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Effectiveness of a Modified Plyometric Training Model in Improving Ushiro Mawashi Geri Skill Among Adolescent Karate Athletes Aged 15–17 Years

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Abstract

This study aimed to develop and examine the effectiveness of a modified plyometric training model in improving ushiro mawashi geri skill among adolescent karate athletes aged 15–17 years. The study employed a Research and Development (R&D) approach using the ADDIE development model, consisting of the phases of analysis, design, development, implementation, and evaluation. The participants were 45 adolescent karate athletes aged 15–17 years who were actively involved in a training program at INKANAS Central Jakarta Branch. The developed product was a modified plyometric training model designed based on the biomechanical characteristics of the ushiro mawashi geri technique and validated by karate experts, measurement and evaluation experts, and training model experts. Data were collected through ushiro mawashi geri skill assessments administered before (pre-test) and after (post-test) a six-session training intervention. The results indicated that the mean ushiro mawashi geri skill score increased from 28.24 (39%) in the pre-test to 66.84 (93%) in the post-test. The normality test revealed that the data were normally distributed ($p > 0.05$), while the homogeneity test indicated homogeneous variance ($p = 0.661$). Furthermore, the Paired Sample t-Test demonstrated a significant difference between pre-test and post-test scores ($t = -59.298$; $p < 0.05$). The N-Gain analysis yielded an average score of 87.76%, which was categorized as highly effective. These findings indicate that the modified plyometric training model was effective in enhancing ushiro mawashi geri skill among adolescent karate athletes. Therefore, the developed training model is considered feasible for implementation as an alternative training program and may serve as a practical guideline for karate coaches in improving ushiro mawashi geri kicking performance among athletes aged 15–17 years.

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INTRODUCTION

Karate competition requires athletes to possess well-developed technical, physical, and psychological attributes to achieve optimal performance (Przybylski et al., 2021). In kumite, where two athletes compete directly against one another, effective offensive and defensive capabilities are essential determinants of success (Vuković et al., 2022). Among the various scoring techniques, kicking actions are frequently employed due to their high scoring potential under the official competition rules (Vagner et al., 2023). The effectiveness of kicking performance is largely influenced by the athlete's level of motor skill proficiency and movement efficiency (Ritter et al., 2022). Consequently, mastery of kicking techniques is considered a fundamental factor contributing to competitive achievement in karate (Błaszczyszyn et al., 2019).

One of the most technically demanding kicking techniques in karate is the ushiro mawashi geri (Septri et al., 2025). This technique involves a backward rotational movement followed by a rapid swinging action of the lower limb toward the target, making the attack difficult for opponents to anticipate (Vagner et al., 2023; Makaruk et al., 2020). In kumite competition, ushiro mawashi geri is commonly executed as a head-level attack and has the potential to generate high-scoring opportunities (Irawan et al., 2021; Bahtiar et al., 2023). Successful execution of this technique requires a high level of movement coordination to ensure speed, accuracy, and control throughout the kicking motion (Suswanti et al., 2025). Inadequate technical execution may compromise balance and reduce the effectiveness of the attack (Rahmatilah et al., 2026).

The performance of ushiro mawashi geri is influenced not only by technical proficiency but also by the athlete's physical condition (Chen et al., 2026). Several physical components play a critical role in executing the technique effectively, including lower-limb explosive power, balance, coordination, flexibility, and movement speed (Ilyas et al., 2026). Lower-limb explosive power is particularly important because kicking actions require the rapid generation of force within a very short period of time (McClung et al., 2022). Athletes with greater explosive capabilities are generally able to produce faster and more powerful kicks (Li et al., 2019). Furthermore, adequate coordination and balance contribute to maintaining postural control during rotational movements (Fiechter et al., 2025). Therefore, the development of sport-specific physical capacities is essential for enhancing ushiro mawashi geri performance (Gaweł et al., 2025).

