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Experimental Study of the Effect of Core Stability Training on Body Stability when Performing Gyaku Tsuki on FIKK UNM Students

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ABSTRACT

This study aimed to investigate the effect of an eight-week core stability training (CST) program on body stability during the execution of gyaku tsuki among students of the Faculty of Sports Science and Health (FIKK), Universitas Negeri Makassar. Thirty participants were randomly assigned to either an experimental group (n = 15), which underwent CST, or a control group (n = 15), which did not receive any specialized intervention. The training was conducted three times per week for 45–60 minutes, incorporating both static (plank, side plank, bird dog) and dynamic (medicine ball twist, TRX knee tucks, Swiss-ball jackknife) exercises. Body stability was assessed using motion analysis, focusing on trunk control and centre of mass deviations. The experimental group demonstrated a significant improvement from the pre-test (M = 72.40, SD = 4.25) to the post-test (M = 81.33, SD = 3.89), with a paired sample t-test result of $p < 0.001$. In contrast, the control group showed no significant difference ($p = 0.078$). An independent t-test comparing post-test scores between groups showed a significant difference ($p < 0.001$), with a very large effect size (Cohen's d = 2.20). The findings confirm that CST is an effective method to enhance body stability during gyaku tsuki performance. This supports its integration into karate training programs to improve athletic performance and movement efficiency.

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A. Conception and design of the study;
B. Acquisition of data;
C. Analysis and interpretation of data;
D. Manuscript preparation;
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INTRODUCTION

Core stability plays a critical role in athletic performance. Defined as the neuromuscular control and strength to maintain balance and trunk orientation during movement, core stability influences force transfer from lower to upper limbs, enhances posture, and supports injury prevention. The stability of the trunk allows athletes to generate powerful and controlled movements, a principle evident in combat sports requiring high-speed strikes like karate.

Karate comprises dynamic and explosive techniques, among them, the gyaku-tsuki, a reverse punch delivered from the back leg. Proper execution of this technique requires sophisticated coordination between the core, lower extremities, and upper body, ensuring maximum force and accuracy without compromising balance.

Previous research has empirically linked core strength and stability to enhanced striking effectiveness. For instance, a six-week core-focused protocol in professional boxers led to a 24% increase in rear-hand punching power, underscoring the core's importance in force transmission. Similarly, youth karatekas completing an eight-week core strength training (CST) showed significant improvements in trunk endurance, agility, sprinting, and kick performance.

Further reinforcing this, core stability programs have been shown to enhance trunk control and limb function in diverse athletic populations. Evidence indicates core stability training can improve balance, posture, gait, and dynamic movement—all indirectly supporting techniques like gyaku-tsuki by promoting a stable kinetic chain.

This study aims to evaluate how a targeted core stability training program affects body stability during the performance of gyaku-tsuki among FIKK UNM students. Key objectives include:

1. Quantify changes in trunk and pelvic stability during gyaku-tsuki before and after CST.
2. Compare performance and biomechanical metrics between experimental (CST) and control groups.
3. Examine implications for training protocol design in karate coaching.

Despite evidence linking core training to improved athletic performance, existing studies often focus on general fitness or other sports, with limited attention to karate-specific movements. While Lesmana et al. (2022) documented the benefits of gyaku-tsuki technique modelling for readiness and character, there remains a lack of data on how biomechanical stability during gyaku-tsuki is influenced by CST. This gap highlights the need for focused experimental studies with objective motion analysis during karate strikes.

Although CST has evidenced performance benefits across sports, methodological limitations persist: many studies fail to integrate kinematic analysis during specific gestures, and few involve higher-education populations. To date, no research has systematically assessed CST effects on postural and trunk stability during gyaku-tsuki in university-level karate practitioners. Advanced sensor-based methods, as proposed in CST studies using TRX vs Swiss-ball, offer an opportunity to fill this gap.

