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Systematic Literature Review: Population Density Mapping Using Data Mining

M. Risky Novji Tiara & Tjung Hauw Sin
Padang State University, Indonesia
riskyandry5@gmai.com

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Abstract

Badminton smash accuracy is an important concern in athlete training because the smash is one of the most decisive attacking techniques for gaining points during a match. However, limited research has examined the use of fixed target and moving target training methods to improve smash performance among young athletes at PB Muda Mandiri. This study aims to analyze the effect of fixed target and moving target training methods on badminton smash performance. A quantitative approach was employed using a quasi-experimental design, involving 10 male badminton athletes selected through purposive sampling from a total population of 25 athletes at PB Muda Mandiri. Data were collected using a badminton smash performance test and analyzed through the Lilliefors normality test and t-test at a significance level of $\alpha = 0.05$. The findings indicate that fixed target and moving target training methods significantly improved badminton smash performance. The average pre-test score was 12, while the average post-test score increased to 20 after the treatment. Hypothesis testing showed that t-count = 4.57 was higher than t-table = 1.833, indicating that the null hypothesis was rejected and the alternative hypothesis was accepted. The study concludes that fixed target and moving target training methods play an important role in enhancing badminton

smash performance. These findings contribute to the development of badminton training methods by demonstrating the effectiveness of structured target-based exercises in improving smash accuracy. Practically, the study recommends that coaches integrate fixed target and moving target exercises into technical training programs, while future research should involve larger samples, control groups, and additional performance indicators such as smash speed, power, and match effectiveness.

Keywords: Badminton Training; Fixed Target Training; Moving Target Training; Smash Accuracy; Smash Performance

INTRODUCTION

Sport has become an important part of modern social life because it is no longer understood merely as a recreational activity, but also as a medium for health development, education, character building, and achievement (Atalay et al., 2024; Hedenborg et al., 2024; Siedentop & Van der Mars, 2022). At the international level, sport development continues to move toward more systematic coaching, scientific training, and measurable performance evaluation (Babayev et al., 2025; Cunningham et al., 2022; Lara-Bercial et al., 2022). Badminton is one of the sports that has experienced this development. The game is played by hitting the shuttlecock over the net using a racket, either in singles or doubles, with the aim of placing the shuttlecock in the opponent's court and preventing it from falling in one's own area . The international standardization of badminton can also be seen in the official rules, court dimensions, and competition regulations established by the Badminton World Federation (Bantekas, 2023; SORIANO & Dolendo, 2024). This indicates that badminton is not only a popular sport, but also a competitive sport that requires technical mastery, physical readiness, tactical intelligence, and continuous training.

In Indonesia, badminton has a strong historical and social position because this sport has contributed significantly to national sporting achievements (Ma'mun et al., 2022; Walidiandri & Nurrachmad, 2024). The development of sport in Indonesia is also supported by a legal foundation through Law Number 11 of 2022 concerning Sports, which regulates sport development, sport management, infrastructure, coaching, competition, funding, and the use of sport science and technology (Republic of Indonesia, 2022). This regulation shows that sports achievement should be developed through planned, gradual, sustainable, and scientifically based coaching. Therefore, badminton

coaching at the club level needs serious attention because clubs are the earliest environment where young athletes build basic skills, training discipline, competitive mentality, and long-term achievement orientation.

Badminton performance is strongly influenced by mastery of basic techniques. Several basic techniques that players need to master include grip, footwork, body position, service, return service, overhead stroke, smash, dropshot, and netting (Luo, 2022). Among these techniques, the smash is one of the most decisive attacking strokes because it is performed with speed, power, accuracy, and a downward trajectory toward the opponent's court. A smash that is powerful but inaccurate will not give an advantage to the player; instead, it may result in an error and give points to the opponent. For this reason, smash training should not only emphasize strength and speed, but also the accuracy of directing the shuttlecock to specific target areas.

The researcher views this issue as an important problem in badminton coaching because technical errors in smash execution often occur not because athletes lack effort, but because the training method does not sufficiently guide them to control direction, timing, and target placement. In training theory, a program must be arranged systematically so that the athlete's physical, technical, tactical, and mental components develop in a balanced way (Supriatna et al., 2023). Physical condition is also an inseparable component in sports performance because strength, endurance, speed, flexibility, explosive power, and balance support the implementation of technical skills during training and competition (Acevedo & Zeigler, 2025). However, physical training alone is not enough if its is not accompanied by specific technical training that directly addresses the athlete's weaknesses.