Plyometric training has been widely recognized as an effective method for improving explosive performance capabilities (Ramirez-Campillo et al., 2023). This training approach utilizes the stretch–shortening cycle mechanism, enabling muscles to generate force more rapidly and efficiently (Deng et al., 2023). Previous studies have demonstrated that plyometric training can significantly improve muscular power, movement speed, and overall athletic performance (Yuan et al., 2025). However, many existing plyometric training programs remain general in nature and are not specifically designed to address the biomechanical demands of ushiro mawashi geri (Terbalyan et al., 2025). As a result, there is a need for training modifications that integrate the technical characteristics of kicking movements with established plyometric principles. A modified plyometric training model may provide a more specific training stimulus for karate athletes, as training adaptations tend to be greater when exercise characteristics closely match sport-specific performance requirements (Hariri & Sadeghi, 2018).

Within karate coaching practice, training programs often emphasize technical mastery while providing limited attention to the development of sport-specific physical capacities (Güler & Ramazanoglu, 2018). Such an approach may restrict the optimal development of kicking performance (Molinaro et al., 2020). Existing studies examining plyometric interventions in combat sports have predominantly focused on general improvements in explosive power and movement speed (Ioannides et al., 2020). Research specifically investigating the application of a modified plyometric training model to enhance ushiro mawashi geri skill in adolescent karate athletes remains limited (Yuan et al., 2025). This issue is particularly relevant because athletes aged 15–17 years experience substantial physical and neuromuscular development, creating an important window for performance enhancement (Parry et al., 2024). The scarcity of sport specific research highlights the need to develop and evaluate training models that are directly aligned with the technical demands of the skill being trained.

To address these limitations, a training model capable of simultaneously enhancing physical capacities and technical execution of ushiro mawashi geri is required. The modified plyometric training model is expected to provide an effective alternative approach for improving kicking skill among adolescent karate athletes. In addition to enhancing lower-limb explosive power, the model is designed to support the development of coordination, balance, and movement quality during kicking actions. Evaluating the effectiveness of the proposed training model is therefore essential to determine its practical value within athlete development programs. The findings of this study are expected to provide evidence-based guidance for coaches in designing more specific and athlete-centered training programs aimed at improving ushiro mawashi geri performance.

METHODS

This study employed a Research and Development (R&D) approach using the ADDIE instructional design model, which consists of five phases: analysis, design, development, implementation, and evaluation. During the analysis phase, a needs assessment was conducted through field observations and interviews with karate coaches to identify issues related to ushiro mawashi geri skill among karate athletes aged 15–17 years. The design phase involved developing a modified plyometric training model tailored to the biomechanical characteristics of the ushiro mawashi geri technique and the training requirements of adolescent athletes. Subsequently, the development phase focused on constructing the training model and conducting expert validation involving karate specialists, measurement and evaluation experts, and training model experts to assess the feasibility and appropriateness of the developed product. After the training model was deemed feasible, the implementation phase was carried out by applying the modified plyometric training program to adolescent karate athletes over six training sessions conducted across a three-week period, with a frequency of two sessions per week. The evaluation phase aimed to determine the effectiveness of the training model by comparing ushiro mawashi geri skill performance between the pre-test and post-test assessments. The ADDIE model was selected because it provides a systematic framework for developing, validating, and evaluating the effectiveness of training products in sports settings.

