



## The Effect Of Dumbbell Over Head Exercises On Smash Hit Ability In Badminton Games In Students Of Vocational School 6 Makassar

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A. Conception and design of the study; B. Acquisition of data;  
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### ABSTRACT

This study aims to determine the effect of dumbbell overhead training on badminton smash ability among students of SMKN 6 Makassar. The background of this study is based on the fact that badminton smash is an offensive stroke requiring arm strength, shoulder stability, wrist control, explosive power, and coordinated overhead movement. In school-based badminton activities, students often experience difficulty producing powerful and accurate smash strokes because their upper-limb strength and technical execution are still limited. This study used a quantitative experimental method with a control group pre-test-post-test design. The population consisted of 40 male students who actively participated in badminton extracurricular activities at SMKN 6 Makassar. The sample was divided into two groups: an experimental group receiving dumbbell overhead training and a control group receiving regular training without specific dumbbell overhead exercises. Data were collected using a badminton smash ability test and analyzed through descriptive statistics, normality test, homogeneity test, paired sample t-test, and independent sample t-test. The results showed that the experimental group improved from a pre-test mean score of 10.70 to a post-test mean score of 16.80, with a mean difference of 6.10 points. The paired sample t-test showed  $t = 22.031$  and  $p = 0.000 < 0.05$ . The control group improved from 10.70 to 12.90, with a mean difference of 2.20 points. The independent sample t-test showed a significant post-test difference between groups, with  $t = 3.847$  and  $p = 0.000 < 0.05$ . It can be concluded that dumbbell overhead training significantly improves badminton smash ability and is more effective than regular training alone.

### INTRODUCTION

Badminton is a dynamic racket sport that requires a complex integration of physical fitness, technical skill, tactical awareness, and psychological readiness. During a match, players must perform rapid movements such as jumping, lunging, accelerating, decelerating, changing direction, and striking the shuttlecock with precision under time pressure. These movement patterns demand strength, speed, agility, endurance, power, reaction ability, coordination, and balance (Cádiz Gallardo et al., 2023; Green et al., 2023; Ma et al., 2025; Phomsoupha & Laffaye, 2020). In the context of school-based badminton learning, students are not only expected to understand the rules of the game but also to master fundamental motor skills, including grip, stance, footwork, service, lob, drive, netting, dropshot, and smash (Gusrinaldi et al., 2020; Sudiadharma &



Ishak, 2020). Among these basic techniques, the smash is one of the most important offensive strokes because it is performed with high speed, sharp trajectory, and attacking intention. A successful smash enables players to break the opponent's defense, create direct scoring opportunities, and dominate the rhythm of the game (Dong et al., 2024; Hamid et al., 2025; Ishak et al., 2024). However, performing an effective smash is not simple. It requires proper body positioning, shoulder rotation, elbow extension, wrist action, racket-head speed, timing, and explosive upper-limb force (Artazila et al., 2024; Rusdiana et al., 2023). Inadequate arm strength and poor overhead movement coordination may reduce shuttlecock speed, accuracy, and power, causing the smash to become weak, predictable, or easily returned by the opponent (Munizar et al., 2016; Rachmadian, 2021; Taib & Adam, 2022). This problem is also observed among students of SMKN 6 Makassar. Although badminton is one of the sports activities followed by students at the school, the level of basic technical mastery, especially smash ability, remains varied. Some students are able to hit the shuttlecock but still lack power, direction, and sharpness. This condition indicates that technical practice alone may not be sufficient if it is not supported by structured physical conditioning, particularly exercises that develop arm and shoulder strength. Therefore, a specific training model is needed to improve students' smash ability through exercises that are simple, measurable, safe, and suitable for school training conditions.