A good training program should be clear, measurable, and adjusted to the needs of athletes. Fajar et al. (2022) explain that a training program functions as a written guideline that directs what must be achieved during the training process. In badminton, this means that coaches need to design exercises that are not monotonous, but still focused on improving specific skills. Variation in training is needed so that athletes do not feel bored and remain motivated during the training process. Motivation is also an important psychological factor because it encourages athletes to train seriously, maintain discipline, and pursue achievement goals (MAWARDI et al., 2023). Thus, training methods that are varied, targeted, and relevant to real match situations are needed to improve smash quality.

From the perspective of motor learning, repeated practice with clear targets can help athletes build movement consistency, while variable practice can help athletes adapt to changing situations during competition. Schmidt et al. (2019) state that motor skills develop through practice and experience that produce relatively permanent changes in performance. In this context, fixed target training can help athletes improve consistency because the shuttlecock is directed repeatedly to the same target area. Meanwhile, moving target training can provide a more dynamic stimulus because athletes must adjust their timing, direction, and movement control according to changing target positions. Both methods are relevant to badminton because players are required to hit accurately not only in stable situations, but also in unpredictable match conditions.

Previous studies have shown that target-based and drill-based exercises can improve smash accuracy in badminton. Hadi et al. (2026) found that drill training methods consistently contributed to improving smash accuracy among badminton athletes. Rizal et al. (2026) also reported that target media had a significant effect on improving the accuracy of badminton smash shots. More specifically, Masail et al. (2025) examined fixed and moving target drilling methods among badminton players aged 14–16 years and found that these methods were relevant for improving smash performance. These studies indicate that target-oriented training has strong potential in badminton coaching. However, the gap remains in the limited application of fixed target and moving target training in specific local club contexts, especially in PB Muda Mandiri, where the athletes' smash accuracy still needs to be improved through a structured experimental approach.

Based on observations and interviews with the coach of PB Muda Mandiri, several athletes still experience difficulties in performing accurate smash shots. Many smashes are not directed properly, often going too wide to the right or left side of the court. This condition makes the smash, which should function as an attacking weapon to gain points, become a source of errors that benefits the opponent. The training pattern at PB Muda Mandiri has also tended to emphasize physical exercises and game play, while specific smash accuracy training has not received enough attention. The club has 25 young athletes aged 12–15 years, consisting of 20 male athletes and 5 female athletes. Although PB Muda Mandiri has participated in several tournaments in the last five years, the club has not yet achieved first place, with its best achievements being third place and second place in 2018. This situation shows the need for a more focused training method to improve athletes' smash performance.

The novelty of this study lies in its effort to compare fixed target and moving target training methods in improving badminton smash performance among PB Muda Mandiri athletes. This study is expected to provide practical evidence for coaches in selecting training methods that are more appropriate for young badminton athletes. The focus of this research is to determine the effect of fixed target and moving target training methods on badminton smash performance at PB Muda Mandiri. Through this research, it is expected that the training process can become more directed, varied, and relevant to the actual needs of athletes in improving smash accuracy and supporting better competitive achievement.

METHODS

This study used a quantitative approach with a quasi-experimental method. A quantitative approach was chosen because the study aimed to measure the effect of fixed target and moving target training methods on badminton smash performance through numerical data obtained from pretest and posttest scores. Quantitative research is appropriate when researchers seek to test relationships, differences, or effects between variables using measurable data and statistical procedures (Creswell & Creswell, 2018). The research design applied in this study was a one-group pretest-posttest design, in which the same participants were measured before and after receiving treatment. This design was considered relevant because the researcher intended to identify changes in athletes' smash performance after being given fixed target and moving target training. The treatment was conducted in 16 training sessions, with one initial test and one final test. Training was carried out three times a week at the PB Muda Mandiri badminton court, starting at 15.00 WIB. This design differs from several previous badminton training studies that commonly compared separate experimental groups, whereas this study focused on observing the improvement of the same athletes after receiving structured target-based smash training.

