to follow the natural movement pattern of the shoulder and arm during overhead serve movements, including the arm cocking, acceleration, and follow-through phases. In addition, resistance bands are practical, portable, relatively inexpensive, and safe to use, particularly for adolescent athletes who are still undergoing neuromuscular development. A systematic review by (Seguin, Cudlip, & Holmes, 2022) also found that elastic resistance training can significantly improve upper-body muscle strength through the progressive resistance stimulus it provides during training.

Based on theoretical principles of resistance training and previous research, this study aims to examine the effect of overhead serve training with resistance bands on arm muscle strength in volleyball players at Citra Club. It is hypothesized that players participating in the overhead serve training program using resistance bands will demonstrate a significant increase in arm muscle strength between pretest and posttest measurements.

METHOD

This study used a quantitative, experimental design to determine the effect of a specific training treatment on arm muscle strength in volleyball players. This approach was chosen to empirically assess the effect of resistance band serve training on arm strength using statistical analysis. Quantitative methods enable testing of causal relationships and provide empirical evidence regarding training effectiveness (Creswell, JW, & Plano Clark, 2023). The experimental design enabled observation of changes in arm strength following structured training.

This study used a One-Group Pretest-Posttest Design, a pre-experimental method. Participants were measured before the intervention (pretest), received a specific treatment, and were measured again after the intervention (posttest) to track changes resulting from the training program. This design lets researchers assess intervention effectiveness by comparing pre- and post-treatment conditions within the same group (Allen, 2017). Without a comparison group, external variables may still influence results. Therefore, this pilot provides preliminary evidence on the use of resistance band-based training for volleyball players at Citra Club, where the athlete pool is small. To limit confounding variables, participants did not engage in outside strength training during the five-week intervention. Training schedules, duration, and exercise intensity remained consistent to standardize the treatment. Still, findings should be interpreted with caution, as uncontrolled factors may affect the results (Bierer et al., 2025).

The research was conducted at the volleyball training facility of Citra Club, located in Citembong Hilir hamlet, Cikeusi, Darmaraja district, Sumedang regency, West Java. The training program consisted of 10 sessions over 5 weeks, with 2 sessions per week. Each training session lasted approximately 90–120 minutes and consisted of three phases: warm-up, core training, and cool-down. The research was conducted at the volleyball training facility of Citra Club located in Citembong Hilir hamlet, Cikeusi village, Darmaraja district, Sumedang regency, West Java. The training program was implemented over 10 sessions within a five-week period, with two sessions per week. Each session lasted approximately 90–120 minutes and was structured into three phases: warm-up, core training, and cool-down. The program design referred to contemporary resistance training principles, particularly progressive overload, specificity, and neuromuscular adaptation, which are essential for improving muscular strength in youth athletes.

Komponen	Spesifikasi	Dasar Teori
Frekuensi	2 kali/minggu selama 5 minggu (10 sesi)	Frekuensi latihan 2–3 kali/minggu efektif meningkatkan kekuatan otot pada atlet (Schoenfeld, Ogborn, & Krieger, 2016)
Intensitas	Resistensi band ringan–sedang (individualized)	Progressive overload meningkatkan adaptasi kekuatan otot (Suchomel, Nimphius, & Stone, 2018); elastic resistance memberi tegangan

Komponen	Spesifikasi	Dasar Teori
		sepanjang ROM (Oranchuk, DJ, Ecsedy, EN, 2021)
Volume	3–4 set × 10–12 repetisi	Volume moderat efektif untuk peningkatan kekuatan (Ralston, Kilgore, Wyatt, & Baker, 2017)
Interval	60–90 detik	Interval moderat mendukung pemulihan dan performa set berikutnya (Henselmans, M., & Schoenfeld, 2014)
Spesifik Drill	Internal–external rotation, triceps extension, overhead arm pull	Prinsip spesifisitas meningkatkan transfer ke performa teknik (Athletes, 2022)
Struktur Latihan	Pemanasan 15, inti 60, pendinginan 15	Pemanasan dinamis meningkatkan kesiapan otot dan performa (Ruffieux, Wälchli, Kim, & Taube, 2020)
Media	Resistance band	Efektif meningkatkan kekuatan otot ekstremitas atas (Suryawan et al., 2022)

Table 1. Structure of Resistance Band–Based Overhead Serve Training Program

The warm-up phase consisted of dynamic movements to increase muscle temperature and joint mobility. The core phase integrates overhead serving techniques with resistance-band exercises to enhance arm strength through sport-specific movement patterns. The cool-down phase involved stretching to facilitate recovery and reduce muscle tension. Overall, this program aligns with recent evidence-based resistance training guidelines and is considered safe and effective for adolescent volleyball players.

