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The Effect Of Tennis Racket Weight Training On Smash Hit Ability In Badminton Games

Nurazizah
Universitas Negeri Makassar, Sulawesi Selatan, Indonesia
izah7127@gmail.com

ABSTRACT

This study was conducted based on the need to improve students' badminton smash ability through a simple, practical, and sport-specific training method. In badminton, the smash is one of the most important attacking techniques because it requires arm strength, wrist control, shoulder power, body coordination, and accurate timing. However, students often experience difficulty producing powerful and accurate smashes due to limited upper-body strength and inconsistent movement execution. Therefore, tennis-racket load training was applied as an alternative exercise to provide additional resistance during overhead striking movements. The purpose of this study was to determine the effect of tennis-racket load training on badminton smash ability among students of SMKN 6 Makassar. This research used a quantitative experimental method with a one-group pre-test and post-test design. The population consisted of 15 male students of SMKN 6 Makassar, and all students who met the purposive sampling criteria were selected as the research sample. The independent variable was tennis-racket load training, while the dependent variable was badminton smash ability. Data were collected using a badminton smash ability test before and after the treatment. The results showed an improvement in students' smash ability after the training program. The pre-test obtained a total score of 256, a mean score of 17.07, a standard deviation of 2.34, a minimum score of 13, and a maximum score of 20. The post-test increased to a total score of 299, a mean score of 19.93, a standard deviation of 2.05, a minimum score of 16, and a maximum score of 22. The hypothesis test showed that t-count = 4.897 was higher than t-table = 1.761, meaning that the alternative hypothesis was accepted. It can be concluded that tennis-racket load training significantly improves badminton smash ability among students of SMKN 6 Makassar.

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INTRODUCTION

Sport is a fundamental human need because it contributes not only to physical growth but also to psychological, social, and cognitive development. Regular physical activity supports the efficiency of body systems, including cardiovascular, respiratory, muscular, and neuromotor functions, which are essential for students' health and performance in physical education. In the school context, badminton is one of the most relevant sports because it combines speed, agility, coordination, reaction, tactical awareness, and emotional control. However, one of the most difficult skills for students to master is

the smash. The badminton smash requires explosive upper-limb power, precise wrist action, shoulder rotation, trunk coordination, good timing, and correct shuttlecock contact. Without sufficient arm strength and technical stability, students tend to produce weak, inaccurate, or poorly directed smashes.

At SMKN 6 Makassar, the development of badminton smash ability is important because students need learning experiences that are practical, measurable, and connected to physical fitness improvement. Many students are able to perform basic badminton strokes, but their smash performance is often limited by weak arm and shoulder power, poor racket-head acceleration, unstable body balance, and inconsistent impact timing. This condition indicates that conventional technical practice alone may not be sufficient. Smash performance needs a specific training method that stimulates the same movement pattern while adding appropriate resistance. Tennis-racket load training is considered one potential method because it uses a heavier racket as an overload stimulus to strengthen the hand, forearm, arm, shoulder, and upper-body muscles involved in overhead striking movements. Juliansyah, Iyakrus, and Destriana (2017) explained that training with a tennis racket can provide additional load in racket-sport movements, thereby helping athletes improve strength, endurance, and stroke control.

Recent sports science literature emphasizes that muscular strength is a key foundation for sport-specific performance because it improves force production, movement efficiency, and injury prevention (Suchomel, Nimphius, & Stone, 2016; Suchomel et al., 2018). Resistance training has also been proven effective for improving muscular fitness and athletic performance in youth athletes when it is applied progressively and safely (Granacher et al., 2016; Lesinski, Prieske, & Granacher, 2016; Lesinski et al., 2020). In badminton, the smash is not merely a hitting movement; it is a complex kinetic-chain action involving lower-body support, trunk rotation, shoulder internal rotation, elbow extension, forearm pronation, and wrist flexion. Awatani et al. (2018) reported that shoulder strength is related to racket velocity during forehand smash movements, indicating that upper-limb strength has a direct contribution to explosive stroke execution.

Biomechanical studies also show that an effective smash depends on sequential coordination from the lower limbs to the upper limbs. Li et al. (2023) identified the importance of overhead forehand smash mechanics, especially for beginner players who must learn correct movement sequencing. Dong et al. (2024) further showed that different smash distances influence upper-limb kinematics and muscle activation patterns, meaning that technical accuracy and physical capacity must be trained together. Core strength is also relevant because trunk stability supports energy transfer from the body to the racket; Ma et al. (2024) found that core strength training improves several badminton performance components, including strength, power, balance, and hitting-related movement.