Recent studies in badminton performance have emphasized that physical conditioning is a decisive factor in supporting technical execution. Systematic reviews and meta-analyses show that structured training programs such as resistance training, core training, plyometric training, balance training, and high-intensity interval training can improve badminton-related performance components, including agility, power, balance, endurance, and stroke quality (Ma et al., 2024; Ma et al., 2025; Wang et al., 2025). Other studies have also demonstrated that lower-limb strength, agility, dynamic balance, and core stability contribute to movement efficiency in badminton, particularly in reaching the shuttlecock and maintaining body control during offensive strokes (Alikhani et al., 2019; Charee et al., 2022; Hu et al., 2025; Sonoda et al., 2018). In relation to smash performance, biomechanical studies explain that the badminton smash is produced through a coordinated kinetic chain involving the lower limbs, trunk, shoulder, elbow, forearm, wrist, and racket movement (Artazila et al., 2024; Dong et al., 2024; Rusdiana et al., 2023). The upper limb plays a central role because the final acceleration of the racket is strongly influenced by shoulder internal rotation, elbow extension, forearm movement, wrist action, and grip control. Dong et al. (2024) found that different smashing distances require changes in upper-limb muscle activation and joint angular velocity, showing that smash performance depends on the ability to coordinate power and control. Fatigue has also been reported to reduce jump-smash performance by decreasing shuttlecock speed and altering body-segment movement (Rusdiana et al., 2023). Empirical studies in Indonesia further support the importance of arm muscle strength for badminton smash ability. Sudiadharma and Ishak (2020) reported that pull-over training influenced smash ability in badminton. Ishak et al. (2024) found that dumbbell training and rubber weight training significantly improved badminton smash shots among BKMFIK UNM players. Hamid et al. (2025) also showed that targeted arm-muscle strength training through tricep dip exercises improved smash ability in young badminton athletes. Similarly, studies by Fauzi (2025), Jayanto (2024), Nasution et al. (2024), and Septiyani and Apriani (2023) indicate that arm strength, hand-eye coordination, and specific resistance exercises are associated with better smash performance.

Although previous studies have examined several forms of strength training for badminton performance, there are still several gaps that need further investigation. First, many studies focus on athletes in clubs or university-level badminton units, while research involving vocational high school students remains limited. School students have different physical characteristics, training experience, motivation, and technical mastery compared with trained athletes. Therefore, findings from athlete-based studies cannot be directly generalized to students in physical education or extracurricular contexts. Second, previous research has often discussed arm strength in general, but fewer studies specifically examine dumbbell overhead training as a practical intervention for improving smash ability. Dumbbell overhead exercise is relevant to badminton because the movement pattern involves shoulder elevation, elbow extension, arm stabilization, and overhead force production, which are closely related to the mechanical demands of smash strokes. Third, there is still a need for empirical evidence from local school contexts in Makassar, especially SMKN 6 Makassar, where students' smash ability differs and requires a structured training solution. This gap justifies the need for a focused study examining the effect of dumbbell overhead exercise on badminton smash ability among students.

This study aims to determine the effect of dumbbell overhead training on smash ability in badminton among students of SMKN 6 Makassar. Conceptually, this study is based on the assumption that the smash is not merely a technical stroke but a performance skill supported by upper-limb strength, movement coordination, shoulder stability, and explosive force production. Empirically, this study seeks to test whether a structured dumbbell overhead exercise program can improve students' ability to perform stronger, sharper, and more effective smash strokes. The novelty of this study lies in its specific focus on the application of dumbbell overhead exercise in a vocational high school setting. While previous studies have investigated dumbbell training, tricep dips, pull-over exercises, rubber weight training, and other strength-based interventions, this study positions dumbbell overhead training as a practical, low-cost, and school-applicable method to support badminton skill development. The study also contributes to the development of evidence-based training models for physical education teachers and school coaches, especially in designing simple resistance-training programs that directly support technical performance.

Based on the theoretical and empirical evidence, badminton smash ability is strongly influenced by the interaction between technical mastery and physical conditioning, particularly upper-limb strength and overhead movement coordination. Students with weak arm strength and poor overhead control may experience difficulty producing a powerful and accurate smash. Therefore, dumbbell overhead training is considered a relevant intervention because it targets the shoulder, arm, and upper-body muscles needed in smash execution. This study is expected to provide scientific evidence regarding the effectiveness of dumbbell overhead training in improving badminton smash ability among students of SMKN 6 Makassar and to offer practical implications for school-based badminton training programs.

