

Biomechanical Analysis of Joint Range of Motion During Execution of Ura Mawashi Geri in an Elite Female Karateka: A Single-Subject Case Study

Arslanov Tolibjon

Uzbek State University of Physical Education and Sports

Abstract

Background: Ura mawashi geri is among the most technically demanding, rotationally driven striking techniques in karate, and its successful execution depends on the coordinated movement of the trunk, hip, knee and ankle joints. **Objective:** To determine the joint range of motion (ROM) of an elite female karateka across all major body segments (neck, trunk, shoulders, elbows, hips, knees, ankles) during execution of ura mawashi geri using three-dimensional motion analysis, and to evaluate the degree of left-right asymmetry. **Methods:** A single elite female karate athlete was tested at the Sports Biomechanics Laboratory using an optoelectronic three-dimensional motion analysis (3DMA) system. For each joint and movement plane, minimum, maximum and total range-of-motion values (in degrees) were recorded, with bilateral (left/right) values reported separately where applicable. **Results:** The largest bilateral asymmetry was recorded at the knee (left 83°, right 25° - i.e., the left knee moved through roughly three times the range of the right), followed by shoulder flexion-extension (left 63°, right 30°) and hip flexion-extension (left 42°, right 6°). The elbow and hip abduction-adduction showed negative range values on the right side, indicating that these joints remained in a comparatively fixed position. **Conclusion:** The observed left-right asymmetry is consistent with the unilateral, rotational nature of ura mawashi geri, with the left side functioning as the active, striking side and the right side functioning as the stabilising support side. Single-subject, whole-body ROM profiling of this kind may serve as a useful adjunct to technical and physical preparation monitoring for elite karateka.

Keywords: *karate; ura mawashi geri; range of motion (ROM); biomechanics; 3D motion capture; case study*

Introduction

Rotational kicking techniques of the mawashi geri family, including ura mawashi geri, are among the most frequently applied and technically demanding lower-body techniques in competitive karate. Their effectiveness depends on the coordinated, sequential movement of several joints - hip rotation, knee flexion-extension and trunk stabilisation - commonly described in the literature as a proximal-to-distal kinetic chain.

Recent kinematic and surface electromyographic comparisons between elite and sub-elite female karateka performing Mawashi Geri Jodan have shown that elite athletes complete the technique in significantly less time, display smaller vertical centre-of-mass displacement during the striking phase, and achieve a greater hip joint range of motion than sub-elite athletes, indicating that hip mobility and trunk-pelvis control are central to high-level execution.

Earlier biomechanical modelling of the Mawashi Geri Jodan kick similarly proposed that the sequential transfer of hip, thigh, shank and foot velocities, together with the athlete's postural stability, underlies successful technical execution. Comparative work across striking disciplines (Muay Thai, karate, taekwondo) has further shown that expert practitioners of different disciplines achieve comparable kicking outcomes through markedly different joint-coordination strategies, which argues for describing ROM profiles at the level of the individual athlete and technique rather than relying solely on group averages.

Despite this, ROM data specific to ura mawashi geri in elite female karateka, covering the full body and explicitly reporting left-right asymmetry, remain scarce in the published literature. Most available studies focus either on the lower-limb joints in isolation or on group-averaged kinematics, without separately analysing the asymmetry inherent to a unilateral striking technique. The present case study addresses this gap by reporting a full-body, joint-by-joint ROM profile, with explicit left-right comparison, for a single elite female karateka performing ura mawashi geri.

The aim of this study was therefore twofold: (1) to quantify the minimum, maximum and total range-of-motion values at the neck, trunk, shoulders, elbows, hips, knees and ankles during execution of ura mawashi geri in an elite female

karateka, and (2) to characterise the degree of left-right asymmetry across these joints as an indicator of the technique's unilateral demand.

Methods

Participant

The participant was an elite female karate athlete (born 19 January 2006) affiliated with a national training programme. The athlete had no reported musculoskeletal injury at the time of testing and provided informed consent to participate in the assessment and for the anonymised research use of the resulting data.