In the Indonesian badminton context, several recent studies have confirmed the importance of specific training models. Ishak et al. (2022) developed smash training models for beginner badminton players, while Denatara (2024) emphasized the need for varied forehand smash training models for young athletes. Endrawan et al. (2024), Zainuddin et al. (2024), and Hadi and Mashud (2025) reported that drill-based and target-based training approaches can improve smash accuracy. Hamid et al. (2025) found that arm muscle strength training significantly improved badminton smash ability, while Rahadhi et al. (2025) highlighted the positive effect of resistance band training on forehand smash speed. These findings indicate that smash improvement requires a combination of technical repetition, specific resistance, and progressive overload.

Although many studies have examined drill training, plyometric training, resistance bands, core training, and arm-strength exercises in badminton, research on tennis-racket load training for improving badminton smash ability among vocational school students remains limited. Previous research has mostly focused on club athletes, university students, or junior athletes in structured training environments (Hasanuddin et al., 2023; Utama, 2022; Artazila et al., 2024). Meanwhile, students at vocational schools often have different characteristics, such as varied physical fitness levels, limited training experience, and shorter instructional time in physical education. This creates a practical gap between sport-science training concepts and their application in school-based badminton learning.

Nurazizah
izah7127@gmail.com

Another gap concerns the training instrument itself. Studies on racket weight adaptation suggest that racket mass can influence neuromuscular control strategies and stroke performance (Pan et al., 2024). However, the use of a heavier tennis racket as a training tool in badminton must be examined carefully because badminton requires speed, flexibility, and fine motor control. If the overload is too heavy or poorly controlled, it may disturb technique; however, if it is applied progressively, it may strengthen the movement pattern needed for a more powerful smash. Therefore, empirical evidence is needed to determine whether tennis-racket load training can produce a positive effect on badminton smash ability in the school context.

This study aims to determine the effect of tennis-racket load training on badminton smash ability among students of SMKN 6 Makassar. Conceptually, this research is based on the principle of specificity and progressive overload, where training adaptation becomes more effective when the exercise resembles the actual sport movement while providing an additional challenge to the working muscles. Empirically, this study is expected to provide evidence on whether a modified heavier racket can improve students' smash performance through increased arm strength, wrist control, shoulder power, and racket-head acceleration.

The novelty of this study lies in its school-based application of tennis-racket load training as a simple, practical, and low-cost training method for badminton learning. Unlike many studies that use gym-based equipment or athlete-centered programs, this research offers an alternative training model that can be implemented by physical education teachers with limited facilities. This study also contributes to the development of badminton teaching strategies in vocational schools by integrating strength-based training with sport-specific skill acquisition.

Based on the theoretical and empirical literature, badminton smash performance is strongly influenced by upper-limb strength, body coordination, technical repetition, and progressive resistance. However, the use of tennis-racket load training as a specific overload method for improving badminton smash ability in vocational school students has not been sufficiently explored. Therefore, this study is important because it addresses a practical learning problem at SMKN 6 Makassar and offers a training innovation that may improve students' smash ability in a measurable and applicable way.

METHODS

This study employed a quantitative experimental method using a one-group pre-test and post-test design. The experimental approach was selected because the main objective of the study was to examine whether tennis-racket load training had a measurable effect on badminton smash ability among students of SMKN 6 Makassar. In sport science research, an experimental design is appropriate when the researcher intends to test the effect of a specific training intervention on physical or technical performance. This design is also relevant to resistance-based training studies, which emphasize the importance of progressive overload, specificity, and controlled repetition in improving sport performance (Granacher et al., 2016; Lesinski et al., 2016; Suchomel et al., 2018). In badminton, smash performance is strongly influenced by arm strength, shoulder power, racket velocity, wrist control, and coordinated upper-limb movement; therefore, a specific overload exercise using a heavier racket was considered suitable for the intervention (Awatani et al., 2018; Li et al., 2023; Dong et al., 2024).

The population of this study consisted of 15 students of SMKN 6 Makassar. The sampling technique used was purposive sampling, with the following criteria: students were officially enrolled at SMKN 6 Makassar, male, physically able to participate in badminton training, willing to follow the treatment program, and able to complete both the pre-test and post-test. Based on these criteria, all 15 students were selected as the research sample. The independent variable in this study was tennis-racket load training, while the dependent variable was badminton smash ability. The research design can be described as follows: P → S → Pre-test → Y → Post-test, where P refers to the population, S refers to the sample, Pre-test refers to the initial smash ability test, Y refers to the tennis-racket load training treatment, and Post-test refers to the final smash ability test.