The population of this study consisted of 25 badminton athletes at PB Muda Mandiri, including 20 male athletes and 5 female athletes. The sample was selected using purposive sampling, resulting in 10 male athletes who met the research criteria. Purposive sampling was used because the researcher selected participants based on specific considerations relevant to the research objectives, as this technique allows researchers to choose samples that are considered most suitable for the study focus (Sugiyono, 2019). The data were collected using a badminton smash accuracy test adapted from the smash

accuracy test procedure by Saleh Anasir (2010). The test aimed to measure the accuracy of athletes' smash shots by asking each participant to perform 20 smash attempts toward predetermined target areas on the opponent's court. The score ranged from 0 to 5, depending on the shuttlecock landing area. Before the treatment, participants completed a pretest to determine their initial smash performance. After completing 16 training sessions using fixed target and moving target exercises, participants took a posttest using the same test procedure. The data were analyzed using descriptive statistics and a dependent sample t-test to determine whether there was a significant difference between pretest and posttest scores. This analysis was appropriate because the study compared two related measurements from the same participants before and after treatment.

RESULTS

1. Descriptive Statistics of Badminton Smash Performance

The results of this study describe the effect of fixed target and moving target training methods on badminton smash performance among athletes at PB Muda Mandiri. The data were obtained through a pre-test and post-test using a badminton smash accuracy test. The pre-test was conducted before the athletes received the treatment, while the post-test was conducted after 16 training sessions. The descriptive statistics of the pre-test and post-test scores are presented in Table 1.

Table 1. Descriptive Statistics of Pre-Test and Post-Test Smash Performance

Test	Minimum Score	Maximum Score	Mean	Standard Deviation
Pre-test	4	20	12	5.34
Post-test	10	26	20	6.03

Based on Table 1, the pre-test results showed that the lowest score was 4, the highest score was 20, the mean score was 12, and the standard deviation was 5.34. After the athletes received fixed target and moving target training for 16 sessions, the post-test results increased, with the lowest score of 10, the highest score of 26, the mean score of 20, and the standard deviation of 6.03. These results indicate an improvement in badminton smash performance after the treatment was given.

2. Pre-Test Results of Badminton Smash Performance

The frequency distribution of the pre-test scores is presented in Table 2. The data show the initial ability of athletes before they received the fixed target and moving target training methods.

Table 2. Frequency Distribution of Pre-Test Smash Performance

Class Interval	Absolute Frequency	Relative Frequency (%)	Category
>26	0	0	Very Good
19–25	1	10	Good
12–18	4	40	Moderate
6–11	4	40	Poor
<5	1	10	Very Poor
Total	10	100	

Based on Table 2, one athlete, or 10%, was in the good category with a score interval of 19–25. Four athletes, or 40%, were in the moderate category with a score interval of 12–18. Four athletes, or 40%, were in the poor category with a score interval of 6–11. Meanwhile, one athlete, or 10%, was in the very poor category with a score interval below 5. These findings indicate that before the treatment, most athletes were still in the moderate and poor categories in terms of badminton smash performance.

The distribution of the pre-test scores is also illustrated in Figure 1.