Testing Environment and Instrumentation

Testing was conducted at the Sports Biomechanics Laboratory, Uzbek State University of Physical Education and Sport (Chirchik, Uzbekistan), using an optoelectronic three-dimensional motion analysis (3DMA) system. Using retroreflective markers, the system computed joint angles in the sagittal, frontal and transverse planes across all major body segments.

Procedure

Following a standardised warm-up, the athlete performed the ura mawashi geri technique while full-body kinematic data were recorded. For each joint and movement plane, the system extracted the minimum angle, maximum angle and total range of motion (maximum minus minimum) reached during execution of the technique. Left and right values were recorded separately for the shoulders, elbows, hips, knees and ankles; trunk and neck values were recorded as single midline measures.

Data Analysis

As a single-case design, data are reported descriptively (minimum, maximum and range, in degrees), without inferential statistical testing. Left-right asymmetry was evaluated qualitatively by comparing the range of motion of homologous left- and right-side joints.

Results

Table 1 presents the minimum, maximum and range-of-motion values recorded for each joint and movement plane during execution of ura mawashi geri. Trunk tilt and

lateral flexion showed a negligible range (0°), while the neck showed comparatively small ranges of $6\text{--}21^\circ$ across flexion-extension, lateral flexion and rotation.

Segment	Movement / Plane	Side	Min ($^\circ$)	Max ($^\circ$)	Range ($^\circ$)
Trunk	Tilt, anterior[+]/posterior[-]	—	0	0	0
Trunk	Lateral flexion, right[+]/left[-]	—	0	0	0
Neck	Flexion[+]/Extension[-]	—	-22	0	21
Neck	Lateral flexion, right[+]/left[-]	—	-24	-13	11
Neck	Rotation, right[+]/left[-]	—	-62	-55	6
Shoulder	Flexion[+]/Extension[-]	Left	-30	34	63
Shoulder	Flexion[+]/Extension[-]	Right	-14	16	30
Shoulder	Abduction[+]/Adduction[-]]	Left	35	60	25
Shoulder	Abduction[+]/Adduction[-]]	Right	49	0	-50
Elbow	Flexion[+]/Extension[-]	Left	51	0	-52
Elbow	Flexion[+]/Extension[-]	Right	122	126	3
Hip	Flexion[+]/Extension[-]	Left	6	49	42
Hip	Flexion[+]/Extension[-]	Right	-7	0	6
Hip	Abduction[+]/Adduction[-]]	Left	8	27	18
Hip	Abduction[+]/Adduction[-]]	Right	11	0	-12

Segment	Movement / Plane	Side	Min (°)	Max (°)	Range (°)
Knee	Flexion[+]/Extension[-]	Left	15	99	83
Knee	Flexion[+]/Extension[-]	Right	23	48	25
Ankle	Dorsal[+]/Plantar[-] flexion	Left	-14	4	18
Ankle	Dorsal[+]/Plantar[-] flexion	Right	3	25	21

Table 1. Joint range-of-motion values recorded during execution of ura mawashi geri.