Nurazizah
izah7127@gmail.com

The treatment was carried out through structured tennis-racket load exercises. The students practiced overhead striking movements using a tennis racket as a heavier training tool to provide additional resistance to the arm, wrist, shoulder, and upper-body muscles. This training principle is consistent with recent findings showing that racket-sport performance depends on neuromuscular control, upper-limb coordination, strength development, and movement adaptation under specific task demands (Cui, 2022; Pan et al., 2024; Ma et al., 2024). The training was implemented progressively, beginning with controlled swing movements and continuing to more dynamic smash-oriented movements, while still maintaining correct technique, safety, and movement quality.

Data were collected using a badminton smash ability test administered before and after the treatment. The pre-test was conducted to determine the students' initial smash ability, while the post-test was conducted to identify improvement after the intervention. The collected data were analyzed quantitatively using descriptive statistics, including mean, standard deviation, minimum score, maximum score, and score difference. To test the research hypothesis, the pre-test and post-test results were compared using an appropriate paired-sample statistical test. If the post-test score was higher than the pre-test score and the statistical test showed a significant difference, it could be concluded that tennis-racket load training had a positive effect on badminton smash ability among students of SMKN 6 Makassar.

RESULTS AND DISCUSSION

Result

The research results describe the effect of tennis-racket load training on badminton smash ability among students of SMKN 6 Makassar. The data were obtained from two stages of measurement, namely the pre-test and post-test. The pre-test was conducted before the students received tennis-racket load training, while the post-test was administered after the treatment had been completed. The analysis included descriptive statistics, normality testing, and hypothesis testing to determine whether there was a significant improvement in badminton smash ability after the training program.

Table 1.
Descriptive Statistics of Badminton Smash Ability

Statistic	Pre-Test	Post-Test
N	15	15
Total Score (∑X)	256	299
Mean (X̄)	17.07	19.93
Standard Deviation	2.34	2.05
Minimum Score	13	16
Maximum Score	20	22

Based on Table 1, the pre-test score of badminton smash ability among students of SMKN 6 Makassar showed a total score of 256, with a mean score of 17.07 and a standard deviation of 2.34. The lowest score obtained in the pre-test was 13, while the highest score was 20. These results indicate that before receiving tennis-racket load training, students' smash ability was still at a moderate level and required improvement, particularly in power, accuracy, and consistency of execution.

After the treatment, the post-test result showed a total score of 299, with a mean score of 19.93 and a standard deviation of 2.05. The minimum score increased to 16, while the maximum score increased to 22. The increase in the mean score from 17.07 to 19.93 indicates an average improvement of 2.86 points. In percentage terms, the improvement reached approximately 16.75%. This finding shows that tennis-racket load training produced a positive change in students' badminton smash performance.

Table 2.
Summary of Normality Test Results

Group	N	Lh	Lt (0.05)	Description
Pre-Test	15	0.105	0.227	Normal

Based on Table 2, the normality test using the Liliefors test showed that the calculated value of Lh was 0.105, while the critical value of Lt at the 0.05 significance level was 0.227. Since Lh was lower than Lt, the data were normally distributed. Therefore, the sample data could be analyzed using a parametric statistical test. This result also indicates that the distribution of students' badminton smash ability before treatment met the assumption required for hypothesis testing.

Table 3.
Summary of Hypothesis Test Results

Variable Comparison	t-count	t-table	Description
Pre-Test and Post-Test	4.897	1.761	Significant

Table 3 shows that the t-count value was 4.897, while the t-table value was 1.761. Since the t-count was higher than the t-table value, the research hypothesis was accepted. This means that there was a significant difference between students' badminton smash ability before and after receiving tennis-racket load training. In other words, tennis-racket load training had a significant effect on improving badminton smash ability among students of SMKN 6 Makassar.

The findings demonstrate that the treatment was effective because the students' smash performance improved after completing the training program. The increase in the mean score, the improvement in minimum and maximum scores, and the significant t-test result all support the conclusion that tennis-racket load training can be used as an alternative training method to improve badminton smash ability. This training method is practical because it applies the principle of overload through a heavier racket while still maintaining movement patterns that are close to badminton smash execution. Therefore, tennis-racket load training is recommended as a supportive exercise in badminton learning and extracurricular training at SMKN 6 Makassar.