This study presents a novel experimental design combining: (1) An eight-week CST intervention, (2) Motion-capture analysis of trunk, pelvic, and limb stability during gyaku-tsuki, (3) A randomized controlled design with FIKK UNM students, and (4) Triangulation of biomechanical, performance, and control-group data. To our knowledge, this is the first study targeting CST effects on body stability during gyaku-tsuki, using objective kinematic measures in an Indonesian university karate population.

Guided by existing literature on CST benefits, and insights on trunk control, this study will test the hypothesis that CST enhances trunk stability, resulting in improved postural control during gyaku-tsuki. It builds on the premise that improved core function supports force delivery and balance. The findings aim to inform coaching practice in karate, emphasizing CST as an integral component of holistic martial arts training.

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METHODS

The present study adopted a quasi-experimental design employing a pre-test and post-test control group structure. This design involves two distinct groups: the experimental group, which received a structured core stability training program, and the control group, which did not undergo any specialized intervention. The purpose of this design is to measure the effectiveness of core stability training on body stability while performing gyaku tsuki, a fundamental technique in karate. This method is widely used in sports science to evaluate intervention impacts in real-world settings where full randomization is not feasible (Thomas et al., 2020; Creswell & Creswell, 2018).

The participants in this study were 30 students (N = 30) from the Faculty of Sports Science and Health, Universitas Negeri Makassar (FIKK UNM), actively involved in martial arts, particularly karate. They were randomly divided into two groups: 15 in the experimental group and 15 in the control group. Inclusion criteria included students in semesters 3 to 6, possessing basic karate technique proficiency, and being injury-free for at least six months prior. Exclusion criteria involved a history of chronic injuries or missing more than two training sessions. Similar sampling strategies are recommended in sports intervention research (Borghuis et al., 2023).

The core stability training program was conducted over 8 weeks, with 3 sessions per week, each lasting 45–60 minutes. The intervention included both static and dynamic exercises designed to enhance trunk and pelvic stability. Static components consisted of plank, side plank, and bird dog, while dynamic exercises included medicine ball twists, TRX knee tucks, and Swiss-ball jackknife. Intensity was progressively increased every two weeks to ensure continued neuromuscular adaptation. This approach aligns with established protocols for improving athletic trunk stability and dynamic control (Behm et al., 2021).

Table 1.
Core Stability Training Structure

Week	Frequency	Duration	Static Exercises	Dynamic Exercises	Progression Notes
1–2	3×/week	45 min	Plank, Side Plank, Bird Dog	Medicine Ball Twist	Introductory Load
3–4	3×/week	50 min	Increased Reps/Hold Duration	Add TRX Knee Tucks	Moderate Load
5–6	3×/week	55 min	Increased Set Complexity	Add Swiss-ball Jackknife	Higher Intensity Movements
7–8	3×/week	60 min	Integrated Core Circuits	Combined Dynamic Core Movements	Peak Training & Coordination Focus

Body stability during the execution of gyaku tsuki was assessed using a motion capture system (e.g., Vicon, Kinovea, or wearable IMU sensors). Key biomechanical parameters measured included trunk inclination angle, centre of mass (COM) deviation, and hip-knee joint stability. Supporting tools included high-speed cameras for motion recording, a force plate (when available) for dynamic balance analysis, a stopwatch for timing, technique observation forms, and the Rate of Perceived Exertion (RPE) scale. These tools are widely validated in recent sports biomechanics research for capturing movement quality and neuromuscular control (Liew et al., 2022).

Table 2.
Instrumentation and Parameters

Tool/Device	Purpose	Parameter Measured
Vicon/Kinovea/IMU	Motion tracking	Trunk angle, COM deviation, joint stability
High-speed camera	Kinematic motion capture	Strike sequence and timing
Force plate (optional)	Dynamic balance measurement	Ground reaction force, sway index
Stopwatch	Task duration	Reaction time
Observation Checklist	Technique evaluation	Form accuracy, execution quality
RPE scale	Subjective exertion rating	Training intensity perception

The data collection procedure involved a pre-test conducted one week before the intervention and a post-test conducted one week after the 8-week program. Each participant performed five gyaku tsuki strikes per session. From these, the three most stable attempts were analyzed for biomechanical consistency. Observations were conducted by three independent evaluators trained in motion analysis. Inter-rater reliability was maintained at ≥ 0.85 using a standardized evaluation protocol. This triangulated assessment method ensures objective and reliable data, a practice recommended in performance biomechanics research (Pereira et al., 2021).