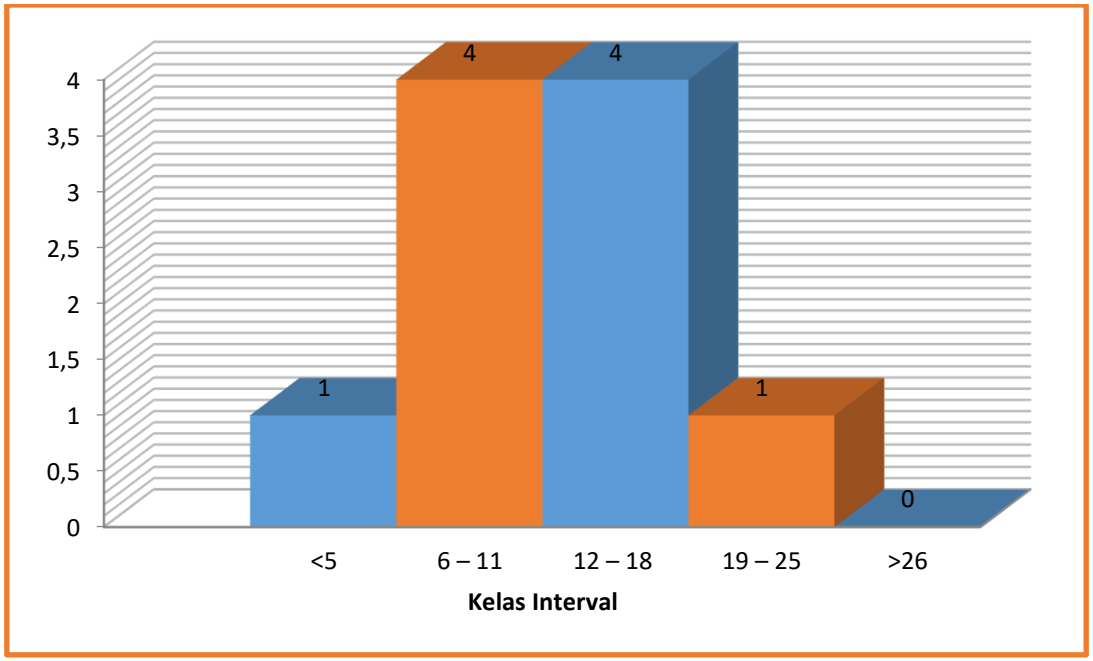

Figure 1. Histogram of Pre-Test Smash Performance

3. Post-Test Results of Badminton Smash Performance

The frequency distribution of the post-test scores is presented in Table 3. The post-test was conducted after the athletes completed 16 training sessions using fixed target and moving target training methods.

Table 3. Frequency Distribution of Post-Test Smash Performance

Class Interval	Absolute Frequency	Relative Frequency (%)	Category
≥26	1	10	Very Good
19–25	5	50	Good
12–18	2	20	Moderate
6–11	2	20	Poor
<5	0	0	Very Poor
Total	10	100	

Based on Table 3, one athlete, or 10%, reached the very good category with a score of 26 or above. Five athletes, or 50%, were in the good category with a score interval of 19–25. Two athletes, or 20%, were in the moderate category with a score interval of 12–18. Two athletes, or 20%, were in the poor category with a score interval of 6–11. No athlete was found in the very poor category. These results show that the athletes' smash performance improved after receiving the fixed target and moving target training methods.

The distribution of the post-test scores is also illustrated in Figure 2.