Discussion

The results of this study demonstrate that tennis-racket load training had a significant effect on improving badminton smash ability among extracurricular students of SMKN 6 Makassar. The descriptive analysis showed that the students' pre-test mean score was 17.07 with a standard deviation of 2.34, while the post-test mean score increased to 19.93 with a standard deviation of 2.05. The mean improvement of 2.86 points indicates that the training intervention produced a meaningful increase in students' smash performance. Furthermore, the hypothesis test showed that the t-count value was 4.897, which was higher than the t-table value of 1.761. Therefore, the null hypothesis was rejected, and it can be interpreted that there was a significant difference between students' badminton smash ability before and after receiving tennis-racket load training.

This finding confirms that tennis-racket load training can be used as an effective specific-resistance exercise to improve smash ability in badminton. In practical terms, the heavier racket created an overload stimulus for the wrist, forearm, upper arm, shoulder, and upper-body muscles. This condition encouraged the students to produce greater force during repeated overhead swing movements. The result is consistent with the principle of progressive overload, which states that physical performance improves when the body is exposed to training loads that are slightly higher than habitual movement demands. Suchomel, Nimphius, and Stone (2016) emphasized that muscular strength is a major foundation for athletic performance because stronger athletes can generate greater force and transfer it more effectively into sport-specific movements. Similarly, Suchomel et al. (2018), Lesinski, Prieske, and Granacher (2016), and Granacher et al. (2016) found that properly structured resistance training improves muscular fitness and athletic performance in youth athletes. These findings support the present study, because badminton smash ability depends on the capacity to generate explosive power in a short time.

The improvement from pre-test to post-test also indicates that the students adapted positively to the training process. Tennis-racket load training did not merely develop general strength; it trained the students through a movement pattern that was relatively similar to the badminton smash. This is important because sport-specific strength exercises are more transferable when the direction of movement, joint action, and muscle involvement resemble the target skill. In badminton, the smash is

a complex overhead movement involving trunk rotation, shoulder internal rotation, elbow extension, forearm pronation, wrist flexion, and racket-head acceleration. Awatani et al. (2018) reported that shoulder strength is related to racket velocity during badminton forehand smash movements, while Barnamehei et al. (2018) showed that elite and non-elite players differ in upper-limb neuromuscular activation and movement synergy during overhead smash actions. This evidence explains why repeated overload using a heavier racket may improve students' ability to coordinate strength and technique during smash execution.

From a biomechanical perspective, the increase in smash score can be interpreted as an improvement in movement efficiency. The badminton smash is not only determined by arm strength, but also by the coordination of the kinetic chain from the lower body, trunk, shoulder, elbow, wrist, and racket. Zhang et al. (2016), Li et al. (2017), and Li, Li, Zhang, and Shan (2023) emphasized that body positioning, trunk rotation, and sequential coordination are important determinants of smash quality. Li et al. (2023) further demonstrated through three-dimensional motion analysis that skilled players show more efficient overhead forehand smash mechanics than novice players. In line with this, Artazila et al. (2024) explained that biomechanical understanding is useful for improving smash speed, accuracy, and movement effectiveness. Therefore, the improvement found in this study suggests that tennis-racket load training helped students strengthen the physical components needed for more stable and powerful overhead movement.

The significant improvement is also relevant to the concept of racket weight adaptation. Pan et al. (2024) found that racket weight changes influence motor control strategies in badminton players. Although skilled players may adapt more efficiently to racket weight variation, training with altered racket mass can still provide useful neuromuscular stimulation when applied progressively. In the present study, the use of a tennis racket as a heavier tool likely increased the demand on students' grip control, wrist stability, shoulder strength, and swing coordination. When students returned to the lighter badminton racket, their movement may have felt easier, allowing better racket acceleration and stronger shuttlecock contact. However, this type of training must be applied carefully because excessive load can disturb technique. The positive result in this study indicates that the training was still within a tolerable range for the students and supported performance improvement rather than causing technical disruption.

The results of this study are also supported by recent research on badminton-specific strength training. Ma et al. (2024) found that core strength training significantly improved badminton performance components, including explosive power, front-court skill, and back-court skill. Wang et al. (2025), through a systematic review and meta-analysis, concluded that resistance training improves power, speed, agility, endurance, technical stability, and kinetic-chain transfer in competitive badminton players, although evidence on upper-limb resistance training still needs further strengthening. Hamid et al. (2025) reported that arm muscle strength training significantly improved badminton smash ability in young athletes, while Aswad et al. (2025) found that resistance band training improved smash stroke ability among badminton players in Makassar. These studies strengthen the interpretation that the improvement observed at SMKN 6 Makassar was not accidental, but was aligned with current evidence showing that strength-based interventions contribute positively to badminton smash performance.