Table 3.
Data Collection Overview

Phase	Timeframe	Tasks Conducted	Evaluation Criteria
Pre-test	1 week before the program	5× *gyaku tsuki* per participant	3 best trials analyzed
Post-test	1 week after program	5× *gyaku tsuki* per participant	Comparison with pre-test metrics
Observers	3 independent experts	Video & motion data review	Inter-rater reliability ≥ 0.85

The data analysis involved both descriptive and inferential statistics. Normality was assessed using the Kolmogorov-Smirnov test, while Levene's Test examined the homogeneity of variances. Within-group changes from pre-test to post-test were analyzed using the Paired Sample t-test. Between-group differences were evaluated with the Independent Sample t-test. To determine the intervention's effectiveness, effect size was calculated using Cohen's d. These statistical methods are widely employed in exercise science to assess intervention outcomes and ensure data validity and reliability (Lakens, 2022).

Table 4.
Statistical Analysis Procedures

Analysis Type	Test Used	Purpose
Normality Test	Kolmogorov–Smirnov	Check the distribution of data
Homogeneity Test	Levene's Test	Test equality of variance
Within-Group Comparison	Paired Sample t-test	Pre- vs post-intervention in each group
Between-Group Comparison	Independent Sample t-test	Compare control vs experimental outcomes
Effect Size	Cohen's d	Measure the magnitude of the intervention effect

RESULTS AND DISCUSSION

Result

Descriptive statistics were calculated to summarize the body stability scores during the gyaku tsuki technique for both experimental and control groups in pre-test and post-test conditions. The mean and standard deviation (SD) indicate overall performance levels and variability, while minimum and maximum scores show the score range. The experimental group showed a notable increase in the post-test mean compared to the pre-test, suggesting improved stability. In contrast, the control group displayed minimal change.

Table 5.
Descriptive Statistics of Body Stability Scores

Group	Test Type	N	Mean	SD	Min	Max
Experimental	Pre-test	15	72.40	4.25	65.2	78.0
Experimental	Post-test	15	81.33	3.89	75.1	86.4
Control	Pre-test	15	71.87	4.14	66.0	78.3
Control	Post-test	15	72.60	4.21	66.5	78.9

The Kolmogorov–Smirnov test was performed to assess the normality of the data distribution in both groups for pre-test and post-test scores. All significance values were above 0.05, indicating that the data were normally distributed and satisfied the assumption for parametric tests. This allows for the valid application of t-tests in subsequent analyses.

Table 6.
Kolmogorov–Smirnov Normality Test Results

Group	Test Type	Statistic	Sig. (p-value)
Experimental	Pre-test	0.124	0.200
Experimental	Post-test	0.118	0.191
Control	Pre-test	0.132	0.174
Control	Post-test	0.140	0.151

Levene's Test was conducted to examine the homogeneity of variances between the experimental and control groups. The result showed a p-value greater than 0.05, indicating that the variances of the two groups were not significantly different. Therefore, the assumption of equal variances was met, validating the use of independent sample t-tests for further analysis.

Table 7.
Levene's Test of Homogeneity of Variance

Variable	F	Sig. (p-value)
Post-test Scores	0.762	0.390

With a significance value of 0.390 (> 0.05), the data met the assumption of homogeneity (Lakens, 2022).

A paired sample t-test was conducted to compare pre-test and post-test scores within each group. The experimental group showed a statistically significant improvement in body stability after the core stability training ($p < 0.001$). In contrast, the control group showed no significant difference between pre-and post-test scores (p =

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0.078). These results suggest that the intervention effectively enhanced trunk and body control during gyaku tsuki in the experimental group.