The participants of this study were volleyball players who are members of Citra Club in Citembong Hilir Hamlet, Cikeusi Village, Darmaraja District, Sumedang Regency, West Java. The research sample consisted of 16 players selected using purposive sampling based on several criteria: (1) active players of the Citra Club, (2) aged between 10 and 18 years, (3) having no history of arm muscle injury, and (4) willing to participate in the entire series of training sessions and measurements. The selection of participants was based on considerations of homogeneity of training background and relevance to the objectives of the study.

The instrument used in this study was selected based on its validity and reliability in measuring the research variables. Research instruments are tools used by researchers to systematically and objectively collect data in accordance with the research objective. The participants of this study were volleyball players who are members of Citra Club in Citembong Hilir Hamlet, Cikeusi, Darmaraja District, Sumedang Regency, West Java. The research sample consisted of 16 players selected using a purposive sampling technique based on several criteria: (1) active players of the Citra Club, (2) aged between 10 and 18 years, (3) having no history of arm muscle injury, and (4) willing to participate in the entire series of training sessions and measurements. The selection of the sample was based on considerations of homogeneity of characteristics and suitability with the objectives of the study.

The instrument used in this study was selected based on its validity and reliability in measuring the research variables. Research instruments are tools used by researchers to systematically and objectively collect data in accordance with the research objectives. (Rohmatunisha, S., Wahyudi, U., & Yudasmara, 2020). Arm muscle strength was measured with a handgrip dynamometer, recording strength in kilograms (kg).



Figure 1. Grip Strength Dynamometer
Source: (Widiastuti, 2015)

This instrument was used to measure the strength of the dominant hand grip as an indicator of general upper-limb muscular strength and is widely used in physical fitness assessments (Pasaribu, 2020). Each participant was given two attempts, and the highest score was recorded as the final result. Measurements were conducted under the same conditions during both the pretest and posttest to maintain consistency and reliability of the results.

The research procedure consisted of three main stages: preparation, treatment implementation, and evaluation. During the preparation stage, initial observations were conducted, coordination with the coach was established, the research sample was selected, and pretest measurements of arm muscle strength were obtained. The treatment stage consisted of overhead serve training using resistance band media, conducted over 10 training sessions. Each session included a warm-up, core training, and a cool-down. After the completion of the entire training program, a posttest measurement was administered using the same procedures as the pretest to ensure data consistency and validity.

The data analysis was conducted using SPSS software. The analysis began with descriptive statistics to determine the mean, standard deviation, minimum, and maximum values for the pretest and posttest results. Furthermore, a normality test was conducted using the Shapiro–Wilk test because the sample size was fewer than 50 participants. If the data were normally distributed ($p > 0.05$), the analysis continued with a paired-samples t-test to determine whether the pretest and posttest results differed significantly. If the data were not normally distributed, a non-parametric Wilcoxon Signed-Rank Test would be applied as an alternative statistical method. In addition, the Normalized Gain (N-Gain) analysis was used to assess the magnitude of improvement in arm muscle strength following the resistance-band-based training intervention.

Before the data collection process began, permission to conduct the research was obtained from the club management and the team coach. All participants were informed of the study's purpose and procedures. Because several participants were under 18, informed consent was also obtained from their parents or guardians prior to participation. The confidentiality of participants' personal information was maintained throughout the research process, and all data were analyzed anonymously to protect participant privacy.

RESULTS

Arm muscle strength was measured using a handgrip dynamometer in 16 volleyball players from Citra Club before and after participating in an overhead serve training program using resistance-band media. The results indicated that all participants increased their arm muscle strength scores following the training intervention.

Subjek	Pretest	Posttest
S1	28	31
S2	19	23
S3	36	42

Subjek	Pretest	Posttest
S4	28	30
S5	12	22
S6	7	13
S7	10	18
S8	7	13
S9	25	30
S10	15	18
S11	23	26
S12	7	8
S13	13	17
S14	15	19
S15	12	20
S16	7	15

Table 2. Pretest and Posttest Score of Arm Muscle Strength (Handgrip)

The lowest pretest score was 7, and the highest was 36, while in the posttest, the lowest score increased to 8, and the highest reached 42. This increase indicates adaptation in arm muscle strength following training with rubber media.

