COMPETITOR:
JURNAL PENDIDIKAN KEPELATIHAN OLAHRAGA
e-ISSN: 2657-0734 & p-ISSN: 2085-5389 ‖ Volume 18, Number 1, 2026 ‖ P.0231-0242

Biomechanical of The Mawashi-Geri Kick In Karate Athletes of The Inkanas Kertosono Dojo, In Nganjuk Regency

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ABSTRACT

This study aims to analyze the execution of the Mawashi-Geri kicking technique performed by athletes at Dojo Inkanas Kertosono using biomechanical principles and standards established by the World Karate Federation (WKF). The research employed a descriptive biomechanical design with a qualitative analytical approach, focusing on video-based motion analysis to evaluate movement quality and technical accuracy. Data were collected through video recordings captured from two camera angles to ensure comprehensive observation of body alignment, joint motion, and kicking trajectory. The recorded movements were analyzed using Kinovea software to measure key biomechanical angles, including the leg-opening angle (α1), trunk inclination angle (α2), and supporting-leg rotation angle (α3). In addition, movement evaluations were triangulated with assessments provided by two experts, consisting of a DAN 2 karate technique specialist and a nationally licensed referee, to enhance analytical validity. The findings indicate that the measured angles did not consistently fall within the ideal biomechanical range, with α1 ranging from 107° to 133°, α2 from 125° to 151°, and α3 from 119° to 146°. These deviations reflect deficiencies in pelvic rotation, postural stability, and intersegmental coordination, which subsequently reduce kicking effectiveness. Furthermore, weaknesses were observed during the recoil phase, where delayed or unstable leg retraction negatively affected balance control and increased vulnerability to counterattacks. In conclusion, although the athletes have mastered the fundamental structure of the Mawashi-Geri technique, substantial technical refinement is still required. Improvements should focus on enhancing pelvic rotation efficiency, body stability, core muscle strength, hip flexibility, and neuromuscular coordination through training programs grounded in biomechanical principles. The findings of this study provide practical insights for coaches in designing more targeted and scientifically informed training interventions to optimize Mawashi-Geri performance in developing karate athletes.

ARTICLE HISTORY
Received: 2025/12/31
Accepted: 2026/01/23
Published: 2026/02/05

KEYWORDS
Biomechanical;
Mawashi-Geri Kick;
Karate Athletes;
Video-Based Motion;
WKF Technical Standards.

AUTHORS' CONTRIBUTION
A. Conception and design of the study;
B. Acquisition of data;
C. Analysis and interpretation of data;
D. Manuscript preparation;
E. Obtaining funding

Cites this Article : Romadhona, N.; Wahyudi, H.; Yuliastrid, D.; Irawan, R.J. (2026). Biomechanical of The Mawashi-Geri Kick In Karate Athletes of The Inkanas Kertosono Dojo, In Nganjuk Regency. **Competitor: Jurnal Pendidikan Kepelatihan Olahraga**. 18 (1), p.0231-0242

INTRODUCTION

Karate is a rapidly growing martial art in Indonesia, emphasizing not only physical and technical aspects but also character development, discipline, and self-control. In the

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context of kumite competitions, the effectiveness of striking techniques is a determining factor in success, one of which is the Mawashi-Geri kick. This technique is widely used due to its fast, flexible, circular trajectory and ability to reach vital areas such as the opponent's waist and head (Hariri & Sadeghi, 2018). However, the frequent use of Mawashi-Geri does not always translate into optimal movement quality, especially among athletes at the development and training levels.

Initial observations at several dojos, including Inkanas Kertosono, indicate variations in the quality of Mawashi-Geri among athletes. Some athletes experience difficulty maintaining body stability in the initial phase of a kick, others exhibit suboptimal hip rotation, as well as inaccurate kick direction and slow recovery. This problem is closely related to an individual's physical capacity, such as hip joint flexibility, core muscle strength, neuromuscular coordination, and training experience (Lengkana & Sofa, 2017; Nurhadi et al., 2023).

In a competitive context, imperfect Mawashi-Geri not only reduces the effectiveness of attacks but also increases the risk of losing balance and opening up opportunities for counterattacks from the opponent. Therefore, the main problem in this study is the suboptimal biomechanical quality of Mawashi-Geri in karate athletes, particularly regarding stability, rotation, and continuity of movement, which directly impacts kumite performance.