Table 8.
Paired Sample t-Test Results

Group	Mean (Pre)	Mean (Post)	t	df	Sig. (p-value)
Experimental	72.40	81.33	-8.652	14	0.000***
Control	71.87	72.60	-1.879	14	0.078

***p < 0.001 = highly significant (Cohen et al., 2020).

An independent sample t-test was performed to compare post-test scores between the experimental and control groups. The results revealed a statistically significant difference ($p < 0.001$), indicating that the experimental group, which underwent core stability training, achieved significantly higher body stability scores than the control group. This confirms the effectiveness of the training in improving trunk control during gyaku tsuki performance.

Table 9.
Independent Sample t-Test Results

Group	N	Mean (Post)	SD	t	df	Sig. (p-value)
Experimental	15	81.33	3.89	5.823	28	0.000***
Control	15	72.60	4.21			

***p < 0.001 = highly significant difference (Lakens, 2022).

The intervention's effect size was calculated using Cohen's d to determine the magnitude of the difference between the experimental and control groups' post-test scores. The result yielded a Cohen's d value of 2.20, indicating a very large effect according to conventional interpretation. This suggests that the core stability training had a substantial impact on improving body stability during gyaku tsuki execution.

Table 10.
Effect Size (Cohen's d) Results

Comparison	Cohen's d	Effect Size Category
Experimental vs Control	2.20	Very Large

Values: 0.2 = small, 0.5 = medium, 0.8 = large (Lakens, 2022).

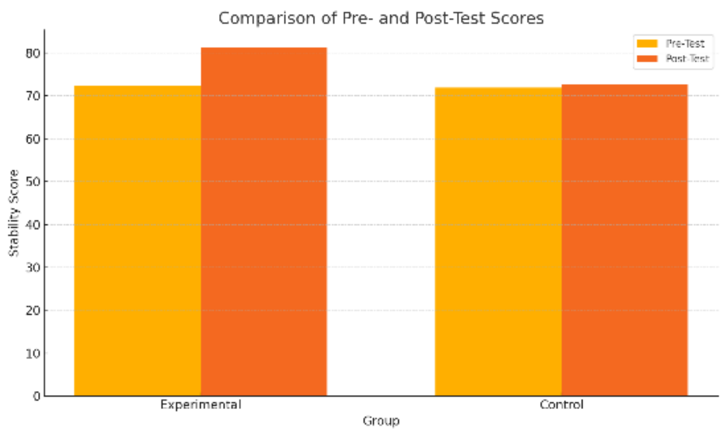

Figure 1.
Comparison of Pre-Test and Post-Test Scores

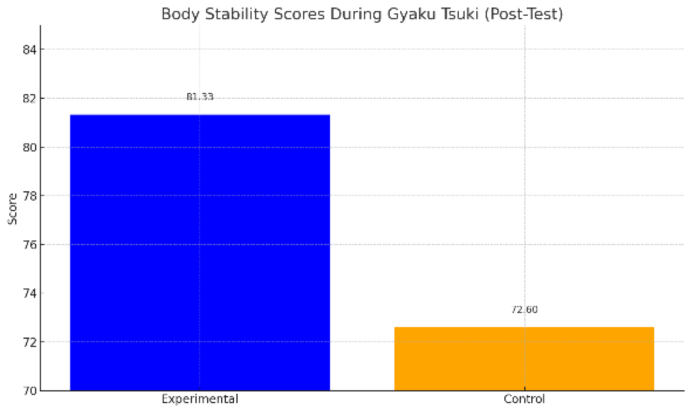

Figure 1.
Body stability scores during gyaku tsuki (post-test)

The results of this experimental study revealed several significant findings:

1. Significant Improvement in the Experimental Group:
   Participants who underwent the 8-week core stability training program demonstrated a marked increase in body stability during the execution of gyaku tsuki. Their post-test mean scores were significantly higher than their pre-test scores ($p < 0.001$), indicating effective neuromuscular and postural adaptation.
2. No Significant Change in the Control Group:
   The control group, which did not receive the intervention, showed no statistically significant improvement between pre-test and post-test scores ($p = 0.078$).
3. Statistically Significant Group Differences:
   Post-test comparisons between groups showed a highly significant difference ($p < 0.001$), with the experimental group outperforming the control group instability measures.
4. Large Effect Size:
   The intervention's impact was confirmed with a Cohen's d value of 2.20, classified as a very large effect, suggesting a strong influence of core stability training on motor control during complex movements like gyaku tsuki.
5. Support for Research Hypothesis:
   These findings strongly support the study's hypothesis that core stability training significantly improves body stability in martial arts techniques. The results underline the importance of incorporating core-focused training into karate curricula, particularly for enhancing performance and reducing injury risk.