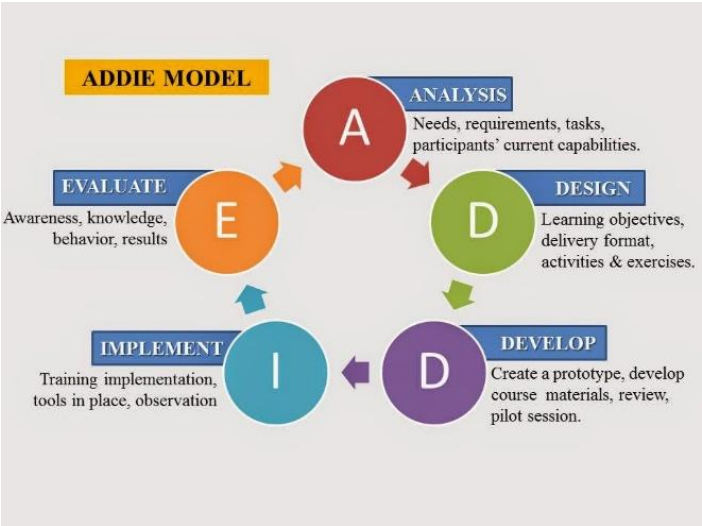


Figure 1. Desain ADDIE

The effectiveness of the developed training model was evaluated using a One-Group Pre-test–Posttest Design. The first session was devoted to the administration of a pre-test to assess athletes' *ushiro mawashi geri* skill. This was followed by four intervention sessions employing the modified plyometric training model, while the final session consisted of a post-test conducted to evaluate changes in kicking performance following completion of the training program.

The study was conducted from April to May 2026 at the INKANAS Central Jakarta Branch training facility. The participants consisted of 45 adolescent karate athletes aged 15–17 years who were actively involved in the club's regular training program. Participants were selected through purposive sampling based on age, training experience, and willingness to complete all stages of the study. Following expert validation and confirmation of the training model's feasibility, the program was implemented over six sessions, comprising one pre-test session, four intervention sessions, and one post-test session.

Data were collected using an *ushiro mawashi geri* skill assessment instrument that had undergone expert validation. Performance evaluation was based on several technical criteria, including starting position, kicking execution phase, movement accuracy, balance control, and finishing position. Research data were obtained from the results of the pre-test conducted prior to the intervention and the post-test administered after completion of the training program.

Data analysis was performed using both descriptive and inferential statistics. Descriptive statistics were used to summarize the mean scores and percentage values of *ushiro mawashi geri* performance before and after the intervention. Prior to hypothesis testing, normality and homogeneity tests were conducted to ensure that the data met the assumptions required for parametric analysis. All statistical analyses were performed using SPSS version 26. The effectiveness of the modified plyometric training model was examined using a Paired Samples t-test with a significance level set at $p < 0.05$.

RESULTS AND DISCUSSION

Prior to implementation, the modified plyometric training model underwent expert validation involving karate specialists, measurement and evaluation experts, and training model experts. The validation results indicated that the training model was classified as highly feasible for implementation following revisions based on expert recommendations. Furthermore, the validation process confirmed that the developed model met the criteria of content appropriateness, safety, practicality, and relevance to *ushiro mawashi geri* skill development.

The effectiveness of the training model was evaluated among 45 adolescent karate athletes aged 15–17 years using a one-group pretest–posttest design. The findings revealed a substantial improvement in *ushiro mawashi geri* performance following the implementation of the modified plyometric training program. These results suggest that the developed training model provided an appropriate and sport-specific training stimulus, contributing to the enhancement of athletes' kicking performance.

Table 1. Pre-test dan Post-test Result

Variable	N	Mean	SD	Percentage
Pre-test	45	28.24	± 2,85	39%
Post-test		66.84	± 2,72	93%

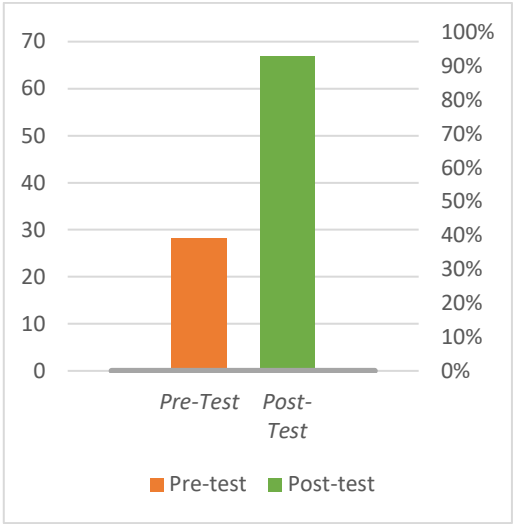


Figure 2. Comparison of Mean Ushiro Mawashi Geri Performance

As presented in Figure 1, the mean *ushiro mawashi geri* skill score increased following participation in the modified plyometric training program. This finding indicates that the developed training model provided an appropriate training stimulus that contributed to improvements in the execution of the kicking technique. Furthermore, the relatively low standard deviation values suggest that the improvement in performance was achieved consistently across the majority of athletes who participated in the training program.