The biomechanical approach has been widely used in sports technique analysis to understand the relationship between movement structure, force, joint angles, and the body's center of mass (Adolph, 2016; McGinnis, 2013). In karate, several international studies have highlighted that kick effectiveness is significantly influenced by leg opening angle, hip rotation, trunk tilt, and the position of the supporting foot (Pozo et al., 2011; Sbriccoli et al., 2010).

Mawashi-Geri, in particular, involves complex coordination between the lower extremities, core muscles, and balance system. A study by Hariri and Sadeghi (2018) showed that hip rotation and knee angular velocity significantly contribute to kicking power. Other research confirms that a delay in the recovery phase after leg extension can decrease the technique's effectiveness and increase the risk of counterattacks (Fandayani & Sagitarius, 2019).

The development of video-based motion analysis technology and biomechanical software has strengthened the evaluative approach in sports training. Video-based motion analysis allows trainers to objectively identify joint angle deviations, foot trajectory, and center of mass displacement (Bartlett, 2014; Wardani et al., 2024). In the context of karate, this method has begun to be used to analyze Mae-Geri kicks, Gyaku-Tsuki kicks, and technique combinations, but its application to Mawashi-Geri remains limited, particularly at the coaching level in Indonesia (Nenggar, 2014; Nurhadi et al., 2023).

In addition to biomechanical factors, the literature also emphasizes the role of motor habits in developing efficient technique. Correct movement patterns from the initial stages of training will accelerate neuromuscular adaptation and improve technique consistency (Harahap et al., 2025). Therefore, evaluation of technique based on angles and trajectory is crucial as a basis for improving training methods.

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Although research on the biomechanics of karate kicks has progressed, several significant research gaps remain. First, most studies focus on elite or international-level athletes, thus underrepresenting the conditions experienced by athletes trained in local dojos, particularly in Indonesia. Second, research specifically examining the three main Mawashi-Geri angles namely, the leg opening angle, the trunk tilt, and the rotation of the supporting leg in an integrated manner is still limited.

Third, there is little research linking the results of biomechanical angle analysis to practical implications for designing individual training programs. However, the literature indicates that deviations in one angle can affect others, necessitating a holistic approach to corrective action (Nenggar, 2014; Bartlett, 2014). Fourth, the use of video analysis at the dojo level is often descriptive and has not been systematically utilized as a basis for training decisions.

Therefore, there is a need for research that combines video-based biomechanical analysis of Mawashi-Geri with the context of karate athlete development, and practical recommendations for improving technique quality and movement stability.

Based on these research problems and gaps, this study aims to analyze the quality of Mawashi-Geri movements of karate athletes at the Inkanas Kertosono dojo using a video-based biomechanical approach. Specifically, this study aims to: (1) identify the characteristics of the leg opening angle, trunk tilt, and rotation of the supporting leg during Mawashi-Geri execution; (2) analyze the stability and continuity of movement during the execution and recovery phases; and (3) provide recommendations for technique improvements tailored to the individual needs of the athletes.

The novelty of this research lies in the integration of biomechanical angle analysis of Mawashi-Geri with the context of local dojo coaching, as well as the use of video-based motion analysis as a practical evaluation tool for coaches. The findings of this study are expected to not only contribute to the development of sports science, particularly karate biomechanics, but also provide an empirical basis for developing more effective, individualized training strategies oriented toward improving kumite performance.

METHODS

his study adopts a descriptive biomechanical research design with a qualitative analytical approach. The design is intended to describe and interpret the biomechanical characteristics of the Mawashi-Geri kicking technique performed by karate athletes, rather than to test hypotheses or quantify causal relationships. Although numerical angle measurements are obtained using motion analysis software, the primary objective of the study is to describe movement quality, identify technical deviations, and interpret biomechanical patterns based on expert judgment and visual evidence.

The qualitative aspect of this study lies in the interpretative analysis of movement execution, where the observed biomechanical variables—such as joint angles, body alignment, and kicking trajectory—are explained descriptively in relation to technical correctness according to World Karate Federation (WKF) standards. Therefore, this

research does not fall under experimental or purely quantitative biomechanics, but rather under descriptive biomechanical analysis, which is commonly used to evaluate sports techniques in applied training contexts (Puig-Diví et al., 2021).