Var	N	Mini	Maxi	Mean	SD
Pretest	16	7	36	16,50	9,04
Posttest	16	8	42	21,56	8,56

Table 3. Descriptive Statistics of Arm Muscle Strength

Based on Table 2, the mean pretest arm strength was 16.50 ± 9.04 , and the posttest mean was 21.56 ± 8.56 , reflecting an average improvement of 5.06 points. This indicates an enhancement in arm muscle strength from resistance-band training. The large standard deviation indicates considerable variation in individual scores, suggesting that the degree of improvement varied among players, likely due to differences in biological maturation, growth, and physical development typical of adolescent athletes.

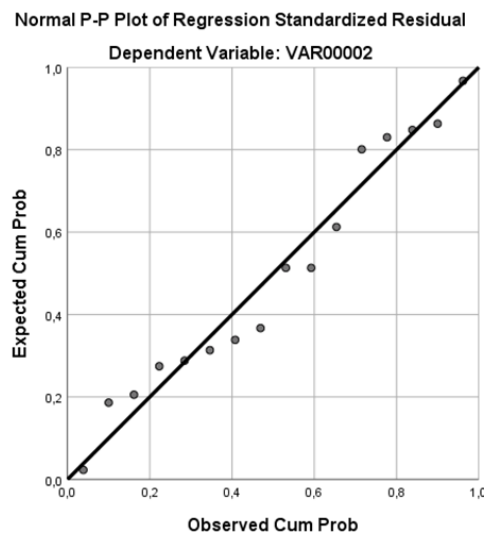


Figure 2. Probability–Probability (Normal P–P Plot)

Based on the results of the Normal Probability–Probability Plot (Normal P–P Plot) of Regression Standardized Residual, it can be seen that the residual points are spread around the diagonal line and follow the direction of the line from the bottom left to the top right. This distribution pattern suggests that the residual distribution in the study is approximately normal. Thus, it can be concluded that the data in this study meet the assumption of normality, making them suitable for parametric statistical analysis in the next testing stage.

Data	Statistik	Sig
Pretest	0,897	0,071
Posttest	0,958	0,620

Table 4. Shapiro–Wilk Normality Test of Arm Muscle Strength

The results of the Shapiro–Wilk normality test showed that the significance value for the pretest data was 0.071 and for the posttest data was 0.620. Both values are greater than 0.05, indicating that the data are normally distributed and meet the assumptions for a paired-samples t-test.

Variabel	t	Sig
Pretest-Posttest	12,931	0,000

Table 5. Paired Sample T-Test Test Arm Muscle Strength

The results of the paired-samples t-test showed a p-value of < 0.05, indicating a significant difference between the pretest and posttest values of arm muscle strength in volleyball players after training with rubber media.

Variabel	N	Min	Max	Mean	SD
N-gain	16	0,1	11	0,0604	0,02816

Table 6. Normalized Gain (N-Gain) of Arm Muscle Strength

The results of the N-Gain analysis showed a minimum of 0.01, a maximum of 0.11, an average of 0.0604, and a standard deviation of 0.02816 across 16 research subjects. The average value indicates that, after treatment, scores increased from pretest to posttest, suggesting a change in ability following the training program. According to the N-Gain interpretation criteria outlined by Melzer in Syahfitri (2008:33), the N-Gain value of 0.0604 falls within the moderate level of improvement. This indicates that the training treatment in this study contributed to improvements in the abilities measured in the research subjects.

DISCUSSION

The results of this study showed that the average arm muscle strength increased from 16.50 kg in the pretest to 21.56 kg in the posttest, indicating an improvement of 5.06 kg (30.7%) after participating in a resistance-band-based overhead serve training program. This increase suggests that training with elastic resistance can provide an effective stimulus for muscular adaptation. From a physiological perspective, resistance training can enhance motor unit recruitment and neuromuscular coordination, which play an important role in increasing muscle strength (Kraemer & Ratamess, 2004). Before conducting the hypothesis test, the data distribution was examined using the Shapiro–Wilk normality test and a Probability–Probability (P–P) Plot, which indicated that the data points followed a diagonal pattern and were normally distributed. Therefore, parametric statistical analysis was considered appropriate for examining the difference between pretest and posttest scores.

The effectiveness of the training intervention was further evaluated using the Normalized Gain (N-Gain) analysis, which showed an average N-Gain score of 0.18, indicating a low to moderate level of effectiveness. Although the magnitude of improvement varied among participants, the results demonstrate that resistance band training produced measurable improvements in arm muscle strength among the volleyball players in this study.