Table 2. Results of the Normality Test

Variable	N	Statistic	Sig.
Pre-test	45	.958	.105
Post-test		.976	.463

As presented in Table 2, the Shapiro–Wilk normality test revealed significance values of p = 0.105 for the pre-test and p = 0.463 for the post-test. Since both values exceeded the significance threshold of 0.05, the data were considered to be normally distributed. These findings indicate that the distribution of *ushiro mawashi geri* performance scores met the assumption of normality, thereby supporting the use of parametric statistical procedures for subsequent hypothesis testing.

Table 3. Homogeneity Test Results

Variable	Levene's Statistic	Sig.
Pre-test dan Post-test	.194	.661

As presented in Table 3, the homogeneity test using Levene's Test yielded a significance value of p = 0.661. Since this value exceeded the significance level of 0.05, the variances of the pre-test and post-test scores were considered homogeneous. These findings indicate that the data satisfied the homogeneity assumption required for parametric statistical analysis and were therefore suitable for subsequent hypothesis testing.

Table 4. Paired Samples t-Test Results

Variable	t	df	Sig. (2-tailed)
Pre-test dan Post-test	-59.298	44	.000

As presented in Table 4, the Paired Samples t-test revealed a t-value of t(44) = −59.298 with a significance level of p = 0.000. Since the obtained p-value was lower than 0.05, a statistically significant difference was observed between the pre-test and post-test scores. These

findings indicate that the modified plyometric training model had a significant positive effect on improving *ushiro mawashi geri* skill among adolescent karate athletes aged 15–17 years.

Table 5. Effectiveness Analysis Results of the Modified Plyometric Training Model

Variable	N	Mean (%)	SD
N-Gain	45	87.76	± 6.16

As presented in Table 5, the N-Gain analysis yielded a mean score of 87.76% ± 6.16. This value falls within the high-effectiveness category, indicating that the modified plyometric training model was highly effective in improving *ushiro mawashi geri* skill among adolescent karate athletes aged 15–17 years.

Based on the statistical analysis, the modified plyometric training model demonstrated a significant effect on the improvement of *ushiro mawashi geri* skill among adolescent karate athletes aged 15–17 years. This improvement was reflected in the increase in skill performance scores following the intervention, which was supported by the results of the hypothesis testing and the high effectiveness value obtained from the N-Gain analysis. These findings suggest that the developed training model provided a training stimulus that was well aligned with the movement characteristics of the *ushiro mawashi geri* technique. Furthermore, the observed improvement indicates that integrating plyometric training principles into sport-specific movement patterns can facilitate motor learning and enhance the acquisition of kicking technique.

The improvement in *ushiro mawashi geri* skill observed in this study may be attributed to the ability of the developed training model to provide a training stimulus that closely matched the movement characteristics of the technique. Repeated practice enabled athletes to improve movement efficiency and optimize neuromuscular coordination patterns involved in kicking execution (Tokgoz et al., 2025). Furthermore, the application of a training model specifically designed for *ushiro mawashi geri* facilitated more targeted adaptations than those typically achieved through general physical training programs (Dojo et al., 2026). These adaptations likely contributed to improvements in technical accuracy, movement speed, and body control during kick execution (Mahmoud Abdel Aal, 2022). The six session training program also provided athletes with sufficient movement experience to refine the quality of technique performance.