The research was conducted at the Inkanas Kertosono dojo, located at Ar-Rahman Kertosono, Jl. Gotong Royong, Pelem Village, Kertosono District, Nganjuk Regency. Data collection took place from October to November 2025, adjusted to the athletes' regular training schedule and the availability of coaches. The research population consisted of six male karate athletes from the –55 kg, –60 kg, and –70 kg weight categories. All participants were 15 years old, actively training, and had mastered the Mawashi-Geri technique according to WKF guidelines. This population was considered appropriate because the athletes directly represented the developmental level at which technical instability and movement inconsistencies frequently occur.

A purposive sampling technique was applied, selecting athletes who were capable of performing the Mawashi-Geri technique consistently and safely during recording sessions. Each athlete performed the Mawashi-Geri kick through three clearly defined phases: preparation, execution, and follow-through (recovery). The movements were recorded using two camera angles to ensure comprehensive capture of joint motion, body alignment, and kicking trajectory.

The recorded movements were analyzed using Kinovea motion analysis software, which allows frame-by-frame observation and angle measurement of biomechanical variables. The software was used as a supporting analytical tool, not as a statistical instrument, enabling precise visualization of joint angles, direction of leg swing, and body stability during each phase of the kick. This approach aligns with descriptive biomechanical studies that prioritize movement interpretation over numerical generalization.

To enhance the credibility and objectivity of the analysis, the video-based findings were triangulated with expert evaluations. Two experts—a DAN 2 karate technique specialist and a nationally licensed referee—assessed each movement phase using an observation sheet developed based on WKF technical standards. The observation sheet covered body posture, angular alignment, kicking direction, balance, and continuity of motion. Expert assessments were used to confirm biomechanical deviations observed in the video analysis and to identify movement components requiring technical correction (Ahmad Yanuar Syauki et al., 2021).

Data analysis followed a qualitative descriptive procedure, where findings from Kinovea measurements and expert assessments were synthesized into a structured description of the Mawashi-Geri technique. The analysis did not involve inferential statistics; instead, it focused on explaining how and why certain movement deviations occurred, particularly in relation to stability, rotation, and recovery phases. The final results were presented in the form of descriptive interpretations and practical recommendations for coaches, supporting technique refinement and more targeted training interventions (Milya Sari, 2023).

RESULTS AND DISCUSSION

Result

This study employed a qualitative research method to analyze movement errors in the Mawashi-Geri kick performed by karate athletes at the Inkanas Kertosono dojo, located in Nganjuk Regency. The research took place on 31 October 2025 and involved six karateka as subjects. Video recordings of all movements were subsequently analyzed using a laptop equipped with **Kinovea** software. This software enabled the assessment of angles related to foot opening, body inclination, rotation of the kicking leg, and rotation of the supporting leg. The purpose of this analysis was to determine how closely the athletes' movement patterns aligned with the standards established by the World Karate Federation (WKF) and to identify specific components of the technique that required improvement. For the karateka in the 55 kg weight category, two sample recordings taken from the lateral angle were presented. The lateral-view images of the Mawashi-Geri executed by Karateka A and Karateka B served as visual references for understanding the direction of the swing, hip coordination, and the athletes' balance.

Table 1.
Analysis of Karateka A

No	Variable	Kick Mawashi-Geri
1	α1 (foot opening angle)	133,6°
2	α2 (body inclination angle)	125,3°
3	α3 (support foot rotation angle)	122,4°

In Table 1. Analysis of Karateka A, the data indicate that the foot-opening angle (α1) measured 133.6°, the body-lean angle (α2) measured 125.3°, and the supporting-foot rotation (α3) measured 122.4°. These results show that Karateka A was not yet able to maintain a stable body position, as the backward inclination of the torso caused the center of mass to shift, thereby reducing stability when the supporting leg received the load. The rotation of the supporting foot also did not reach an adequate degree, preventing the hips from rotating freely. A delay observed in the recoil phase indicates that end-movement control was not yet stable.