## METHODS

This study employed a quantitative experimental research method to examine the effect of dumbbell overhead training on badminton smash ability among students of SMKN 6 Makassar. Experimental research is considered appropriate when a study aims to test the causal effect of a specific treatment on measurable performance outcomes through controlled comparison between groups (Creswell & Creswell, 2018). In sports science, this approach is widely used because training interventions can be systematically planned, implemented, and evaluated using pre-test and post-test measurements (Ma et al., 2025; Wang et al., 2025). The independent variable in this study was dumbbell overhead training, while the dependent variable was badminton smash ability. The research design used was a control group pre-test–post-test design. This design involved two groups: an experimental group that received dumbbell overhead training and a control group that did not receive the specific treatment. Both groups were measured before and after the intervention. This design allows researchers to compare initial ability, observe performance changes after treatment, and determine whether the improvement in the experimental group is greater than that of the control group. Similar pre-test–post-test control group designs have been applied in recent badminton training studies to examine the effect of physical conditioning, resistance training, core training, and arm-muscle strengthening on performance outcomes (Hamid et al., 2025; Kahraman & Kızılcı, 2025; Wang et al., 2025).

The population of this study consisted of 40 male students who actively participated in badminton extracurricular activities at SMKN 6 Makassar. The participants were selected because they had basic badminton experience but showed different levels of smash ability. Random sampling was used to reduce selection bias and to provide equal opportunity for each student to be involved in the study. After sampling, the participants were divided into two groups: the experimental group and the control group. The experimental group followed a structured dumbbell overhead training program, while the control group continued regular badminton activities without additional dumbbell overhead exercises.

The treatment was designed to strengthen the shoulder, arm, and upper-body muscles that contribute to overhead stroke execution. This is theoretically relevant because badminton smash performance depends on coordinated upper-limb movement, shoulder internal rotation, elbow extension, wrist action, and explosive force production (Dong et al., 2024; Pan et al., 2024; Rusdiana et al., 2023). Recent empirical findings also indicate that arm-muscle strength has a significant relationship with smash accuracy and performance in badminton (Hardin et al., 2025; Ilmi et al., 2024). Therefore, dumbbell overhead training was selected as a practical resistance-training intervention that can be implemented in a school-based training context.

Data were collected using a badminton smash ability test conducted before and after the intervention. The test results were analyzed quantitatively through descriptive statistics and inferential analysis. Descriptive analysis was used to describe the mean, standard deviation, minimum score, and maximum score of each group. Inferential analysis was used to test the hypothesis by comparing pre-test and post-test results within and between groups. The findings were interpreted at a significance level of 0.05 to determine whether dumbbell overhead training had a statistically significant effect on students' badminton smash ability.

## RESULTS AND DISCUSSION

### Results

The empirical data in this study were obtained through pre-test and post-test measurements of badminton smash ability among students of SMKN 6 Makassar. The analysis was conducted to determine whether dumbbell overhead training had a significant effect on students' smash performance compared with the control group. The data were first analyzed descriptively to describe the general characteristics of each group, including the number of samples, range, minimum score, maximum score, total score, mean, and standard deviation. Furthermore, prerequisite tests consisting of normality and homogeneity tests were conducted before hypothesis testing. Because the data met the assumptions of normality and homogeneity, the hypothesis was tested using parametric statistics, namely paired sample t-test and independent sample t-test. The results were based on the SPSS output provided in the research data.

### Descriptive Statistical Analysis

**Table 1.** Descriptive Statistics of Badminton Smash Ability

| Group and Test               | N  | Range | Min   | Max   | Sum    | Mean  | Std. Deviation |
|------------------------------|----|-------|-------|-------|--------|-------|----------------|
| Experimental Group Pre-test  | 10 | 6.00  | 8.00  | 14.00 | 107.00 | 10.70 | 1.89           |
| Experimental Group Post-test | 10 | 6.00  | 14.00 | 20.00 | 168.00 | 16.80 | 2.04           |
| Control Group Pre-test       | 10 | 6.00  | 8.00  | 14.00 | 107.00 | 10.70 | 2.26           |
| Control Group Post-test      | 10 | 7.00  | 10.00 | 17.00 | 129.00 | 12.90 | 2.47           |

Table 1 shows that the experimental group experienced a clear increase in badminton smash ability after receiving dumbbell overhead training. The mean score increased from 10.70 in the pre-test to 16.80 in the post-test, with a mean improvement of 6.10 points. This indicates that students who participated in dumbbell overhead training demonstrated better smash performance after the treatment. In the control group, the mean score increased from 10.70 to 12.90, with a mean improvement of 2.20 points. Although the control group also showed improvement, the increase was smaller than that of the experimental group. Conceptually, this finding indicates that regular badminton activity may improve smash ability, but specific upper-limb strength training through dumbbell overhead exercises produces a stronger improvement.