The findings of this study are consistent with previous research demonstrating that resistance band-based training improves not only muscular strength but also sport-specific performance. Research by (Suryawan et al, 2022) reported that six weeks of resistance band training increased arm muscle strength in volleyball athletes by 37.6%. Although the increase observed in the present study was slightly lower (30.7%), the results indicate a similar trend, confirming that elastic resistance training is effective in enhancing upper limb strength. Importantly, improvements in arm muscle strength are closely associated with increased arm swing velocity and ball speed during the execution of the overhead serve. (Baena Raya, 2021) explains that higher serve velocity significantly influences performance outcomes in volleyball, as faster ball speed reduces the opponent's reaction time. In line with this, (Athletes, 2022) emphasize that increased muscular strength contributes to greater force production and acceleration, which are essential for explosive upper limb movements such as the volleyball serve. Furthermore, resistance band exercises that mimic sport-specific movement patterns support improvements in coordination and timing, which are critical for better serve accuracy.

During adolescence, the neuromuscular system is highly adaptable and responsive to resistance training stimuli. Strength gains in youth athletes are predominantly influenced by neuromuscular adaptations, including increased motor unit recruitment, improved synchronization, and enhanced intermuscular coordination. Such adaptations play a key role not only in increasing force production but also in improving movement efficiency during complex motor skills. (Suchomel et al., 2018) highlight that neuromuscular efficiency is a primary determinant of strength development, particularly in the early stages of training. In the context of the overhead serve, increased arm muscle strength contributes to faster arm swing speed, while improved coordination enhances wrist stability at the point of ball contact. This combination is essential for optimizing both serve velocity and accuracy. Supporting this, (Wang, Qin, & Wei, 2024) demonstrate that arm swing mechanics and coordination significantly influence performance outcomes in volleyball-related movements. Additionally, resistance training programs for youth athletes have been shown to safely and effectively improve neuromuscular performance when properly structured (Afendi, Riwalidi Putra, 2025).

From a practical perspective, resistance band training offers several advantages, particularly for grassroots or community-based volleyball programs. Resistance bands are portable, cost-effective, and easy to implement, making them suitable for clubs with limited access to advanced training facilities. Beyond practicality, elastic resistance provides variable tension throughout the range of motion, which is beneficial for developing sport-specific strength and joint stability. This is especially relevant for overhead movements that require shoulder stability and wrist control (Andersen et al., 2022) found that elastic resistance training is effective in improving muscular strength while also enhancing neuromuscular control. Therefore, resistance band training can be considered a low-cost yet high-impact strategy that not only improves physical conditioning but also supports the development of technical performance in volleyball.

Despite these positive findings, several limitations remain. First, the one-group pretest-posttest design, lacking a control group, limits causal inference. Still, this design is effective for observing meaningful changes in real training environments. Consistent improvement across participants, supported by theory and previous findings, indicates the training program played a significant role in the outcomes. Second, the small sample size may limit generalizability but reflects practical constraints for club-level athletes and still yields relevant insights.

Future research should use more rigorous designs, such as randomized controlled trials, to strengthen causal inference. Studies should also include specific, objective performance indicators, such as serve velocity (measured by radar) and serve accuracy (target-based scoring).

Combining these metrics with strength measures will clarify how resistance band training affects both physical and technical performance in volleyball athletes.

CONCLUSION

Based on the results of this study, it can be concluded that the overhead serve training program using resistance band media was effective in improving the arm muscle strength of volleyball players at Citra Club. After completing 10 training sessions over a five-week period, the players demonstrated an increase in average arm muscle strength from 16.50 kg to 21.56 kg, representing an improvement of 5.06 kg or approximately 30.7%. These findings indicate that a short-term resistance band training program can provide a sufficient stimulus to trigger physical adaptations in adolescent volleyball athletes, particularly by improving the muscular strength required for the overhead serve technique.

From a physiological perspective, the increase in arm muscle strength observed in this study is likely associated with neuromuscular adaptations that commonly occur during the early stages of resistance training. Improvements in motor unit recruitment, muscle activation synchronization, and intermuscular coordination can enhance the efficiency of muscle contractions, allowing athletes to generate greater force even within a relatively short training period. These adaptations are particularly prominent in youth athletes because their neuromuscular systems remain highly responsive to strength-training stimuli.

In practice, resistance bands can be a feasible and effective training alternative for volleyball coaching programs, especially in grassroots or school-based environments with limited access to professional strength-training equipment. Resistance bands provide elastic resistance that follows the arm's movement during the serving motion and can therefore support sport-specific strength development. Coaches are encouraged to integrate resistance band exercises into training periodization, particularly during the general and specific preparation phases, with a frequency of two to three sessions per week using progressive resistance. Future research is recommended to employ a more rigorous experimental design with a control group and a larger sample, and to examine the relationship between resistance band training and volleyball performance indicators, such as serve speed and accuracy.

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