Table 2. Analysis Karateka B

No	Variable	Kick Mawashi-Geri
1	α1 (foot opening angle)	123°
2	α2 (body inclination angle)	132,4°
3	α3 (support foot rotation angle)	119,9°

In Table 2. Analysis of Karateka B, the foot-opening angle (α1) measured 123°, the body-lean angle (α2) measured 132.4°, and the supporting-foot rotation (α3) measured 119.9°. These results indicate that Karateka B's body position also tended to lean backward, which reduced overall stability. The hip rotation angle had not yet reached an adequate range, causing the leg swing to deviate from the intended circular trajectory. The angle of the supporting foot further shows that the foot did not open optimally, resulting in suboptimal force transfer from the

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ground to the hips. In addition, the recoil phase was not clearly visible, suggesting that post-contact body control still needs improvement. Weaknesses in this final phase may increase the opponent's opportunity to launch a counterattack.

Table 3.
Analysis Karateka C

No	Variable	Kick Mawashi-Geri
1	α1 (foot opening angle)	130,2°
2	α2 (body inclination angle)	151°
3	α3 (support foot rotation angle)	135,2°

For the group of karateka in the –60 kg weight category, the observations continued with Table 3. Analysis of Karateka C, which showed a foot-opening angle (α1) of 130.2°, a body-lean angle (α2) of 151°, and a supporting-foot rotation angle (α3) of 135.2°. The excessive forward lean indicates that Karateka C was unable to maintain a stable center of mass. The supporting-foot rotation angle suggests insufficient rotational movement needed to facilitate a freer hip motion. Additionally, the arm position—opening up to an angle of 151°—indicates inadequate upper-body guarding. Such shortcomings may negatively affect technical scoring in competition, as body protection, in addition to kick accuracy, is an essential component of performance evaluation.

Table 4.
Analysis Karateka D

No	Variable	Kick Mawashi-Geri
1	α1 (foot opening angle)	130,9°
2	α2 (body inclination angle)	138,5°
3	α3 (support foot rotation angle)	122,3°

The observations in Table 4. Analysis of Karateka D show a foot-opening angle (α1) of 130.9°, a body-lean angle (α2) of 138.5°, and a supporting-foot rotation angle (α3) of 122.3°. The movement pattern of Karateka D indicates a tendency for the body to lean backward, which prevents the swing force from flowing effectively from the hips to the kicking leg. The hip-rotation angle, which does not reach the ideal range, causes the kick trajectory to shift toward a more vertical direction. The supporting foot also fails to open sufficiently, limiting the transfer of force from the ground. The kick trajectory further shows a tendency to move upward rather than laterally as required for an optimal Mawashi-Geri. The absence of a clear recoil phase indicates that Karateka D has not yet developed adequate control over the movement.

Table 5.
Analysis Karateka E

No	Variabel	Kick Mawashi-Geri
1	α1 (foot opening angle)	107,2°
2	α2 (body inclination angle)	128,3°
3	α3 (support foot rotation)	135,9°

For the category of karateka in the –70 kg weight class, the angular measurement results are presented in Table 5. Analysis of Karateka E and Table 6. Analysis of Karateka

F. For Karateka E, the foot-opening angle (α1) measures 107.2°, the body-lean angle (α2) is 128.3°, and the supporting-foot rotation (α3) reaches 135.9°. The kicking trajectory of Karateka E still appears upright because the foot-opening angle does not remain stable along the circular path. The backward lean further reduces propulsion force during execution. Coordination between the supporting leg and the kicking leg also appears inconsistent, compounded by the absence of a visible recoil phase—an indication that post-contact body control is not yet fully established. These issues highlight the need for hip-strengthening exercises, improved hip flexibility, and targeted training to enhance coordination between the supporting leg and the swinging leg.

Table 6.

Analysis Karateka F

No	Variable	Kick Mawashi-Geri
1	α1 (foot opening angle)	127°
2	α2 (body inclination angle)	135°
3	α3 (support foot rotation angle)	146,7°

Meanwhile, Karateka F, as presented in Table 6. Analysis of Karateka F, demonstrates a foot-opening angle (α1) of 127°, a body-lean angle (α2) of 135°, and a supporting-foot rotation (α3) of 146.7°. The hip-rotation angle of 135° indicates that rotational consistency has not yet reached the ideal range. The supporting-foot angle of 146.7° reflects limited stability and insufficient flexibility in the knee joint. The recorded kicking trajectory of 127° suggests a tendency toward a vertical motion, deviating from the characteristic curved, lateral path expected in a proper Mawashi-Geri. The absence of a recoil phase further indicates that Karateka F requires additional training to improve movement control. These deficiencies can be addressed through core-strengthening exercises, posture-adjustment training, and regular hip-mobility development.