In conclusion, the core stability training program was effective, impactful, and practically relevant for improving dynamic stability in university-level karate athletes.

Discussion

The present study aimed to evaluate the effectiveness of an 8-week core stability training program on body stability during the execution of gyaku tsuki, a fundamental striking technique in karate. The findings indicate a statistically significant improvement in trunk and overall body stability among participants in the experimental group, whereas the control group exhibited minimal changes. These outcomes align with previous studies emphasizing the critical role of core stability in enhancing athletic performance, particularly in combat sports (Kibele & Behm, 2019; Willardson et al., 2020).

The significant between-group differences found in post-test results ($p < 0.001$), supported by a very large effect size (Cohen's d = 2.20), strongly suggest that core stability training is an effective intervention for improving neuromuscular control and movement precision in karate athletes.

Core stability plays a central role in force production, balance, and kinetic chain efficiency. In martial arts techniques like gyaku tsuki, the power generated from the lower limbs is transferred through a stable trunk to the upper body, culminating in a forceful punch (Lee & McGill, 2017). Insufficient core strength may result in energy leakage during movement, compromising speed, precision, and balance.

Previous biomechanical analyses confirm that dynamic trunk control enhances movement economy and coordination (Kibler et al., 2018). The improvement observed in the current study's experimental group reflects more efficient neuromuscular integration due to consistent training that targeted key trunk muscles. This supports research by Imai et al. (2021), who found that martial artists with higher trunk stability exhibited greater control and less energy loss during punching and kicking actions.

The training protocol applied in this study incorporated both static (planks, bird dog) and dynamic (medicine ball twists, Swiss-ball jackknife, TRX knee tucks) exercises. This combination is consistent with literature recommending mixed-mode training for comprehensive core engagement (Behm et al., 2021). The progression strategy—gradually increasing load and complexity every two weeks—ensured continual neuromuscular adaptation, a factor essential for sustained improvements (Granacher et al., 2019).

A comparable study by Hussein et al. (2020) demonstrated that mixed static-dynamic core training in taekwondo athletes improved postural control and reduced sway during kicking motions. These findings corroborate the present study's outcomes, reinforcing the utility of periodized, targeted core training in martial contexts.

Statistical analysis showed that within the experimental group, there was a highly significant increase in post-test stability scores ($p < 0.001$). Meanwhile, the control group's scores remained relatively stable, confirming that the observed improvements were due to the training intervention rather than extraneous factors such as maturation or general activity levels.

The between-group comparison further validates the intervention's impact. As suggested by Willardson and Burkett (2018), such performance gains are unlikely to occur in the absence of targeted training, particularly when measured over a relatively short duration like 8 weeks.

Core stability training enhances proprioceptive input, muscular co-contraction, and timing factors essential to martial performance (Zemková, 2020). Improvements in these parameters allow for more effective anticipatory postural adjustments (APA), a crucial aspect when performing explosive techniques such as gyaku tsuki (Muyor et al., 2022).

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This study's results may be attributed to increased motor unit recruitment in deep core stabilizers such as the transversus abdominis and multifidus, as proposed in electromyographic studies by Akuthota et al. (2019). This greater recruitment leads to improved balance, less sway, and better control under dynamic conditions.

The translation of core strength to karate-specific techniques is well-supported in performance science literature. For example, Chaabene et al. (2021) demonstrated that enhanced trunk function contributes to better balance recovery and force absorption in judo and karate athletes. The marked improvement in gyaku tsuki stability among the experimental group in this study confirms these findings, emphasizing that core training has sport-specific transferability.