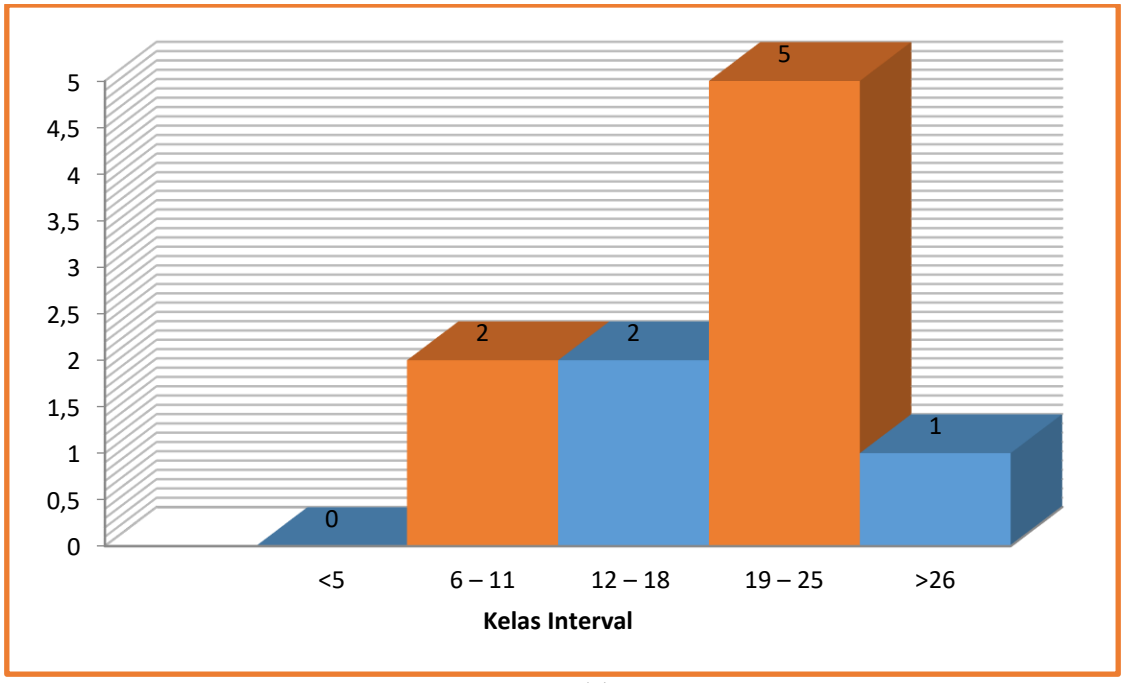

Figure 2. Histogram of Post-Test Smash Performance

4. **Normality Test**

Before conducting the hypothesis test, a normality test was performed to determine whether the pre-test and post-test data were normally distributed. The normality test was conducted using the Lilliefors test at a significance level of 0.05. The results are presented in Table 4.

Table 4. Summary of Normality Test Results

Variable	Group	Lcount	Ltable	Description
Fixed target and moving target training methods on badminton smash performance	Pre-test	0.1673	0.258	Normal
Fixed target and moving target training methods on badminton smash performance	Post-test	0.1515	0.258	Normal

Based on Table 4, the Lcount value of the pre-test was 0.1673, while the Ltable value was 0.258. The Lcount value of the post-test was 0.1515, while the Ltable value was 0.258. Since both Lcount values were lower than Ltable, it can be concluded that the pre-test and post-test data were normally distributed.

5. Homogeneity Test

A homogeneity test was conducted to determine whether the pre-test and post-test data had homogeneous variance. The results of the homogeneity test are presented in Table 5.

Table 5. Summary of Homogeneity Test Results

Variable	Fcount	Ftable	Description
Fixed target and moving target training methods on badminton smash performance	1.28	3.18	Homogeneous

Based on Table 5, the Fcount value was 1.28, while the Ftable value was 3.18. Since Fcount was lower than Ftable, it can be concluded that the pre-test and post-test data were homogeneous. Therefore, the data met the requirements for further hypothesis testing.

6. Hypothesis Testing

The hypothesis was tested using a dependent sample t-test at a significance level of 0.05. The test was conducted to determine whether there was a significant effect of fixed target and moving target training methods on badminton smash performance. The summary of the hypothesis testing results is presented in Table 6.

Table 6. Summary of Hypothesis Testing Results

Smash Performance Test	Mean	Standard Deviation	tcount	ttable	Test Result	Description
Pre-test	12	5.34	4.57	1.833	Significant	Ha accepted
Post-test	20	6.03				

Based on Table 6, the mean score of the pre-test was 12 with a standard deviation of 5.34, while the mean score of the post-test increased to 20 with a standard deviation of 6.03. The t-test result showed that the tcount value was 4.57, which was higher than the ttable value of 1.833. This means that the alternative hypothesis was accepted. Therefore, it

can be concluded that fixed target and moving target training methods had a significant effect on badminton smash performance among athletes at PB Muda Mandiri.

DISCUSSION

The findings of this study show that fixed target and moving target training methods had a significant effect on badminton smash performance among athletes at PB Muda Mandiri. The training was conducted three times a week for 16 sessions, with one pre-test and one post-test to measure changes in athletes' smash ability. The pre-test was used to identify the athletes' initial performance before treatment, while the post-test was used to determine the improvement after the training program was completed. The results showed that the mean score increased from 12 in the pre-test to 20 in the post-test. The hypothesis testing also showed that the tcount value was higher than the ttable value, namely 4.57 > 1.833. This result indicates that the proposed hypothesis was accepted, meaning that fixed target and moving target training significantly improved badminton smash performance.

The improvement occurred because both training methods gave athletes repeated opportunities to direct the shuttlecock toward specific target areas (Sun et al., 2025). Fixed target training helped athletes build consistency because they were required to hit the shuttlecock repeatedly toward a stable and predetermined target. This type of exercise is useful for strengthening movement memory, improving stroke control, and developing accuracy in a more focused situation. Hsu et al. (2024) explains that fixed target training is a hitting process in which the ball or shuttlecock is directed toward a specific target in one stage, with the direction remaining stable. In this study, the fixed target method helped athletes become more familiar with target placement, body position, and racket control when performing a smash.