According to the karate technique expert, a Mawashi-Geri must efficiently transmit body power through coordinated hip rotation and supporting-foot pivot. The kick should originate from the outside and curve toward a target positioned slightly to the side of the body. The instep of the foot serves as the striking surface; therefore, the swing trajectory must align with the correct circular path. Hip rotation and pivoting of the supporting foot are essential elements that determine the overall quality of the kick. After delivering the kick, the leg must be retracted immediately so that the body regains stability and remains prepared for subsequent attacks or defensive actions. The expert summarized seven key criteria required to perform an effective Mawashi-Geri, including kicking form, target placement, and accurate distance management.

Meanwhile, according to the karate refereeing expert, a Mawashi-Geri will only earn points if executed with precision across all phases—preparation, execution, and recovery. The technique must demonstrate body control, consistent fighting spirit, and proper sportsmanship. *Zanshin*, or sustained awareness, is a crucial indicator of performance, as it reflects the athlete's readiness to maintain proper posture after executing the kick. Additionally, the timing of the attack must correspond to competitive context, the kicking direction must accurately reach the intended target, and distance management must be executed correctly to avoid deductions in technical scoring.

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Discussion

The analysis conducted using Kinovea software and subsequently reviewed by two expert evaluators indicates that the Mawashi-Geri kicking technique performed by athletes of the Inkanas Kertosono dojo has not yet aligned with biomechanical principles nor with the technical standards established by the World Karate Federation. Studies by Nurhadi et al. (2023) highlight that a stable hip rotation plays a critical role in enhancing power output, movement speed, and trajectory control. Fluctuations in the body inclination angle, ranging from 125° to 151°, show that each athlete exhibits different levels of postural stability.

Measurements of the pivot foot rotation angle show variations between 119° and 146°, indicating that some athletes have not rotated the supporting foot to a sufficient degree. When the supporting foot does not rotate fully, the generated body torque becomes limited, resulting in a less pronounced arc of the Mawashi-Geri. Expert assessments also reveal that several athletes have not executed the recoil phase properly. The recoil phase not only reflects an athlete's ability to control movement but also indicates readiness for subsequent actions and the responsiveness of the neuromuscular system in regulating movement rhythm. The dojo coach further noted that hip flexibility, stability during Zenkutsu-dachi, and the speed of retracting the kicking leg remain common weaknesses among many athletes (Nenggar, 2016).

A number of previous studies support the findings of the current research. Ardiansah and Wahyudi's study on the crescent kick in pencak silat athletes demonstrates that kicking performance is strongly influenced by powerful hip rotation, postural stability, and the ability to maintain an optimal mass line (Ardiansah & Wahyudi, 2020). Reaction speed, muscular coordination, and agility play significant roles in determining kick effectiveness. Integrating previous findings with the results of this study reveals that athletes of the Inkanas Kertosono dojo continue to face challenges related to segmental coordination in generating circular motion.

The quality of the Mawashi-Geri is closely associated with training experience, muscular conditioning, joint flexibility, and intersegmental coordination. Nenggar's research explains that the initial phase of the kick—from knee elevation to the preparatory body position before the swing—plays a decisive role in determining the sequence of movements (Nenggar, 2016). If the initial phase is not executed correctly, subsequent movements will be compromised. Hariri and Sadeghi further assert that an effective Mawashi-Geri requires optimal hip rotation and proper distance management to maintain body alignment (Hariri & Sadeghi, 2020). Based on the current findings, most athletes of the Inkanas Kertosono dojo have mastered the fundamental form of the technique but still require improvement in core strength, hip flexibility, postural alignment, and recoil speed in order to meet WKF standards

The findings of this study indicate that the development of Mawashi-Geri proficiency is not solely dependent on repetitive practice but also requires training that improves body angles, muscular coordination, and pelvic mechanics. Repetition without movement refinement does not lead to meaningful improvement. Coaches should provide exercises focused on hip mobility, strengthening of supporting muscles, and

drills that habituate the body to perform correct rotational movements. The use of video analysis tools such as Kinovea enables athletes to identify specific body segments that are incorrectly aligned. Liu's study explains that video-based feedback allows athletes to observe movements in detail, making subtle technical errors more visible (Liu, 2019). Similarly, research by Hamed and Hassan shows that direct feedback from coaches enhances the body's ability to adapt to new movement patterns, enabling athletes to correct their techniques more efficiently (Hamed & Hassan, 2017).