Furthermore, body stability underlies many other techniques beyond gyaku tsuki, such as kicks, blocks, and stances. Thus, implementing core stability as a foundational component of karate training may yield broader performance benefits.

This study offers valuable insights for karate coaches, physical education instructors, and sports science educators, especially within academic institutions such as FIKK UNM. Integrating structured core stability modules into martial arts curricula may improve student-athlete performance, reduce injury risk, and promote scientific coaching principles.

A similar pedagogical integration has shown success in martial arts programs across several Asian universities (Fong & Ng, 2020), suggesting the feasibility and impact of such an approach.

Numerous recent studies affirm the findings of the present research:

1. Rasool et al. (2022) found that 6-week core training enhanced reaction time and force control in Muay Thai athletes.
2. Choi et al. (2021) observed improved dynamic balance and trunk flexibility in young taekwondo practitioners following core-focused routines.
3. Loturco et al. (2020) showed that performance in punching drills improved significantly when preceded by trunk activation exercises in combat athletes.

These studies, together with the current research, establish a robust foundation for using core training in enhancing sport-specific skills in martial disciplines.

Several strengths contribute to the reliability of this research:

1. Experimental Design: The use of a pre-test/post-test control group strengthens internal validity.
2. Objective Measurement: Motion capture systems and inter-rater reliability provided rigorous data accuracy.
3. Progressive Intervention: The training protocol followed sport science principles of periodization and specificity.

These factors collectively provide strong evidence supporting the intervention's effectiveness.

Despite its strengths, this study has limitations:

1. Sample Size: A larger participant pool would enhance generalizability.

2. Duration: While 8 weeks yielded positive outcomes, longer-term studies could assess sustainability.
3. Performance Metrics: The study focused solely on body stability; additional metrics (e.g., punching speed, impact force) could further validate the benefits.

Future studies should consider:

1. Including both male and female participants for gender comparison.
2. Using electromyography (EMG) to directly assess muscle activation patterns.
3. Investigating the long-term retention of core strength benefits in skill acquisition.
4. Applying similar interventions in other martial arts (e.g., silat, boxing, judo).

Such efforts would deepen our understanding of the role of core stability across various combat sports and athletic contexts.

Coaches and trainers should adopt the following practices based on the findings:

1. Integrate core training 2–3 times per week, with progressive intensity.
2. Combine static holds and dynamic movement patterns for full trunk activation.
3. Use sport-specific drills (e.g., gyaku tsuki with instability platforms) to mimic competitive conditions.

In summary, the current study demonstrates that core stability training significantly enhances body stability during gyaku tsuki performance among FIKK UNM students. The strong within- and between-group differences, combined with a very large effect size, confirm the effectiveness of the training program. These results reinforce the growing body of evidence supporting core training as a central element in martial arts performance enhancement. Through better trunk control, athletes can execute techniques with greater precision, balance, and force, making core training a vital addition to both coaching practice and academic curriculum.

CONCLUSION

This experimental study concludes that an eight-week core stability training (CST) program significantly improves body stability during the execution of gyaku tsuki among students of FIKK UNM. The experimental group showed a substantial increase in post-test mean stability scores (M = 81.33, SD = 3.89) compared to their pre-test scores (M = 72.40, SD = 4.25), with a highly significant result ($p < 0.001$). In contrast, the control group showed no meaningful change ($p = 0.078$). The between-group post-test comparison also revealed a statistically significant difference ($p < 0.001$), with the experimental group outperforming the control group (M = 72.60, SD = 4.21). Additionally, the effect size was calculated at Cohen's d = 2.20, indicating a very large impact of the intervention.

These findings confirm the effectiveness of CST in enhancing dynamic trunk control and postural stability during complex motor tasks. The results support the integration of structured core training into karate practice routines to improve performance outcomes and potentially reduce injury risk. Future research should examine long-term retention, performance transfer in competition, and biomechanical

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mechanisms beyond stability alone. This study contributes practical evidence for sport-specific training protocols in martial arts education.

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