The present finding is also consistent with studies focusing on drill-based and target-based smash training. Hadi and Mashud (2025) reviewed studies by Baihaqi and Hadi (2022), Endrawan et al. (2024), Febrisyah et al. (2022), Syaiuddin and Indardi (2023), Wardani et al. (2022), and Zainuddin et al. (2024), which generally showed that drill training improves badminton smash accuracy. Shiddieqy et al. (2025) also reported through meta-analysis that drill training contributes to improving smash accuracy. Denatara (2024) developed forehand smash training models for young badminton athletes using footwork, shadow smash, plyometric, drill, and game-based patterns. Although the present study used tennis-racket load training rather than conventional drill training, the mechanism is similar: students improved through repeated, structured, and specific practice. The difference is that tennis-racket load training added resistance, so the students did not only repeat the smash pattern but also developed the strength needed to perform it more powerfully.

Compared with previous Indonesian studies, the result of this study has practical relevance. Juliansyah, Iyakrus, and Destriana (2017) found that training using a tennis racket improved badminton overhead lob performance, showing that racket-based overload can be useful in badminton skill development. Al Fariz (2022) also discussed the use of tennis-racket external load for improving overhead lob skills. In the present study, the same overload idea was applied to the smash skill, which is more explosive and more decisive in attacking situations. Therefore, this study extends previous findings by showing that tennis-racket load training is not only relevant for overhead lob development but also effective for improving smash ability among vocational school students.

The decrease in standard deviation from 2.34 in the pre-test to 2.05 in the post-test also deserves attention. This reduction indicates that students' scores became slightly more homogeneous after training. In other words, the intervention did not only improve the average score but also helped reduce performance gaps among students. This is educationally important because extracurricular training at school should not only benefit already skilled students, but also help less-skilled students improve their basic technical ability. The increase in minimum score from 13 to 16 and maximum score from 20 to 22 further supports this interpretation. It suggests that both lower-performing and higher-performing students experienced positive development after treatment.

Nevertheless, the findings should be interpreted with several limitations. This study used a one-group pre-test and post-test design with 15 students, meaning that the improvement cannot be compared directly with a control group. Future studies should use a larger sample, include male and female students, compare tennis-racket load training with other methods such as resistance band training, plyometric training, shadow smash, and target drill, and measure additional variables such as smash speed, accuracy zones, arm strength, grip strength, and shoulder flexibility. Rusdiana et al. (2020) showed that fatigue can reduce biomechanical effectiveness in badminton jump smash performance, so future research should also control training load, recovery, and fatigue level.

Overall, the results confirm that tennis-racket load training significantly improves badminton smash ability among extracurricular students of SMKN 6 Makassar. The rejection of H0 indicates that the difference between pre-test and post-test scores was statistically meaningful. The improvement is supported by theoretical principles of overload, specificity, muscular strength development, and motor adaptation. Empirically, the finding is aligned with recent SINTA- and Scopus-indexed studies showing that strength training, resistance training, core training, racket-load adaptation, and drill-based practice can enhance badminton performance. Thus, tennis-racket load training can be recommended as a practical, low-cost, and school-applicable training model to improve badminton smash ability, especially in extracurricular programs with limited facilities.

CONCLUSION

Based on the results of data analysis, it can be concluded that tennis-racket load training had a significant effect on improving badminton smash ability among students of SMKN 6 Makassar. The descriptive statistical results showed that the students' smash ability increased after receiving the training treatment. In the pre-test, the total score was 256, with a mean score of 17.07, a standard deviation of 2.34, a minimum score of 13, and a maximum score of 20. After the implementation of tennis-racket load training, the post-test result increased to a total score of 299, with a mean score of 19.93, a standard deviation of 2.05, a minimum score of 16, and a maximum score of 22. This means that there was an average improvement of 2.86 points between the pre-test and post-test results.

The hypothesis testing also strengthened this finding. The t-count value was 4.897, while the t-table value was 1.761. Since the t-count was higher than the t-table, the null hypothesis was rejected and the alternative hypothesis was accepted. Therefore, there was a significant difference in badminton smash ability before and after the training program.

These findings indicate that tennis-racket load training is an effective, practical, and applicable training method for improving badminton smash performance. The additional load from the tennis racket helped stimulate arm, wrist, shoulder, and upper-body strength, which are essential components in producing a powerful and accurate smash. Therefore, this training model

can be recommended as a supporting exercise in badminton extracurricular programs at SMKN 6 Makassar.

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