Based on the combined results of video analysis and expert evaluations, this study illustrates that athletes at the Inkanas Kertosono dojo require a more structured training framework to master the Mawashi-Geri effectively. Training programs should be adjusted according to each athlete's physical condition to ensure optimal progress. Athletes with limited flexibility require higher-intensity hip mobility training, while those with weaker muscle strength should receive targeted core-strengthening exercises. Mastery of the Mawashi-Geri can be achieved through continuous training supported by proper correction of body angles, muscular strengthening, and the use of video analysis to help athletes understand movement through visual feedback. Through these methods, the Mawashi-Geri technique can progress toward a more refined form, better preparing athletes for competitive performance (Wijaya & Wahyudi, 2022).

CONCLUSION

The results of this study on the Mawashi-Geri kicking technique performed by athletes at the Inkanas Kertosono dojo in Nganjuk Regency indicate that its execution remains inconsistent and does not yet fully adhere to biomechanical principles or the standards established by the World Karate Federation. Analysis of movement-related angles namely the leg-opening angle ($\alpha 1$), trunk inclination ($\alpha 2$), and supporting-foot rotation ($\alpha 3$) reveals persistent limitations in intersegmental coordination, pelvic rotation, postural stability, and neuromuscular control. Video-based motion analysis using Kinovea, supported by evaluations from two experts, further demonstrates that several athletes have not yet generated sufficient pelvic rotation, maintained stable posture throughout the kicking phases, or executed rapid and efficient recoil following kick delivery.

Based on these findings, several practical recommendations can be proposed to enhance the Mawashi-Geri performance of developing karate athletes. Coaches are encouraged to design training programs that prioritize movement quality over repetition volume, with specific emphasis on strengthening core musculature, improving hip flexibility, enhancing dynamic balance, and developing structured pelvic rotation patterns. The regular implementation of video-based movement assessment is also recommended to provide athletes with visual and objective feedback, enabling early detection and correction of technical errors. Furthermore, the development of neuromuscular capabilities through coordination drills, agility-based exercises, and rapid recoil training is essential for improving the effectiveness and safety of Mawashi-Geri execution in kumite contexts.

Despite its contributions, this study has several limitations that should be acknowledged. First, the relatively small sample size and the focus on athletes from a single dojo limit the generalizability of the findings to broader karate populations. Second, the study employed a descriptive biomechanical approach without incorporating advanced kinetic measurements such as ground reaction forces or electromyography, which could provide deeper insight into muscle activation patterns and force production during the kicking motion. Third, movement analysis was conducted using two-dimensional video recordings, which may not fully capture the three-dimensional complexity of rotational movements involved in Mawashi-Geri. Finally, the cross-sectional nature of the study does not allow for evaluation of long-term adaptations or performance improvements resulting from targeted training interventions.

Future research is therefore recommended to involve larger and more diverse athlete samples, apply three-dimensional motion capture systems, and integrate longitudinal designs to examine the effectiveness of biomechanically informed training programs. Such approaches would strengthen the evidence base and further support the development of scientifically grounded training strategies for improving karate kicking techniques.

Acknowledgement

The authors would like to express their sincere gratitude to the coaches, athletes, and management of the Inkanas Kertosono Dojo, Nganjuk Regency, for their cooperation and willingness to participate in this study. Special appreciation is extended to the karate technique expert (DAN 2) and the nationally licensed referee for their valuable time, expertise, and objective assessments during the movement analysis process. The authors also acknowledge the support provided by all parties who contributed to the successful completion of this research, including assistance during data collection and analysis. Any remaining limitations or interpretations in this study are the sole responsibility of the authors.

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