Modified plyometric training is closely associated with improvements in lower-limb explosive power because it utilizes the stretch–shortening cycle mechanism that occurs during jumping and explosive movement activities (Duchateau & Amiridis, 2023). This mechanism enables the neuromuscular system to generate greater force within a relatively short period of time, thereby enhancing an athlete's explosive performance capacity (Booth & Orr, 2016). In the execution of *ushiro mawashi geri*, lower-limb explosive power plays a critical role in producing optimal kicking speed and force (Puad et al., 2023). The greater an athlete's ability to rapidly generate force, the greater the potential to execute effective and powerful kicks (Rozi et al., 2025). The training model developed in the present study integrated jumping, rotational, and kicking movements, providing a training stimulus that closely reflected the movement demands of karate performance (Kaczmarski et al., 2026). Therefore, the improvement in *ushiro mawashi geri* skill demonstrated by the athletes may be associated with enhanced lower-limb explosive power resulting from participation in the modified plyometric training program (Togatorop & Dewi Endriani, 2022).

In addition to lower-limb explosive power, coordination and balance are essential components in the successful execution of *ushiro mawashi geri* (Branco et al., 2019). This kicking technique involves complex rotational movements that require effective synchronization among the trunk, pelvis, and lower extremities (Nursamedy et al., 2020). Insufficient movement coordination may reduce an athlete's ability to accurately direct the kick toward the intended target (Saputra et al., 2025). Likewise, balance is crucial for maintaining postural stability throughout the rotational phase and during the completion of the kicking movement (Mahmoud Abdel-Aal, 2022). The modified plyometric training model developed in this study

incorporated activities that required athletes to maintain body control while performing explosive movements, which may have contributed to improvements in coordination and balance (Moreno-Azze et al., 2024). These adaptations likely enabled athletes to execute *ushiro mawashi geri* with greater control, speed, and movement efficiency during performance (Nowakowska et al., 2017).

The findings of the present study are consistent with those reported by Ramirez-Campillo et al., (2018), who demonstrated that plyometric training enhances explosive performance and movement capacity through neuromuscular adaptations induced by systematic training. Similar findings were reported by Ojeda-Aravena et al., (2023), who concluded that plyometric training effectively improves physical performance in combat sport athletes, particularly in activities requiring explosive movement production. Furthermore, Lin et al., (2025) found that plyometric training programs positively contribute to kicking performance and overall movement effectiveness in karate athletes. Nevertheless, the present study offers a distinct contribution by developing a modified plyometric training model specifically designed according to the movement characteristics of *ushiro mawashi geri*. Consequently, the training stimulus provided was more sport-specific and directly aligned with the performance demands of adolescent

CONCLUSION

Based on the findings of the study, the developed modified plyometric training model was deemed feasible for implementation based on the validation results obtained from karate experts, measurement and evaluation experts, and training model experts. Following the recommended revisions, the model was implemented over six training sessions among adolescent karate athletes aged 15–17 years. The effectiveness testing demonstrated an improvement in *ushiro mawashi geri* skill, as evidenced by the increase in mean performance scores from 28.24% in the pre-test to 66.84% in the post-test. This improvement was further supported by the results of the Paired Samples t-test, which revealed a statistically significant difference between the pre-test and post-test scores ($t(44) = -59.298$, $p < 0.001$). Furthermore, the N-Gain value of 87.76% indicated a high level of effectiveness of the developed training model. These findings suggest that integrating plyometric training principles with the movement characteristics of *ushiro mawashi geri* provides an appropriate sport-specific training stimulus for enhancing kicking technique performance. Therefore, the modified plyometric training model can be considered an effective alternative training program for improving *ushiro mawashi geri* skill among adolescent karate athletes aged 15–17 years.

AUTHOR CONTRIBUTIONS STATEMENT

All authors contributed equally to the conceptualization, methodology, data collection, analysis, and drafting of the manuscript. All authors have read, revised, and approved the final manuscript for publication.

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AI USAGE STATEMENT

The authors used Grammarly solely for grammar checking and language refinement during the preparation of this manuscript. No generative AI tools were used for data collection, analysis, or content creation. All scientific findings and conclusions were generated and verified entirely by the authors.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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