### Normality Test

**Table 2.** Normality Test Results

| Variable                         | Kolmogorov-Smirnov |       | Shapiro-Wilk |       | $\alpha$ | Interpretation |
|----------------------------------|--------------------|-------|--------------|-------|----------|----------------|
|                                  | Statistic          | Sig.  | Statistic    | Sig.  |          |                |
| Dumbbell Overhead Training Group | 0.145              | 0.200 | 0.964        | 0.835 | 0.05     | Normal         |
| Control Group                    | 0.174              | 0.200 | 0.907        | 0.263 | 0.05     | Normal         |

The normality test showed that the data in both groups were normally distributed. In the experimental group, the Kolmogorov-Smirnov significance value was 0.200 and the Shapiro-Wilk significance value was 0.835. Both values were higher than 0.05. In the control group, the Kolmogorov-Smirnov significance value was 0.200 and the Shapiro-Wilk significance value was 0.263, also higher than 0.05. Therefore, it can be concluded that the data distribution met the normality assumption and could be analyzed using parametric statistical tests.

## Homogeneity Test

**Table 3.** Homogeneity Test Results

| Initial Test Comparison                            | Levene Statistic | Sig.  | $\alpha$ | Interpretation |
|----------------------------------------------------|------------------|-------|----------|----------------|
| Dumbbell Overhead Training Group and Control Group | 0.735            | 0.403 | 0.05     | Homogeneous    |

The homogeneity test using Levene's test produced a significance value of 0.403, which was higher than 0.05. This result indicates that the variance between the experimental group and the control group was homogeneous. Thus, the two groups had relatively equal initial variance, and the hypothesis testing could be continued using parametric analysis.

## Hypothesis Testing

### Effect of Dumbbell Overhead Training on Badminton Smash Ability

**Table 4.** Paired Sample t-Test of the Experimental Group

| Group              | Test      | Mean  | Mean Difference | t-count | df | Sig. (2-tailed) | t-table | Interpretation |
|--------------------|-----------|-------|-----------------|---------|----|-----------------|---------|----------------|
| Experimental Group | Post-test | 16.80 | 6.10            | 22.031  | 9  | 0.000           | 1.833   | Significant    |
|                    | Pre-test  | 10.70 |                 |         |    |                 |         |                |

The paired sample t-test result for the experimental group showed that the t-count value was 22.031, which was higher than the t-table value of 1.833. The significance value was 0.000, or  $p < 0.05$ . Therefore, the null hypothesis was rejected and the alternative hypothesis was accepted. This means that dumbbell overhead training had a significant effect on badminton smash ability among students of SMKN 6 Makassar. The mean improvement of 6.10 points shows that the treatment provided a strong positive contribution to students' smash performance. Empirically, the students were able to produce better smash results after participating in the dumbbell overhead training program.

### Effect of Regular Training in the Control Group

**Table 5.** Paired Sample t-Test of the Control Group

| Group         | Test      | Mean  | Mean Difference | t-count | df | Sig. (2-tailed) | t-table | Interpretation |
|---------------|-----------|-------|-----------------|---------|----|-----------------|---------|----------------|
| Control Group | Post-test | 12.90 | 2.20            | 7.571   | 9  | 0.000           | 1.833   | Significant    |
|               | Pre-test  | 10.70 |                 |         |    |                 |         |                |

The paired sample t-test for the control group also showed a significant difference between the pre-test and post-test scores. The t-count value was 7.571, which was higher than the t-table value of 1.833, with a significance value of 0.000, or  $p < 0.05$ . This result indicates that the control group also experienced improvement in smash ability. However, the mean improvement was only 2.20 points, which was lower than the improvement achieved by the experimental group. This suggests that regular badminton activities can improve students' smash ability, but the improvement is not as large as that produced by dumbbell overhead training.

### Difference Between the Experimental Group and the Control Group

**Table 6.** Independent Sample t-Test of Post-test Scores

| Test      | Group          | Mean  | Mean Difference | t-count | df | Sig. (2-tailed) | t-table | Interpretation |
|-----------|----------------|-------|-----------------|---------|----|-----------------|---------|----------------|
| Post-test | Dumbbell       |       |                 |         |    |                 |         |                |
|           | Overhead       | 16.80 | 3.90            | 3.847   | 18 | 0.000           | 2.093   | Significant    |
|           | Training Group |       |                 |         |    |                 |         |                |
|           | Control Group  | 12.90 |                 |         |    |                 |         |                |

The independent sample t-test showed that there was a significant difference between the post-test scores of the experimental group and the control group. The t-count value was 3.847, which was higher than

the t-table value of 2.093, with a significance value of 0.000, or  $p < 0.05$ . This result confirms that dumbbell overhead training produced a significantly greater effect than regular training without specific dumbbell overhead exercises. The mean post-test score of the experimental group was 16.80, while the control group obtained a mean score of 12.90, with a mean difference of 3.90 points.