Moving target training also contributed to the improvement of smash performance because it created a more dynamic training situation (Masail et al., 2025). Unlike fixed target training, moving target training requires athletes to adjust their direction, timing, and hitting control according to changing target positions. Hidayat et al. (2022) state that moving target training is a hitting process that directs the ball or shuttlecock to several different targets in one stage, usually starting from one side, moving to the center, and then to the other side. This pattern is highly relevant to badminton because real match situations are

rarely static. Players must be able to respond quickly to changing shuttlecock directions and place their smash accurately in open spaces. Therefore, moving target training helped athletes improve not only accuracy, but also adaptability during attacking situations.

The results of this study are in line with the principle of motor learning, which states that repeated and structured practice can improve movement skills and performance consistency. In badminton, a smash does not only depend on arm strength, but also on coordination, timing, body position, footwork, and accuracy. A strong smash without proper direction may become an error and give points to the opponent. Through fixed target and moving target training, athletes were trained to combine power and accuracy. This finding also supports the idea that technical training should be designed specifically according to the athletes' weaknesses. The problem found at PB Muda Mandiri was that several athletes often performed smashes that went too wide to the right or left side of the court, causing the smash to become less effective as an attacking technique. This condition confirms the importance of target-based training in improving smash quality.

These findings are also consistent with previous studies showing that target-oriented and drill-based exercises can improve badminton smash accuracy. Training with clear target areas allows athletes to evaluate the direction and quality of each stroke more easily. Compared with ordinary game-based practice, target-based training gives a more specific stimulus because athletes are not only asked to hit hard, but also to place the shuttlecock accurately. In the context of this study, the combination of fixed and moving targets provided two complementary benefits. Fixed targets strengthened consistency, while moving targets developed flexibility and response to changing situations. This combination makes the training program more meaningful for young athletes who still need strong technical foundations.

The practical implication of this study is that badminton coaches, especially at the club level, can use fixed target and moving target training as an alternative method to improve smash performance. Coaches should not rely only on physical training and match play, because technical weaknesses such as smash accuracy require specific and measurable exercises. Theoretically, this study strengthens the view that skill improvement in badminton is influenced by structured repetition, target clarity, and variation in practice. A training program that combines stable and dynamic targets can help athletes develop better technical control and prepare them for more realistic match situations.

However, this study has several limitations. First, the sample size was relatively small, involving only 10 male athletes from PB Muda Mandiri, so the results cannot be generalized to all badminton athletes. Second, this study used a one-group pre-test and post-test design without a control group, so other factors outside the treatment, such as additional practice, motivation, physical condition, rest, or nutrition, may also have influenced the results. Third, the measurement focused only on smash accuracy and did not examine other important aspects such as smash speed, power, biomechanics, or decision-making during actual matches. Therefore, future studies are recommended to involve a larger sample, include male and female athletes, use a control group, and measure more complete aspects of smash performance so that the effectiveness of fixed target and moving target training can be examined more comprehensively.

CONCLUSION

This study concludes that fixed target and moving target training methods had a significant effect on improving badminton smash performance among athletes at PB Muda Mandiri. The improvement can be seen from the increase in the average score from 12 in the pre-test to 20 in the post-test after the athletes completed 16 training sessions. The results of the hypothesis test also showed that the tcount value was higher than the ttable value, namely 4.57 > 1.833. Therefore, the null hypothesis was rejected, while the alternative hypothesis was accepted. This means that the training methods applied in this study were effective in improving the athletes' badminton smash performance.

The findings indicate that fixed target training helped athletes improve smash accuracy by directing the shuttlecock repeatedly toward a stable target, while moving target training trained athletes to adjust their smash direction toward changing targets. The combination of these two methods provided more varied, focused, and practical training experiences for young badminton athletes. These results provide practical information for coaches that target-based training can be used as an alternative method to improve smash quality, especially in terms of accuracy and consistency. Future research is recommended to involve a larger number of athletes, include a control group, and examine other aspects of smash performance such as speed, power, footwork, and effectiveness in real match situations.

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