### Summary of Findings

Based on the descriptive and inferential statistical analysis, the results demonstrate that dumbbell overhead training significantly improved badminton smash ability among students of SMKN 6 Makassar. The experimental group showed a greater mean improvement than the control group, indicating that specific upper-limb resistance training is more effective than regular training alone. Conceptually, dumbbell overhead training strengthens the shoulder, arm, and upper-body muscles involved in overhead stroke execution. Empirically, this was reflected in the increase of the experimental group's mean score from 10.70 to 16.80. Therefore, the findings support the conclusion that dumbbell overhead training is an effective training method for improving smash ability in badminton among students.

### Discussion

The findings of this study demonstrate that dumbbell overhead training had a significant effect on badminton smash ability among students of SMKN 6 Makassar. The experimental group showed an increase in mean score from 10.70 in the pre-test to 16.80 in the post-test, with a mean difference of 6.10 points. The paired sample t-test showed that the improvement was statistically significant, with  $t\text{-count} = 22.031$ ,  $df = 9$ , and  $p = 0.000 < 0.05$ . In comparison, the control group also improved from 10.70 to 12.90, with a smaller mean difference of 2.20 points. The independent sample t-test further confirmed that the post-test result of the experimental group was significantly higher than that of the control group, with  $t\text{-count} = 3.847$ ,  $df = 18$ , and  $p = 0.000 < 0.05$ . These results indicate that dumbbell overhead training produced a stronger training effect than regular badminton practice without specific upper-limb resistance training.

Conceptually, the improvement in the experimental group can be explained through the principle of specificity in sports training. The badminton smash is an overhead attacking stroke that requires the integration of shoulder strength, elbow extension, forearm acceleration, wrist control, trunk stability, and racket-head speed. Therefore, an exercise that strengthens the upper limbs through an overhead movement pattern is highly relevant to the mechanical demands of the smash. This interpretation is supported by recent biomechanical studies showing that smash performance is influenced by body angle, trunk rotation, racket speed, upper-limb coordination, and muscle activation patterns during overhead hitting actions (Artazila & Adi, 2024; Dong et al., 2024; Pan et al., 2024; Rusdiana et al., 2023). In this context, dumbbell overhead training does not only improve arm strength but also supports the neuromuscular coordination needed to generate force in an overhead stroke.

The empirical result of this study is also consistent with current evidence in badminton training. Ma et al. (2025) reported that structured physical training programs, including strength and resistance training, contribute to improvements in agility, power, balance, and badminton performance. Wang et al. (2025) also emphasized that resistance training is important for improving physical performance and sport-specific skills in competitive badminton players. Specific to smash ability, Hamid et al. (2025) found that arm muscle strength training significantly improved badminton smash performance in young athletes, while Ishak et al. (2024) reported that dumbbell training and rubber weight training had a positive effect on badminton smash shots. These findings strengthen the argument that upper-limb resistance training is an important component in developing offensive stroke quality in badminton.

The greater improvement in the experimental group may also be related to the physiological adaptation caused by repeated resistance loading. Dumbbell overhead training provides external resistance to the shoulder, triceps, deltoid, upper back, and stabilizing muscles involved in arm elevation and extension. When performed systematically, this type of exercise can increase muscular strength, power output, joint stability, and motor unit recruitment. Such adaptation is highly beneficial for students because badminton smash performance requires rapid force production in a short movement time. This explanation is in line with youth resistance training literature, which states that properly designed and supervised resistance training can improve muscular strength, power, motor performance, and sport-specific ability in children and adolescents (Chaabene et al., 2020; França et al., 2023; Granacher et al., 2016; León-Reyes et al., 2025; McQuilliam et al.,

2020; Moreno-Torres et al., 2025). Thus, the use of dumbbells in this study can be considered safe and effective as long as the load, repetitions, technique, and supervision are adjusted to students' physical capacity.

The control group also showed a significant improvement, although the increase was smaller than that of the experimental group. This finding indicates that regular badminton practice can still improve smash ability because students repeatedly perform technical movements such as footwork, body positioning, timing, and racket swing. Repetition in sport skills can improve motor learning, movement familiarity, and confidence in executing the stroke. However, the smaller increase of 2.20 points suggests that technical practice without specific strength stimulus may not be sufficient to produce optimal smash improvement. This supports the view that badminton performance is multidimensional and requires the combination of technical training, physical conditioning, coordination, reaction ability, and tactical understanding (Abiwan et al., 2024; Cádiz Gallardo et al., 2023; Green et al., 2023; Hu et al., 2025; Phomsoupha & Laffaye, 2020; Sonoda et al., 2018). Therefore, regular practice needs to be strengthened with targeted conditioning exercises if the training objective is to improve powerful offensive strokes.

The difference between the experimental and control groups provides an important practical implication. The experimental group's post-test mean score was 16.80, while the control group only reached 12.90, producing a mean difference of 3.90 points. This shows that dumbbell overhead training was more effective in improving smash ability than training without dumbbell overhead exercises. In badminton, a powerful smash is not produced only by racket technique but also by the ability of the upper limbs to transfer force efficiently through the kinetic chain. Studies on smash accuracy and upper-limb function have shown that shoulder and wrist flexibility, hand muscle strength, arm power, and movement control are related to smash quality (Abiwan et al., 2024; Artazila & Adi, 2024; Dong et al., 2024; Hamid et al., 2025; Kamaruddin et al., 2025; Santoso et al., 2025). Therefore, dumbbell overhead training can be recommended as a practical school-based intervention to support badminton skill development.

From an educational and coaching perspective, the results of this study are meaningful because SMKN 6 Makassar students are not elite athletes but school learners who require simple, applicable, and measurable training methods. Dumbbell overhead training is relatively easy to implement in extracurricular badminton programs because it does not require expensive equipment, large training space, or complex technology. Teachers and coaches can integrate this exercise into warm-up conditioning, circuit training, or specific strength sessions. However, the training must still follow progressive overload, correct posture, controlled movement, and sufficient recovery to prevent technical errors and overuse injuries (Creswell & Creswell, 2018; Faigenbaum et al., 2016; Lloyd et al., 2016; Suchomel et al., 2018; Sugiyono, 2019).

Overall, this study confirms that dumbbell overhead training significantly improves badminton smash ability among students of SMKN 6 Makassar. The empirical evidence shows that students who received dumbbell overhead training achieved greater improvement than students in the control group. Conceptually, this improvement occurred because the exercise strengthened the arm and shoulder muscles involved in overhead striking movements. Practically, the findings suggest that physical education teachers and badminton coaches should not rely only on technical repetition but also integrate specific upper-limb resistance training to optimize smash performance. Therefore, dumbbell overhead training can be considered an effective, efficient, and applicable training method for improving badminton smash ability in school-based sports programs.

## CONCLUSION

Based on the results of the study, it can be concluded that dumbbell overhead training has a significant effect on badminton smash ability among students of SMKN 6 Makassar. Empirically, the experimental group showed a substantial improvement from the pre-test mean score of 10.70 to the post-test mean score of 16.80, with a mean difference of 6.10 points. The paired sample t-test result showed that the t-count value was 22.031 with a significance value of  $0.000 < 0.05$ , indicating that the improvement was statistically significant. This means that the application of dumbbell overhead training was effective in improving students' ability to perform badminton smash strokes.

The control group also showed an increase from 10.70 to 12.90, with a mean difference of 2.20 points. However, this improvement was lower than that of the experimental group. The independent sample t-test further confirmed that there was a significant difference between the post-test results of the experimental group and the control group, with t-count = 3.847 and  $p = 0.000 < 0.05$ . This finding indicates that dumbbell overhead training produced a greater effect than regular training without specific upper-limb resistance exercises.

Conceptually, the improvement occurred because dumbbell overhead training strengthens the shoulder, arm, and upper-body muscles that support overhead stroke execution. In badminton, the smash requires explosive arm movement, shoulder stability, wrist control, and coordinated force transfer. Therefore, dumbbell overhead training can be recommended as an effective, practical, and school-applicable training method to improve badminton smash ability among students.

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