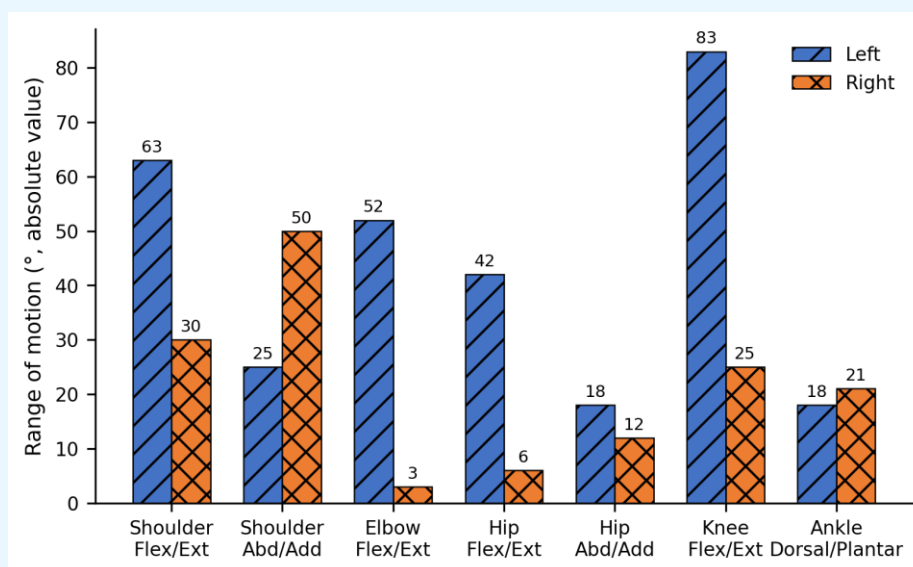


Figure 1. Left-right comparison of absolute range of motion (°) at the bilateral joints during execution of ura mawashi geri.

Figure 1 summarises the bilateral comparison graphically. The most striking finding was the consistent left-right asymmetry recorded at the peripheral (distal) joints of the body. At the knee, the left side moved through an 83° flexion-extension range, compared with only 25° on the right - the left knee thus moved through roughly three times the range of the right. At the shoulder, flexion-extension range was greater on the left (63°) than on the right (30°). The hip showed a similar pattern: the left hip moved through a 42° flexion-extension range, whereas the right hip range was only 6°, remaining almost stationary. At the elbow, the left side moved

from 51° to 0° (a negative range of -52°), indicating that the left elbow moved from a flexed position toward near-full extension, while the right elbow remained within a narrow $122\text{-}126^{\circ}$ band, essentially unmoving. Hip abduction-adduction also showed a negative range on the right side (-12°), indicating that this joint remained adducted, whereas the left hip showed 18° of active abduction. Shoulder abduction-adduction followed the same tendency: left 25° , right -50° (remaining adducted). Only the ankle showed comparable range values on both sides (left 18° , right 21°), though the left ankle operated in a more plantarflexed arc (-14° to 4°) while the right ankle operated in a more dorsiflexed arc (3° to 25°).

Discussion

The joint ROM profile recorded in this case study is fully consistent with the biomechanical signature expected of a unilateral striking technique such as ura mawashi geri, in which one side of the body (the striking leg and its ipsilateral shoulder-elbow complex) performs the active rotational action while the contralateral side functions predominantly as a stable base. This interpretation is supported by the left knee, shoulder and hip showing two- to seven-fold greater range of motion than their right-side counterparts, together with the negative abduction-adduction values recorded at the right hip and shoulder, indicating that these joints remained adducted, or effectively locked, throughout the movement.

The pronounced asymmetry at the knee (83° versus 25°) is particularly noteworthy, since prior biomechanical modelling work has identified the sequential transfer of velocity through the hip-thigh-shank-foot chain as a key factor underlying successful execution of the Mawashi Geri Jodan technique; the large knee range recorded here may represent precisely this terminal-acceleration phase. The negative elbow range (the left elbow moving from flexion toward near-full extension) may likewise reflect the arm's active role in counterbalancing trunk rotation and maintaining balance during the strike.

The comparatively small and symmetrical trunk and neck ranges may reflect the athlete's effort to maintain an upright, stable posture, consistent with earlier reports identifying trunk-pelvis stability as one of the key determinants of technical quality in the mawashi-geri family of kicks. Moreover, a recent comparison of elite and

sub-elite female karateka found that elite athletes show smaller vertical centre-of-mass displacement during the striking phase alongside a greater hip range of motion; the substantial hip range recorded here (42° on the left) together with the athlete's relatively stable trunk posture is broadly consistent with this pattern.

The comparable ankle range values on both sides (left 18° , right 21°), despite each side moving through a fundamentally different arc (plantarflexion-dominant on the left, dorsiflexion-dominant on the right), suggest that the technique places distinct but equally important demands on each foot: the striking-side ankle contributing to correct foot orientation at the moment of impact, and the supporting-side ankle contributing to control of trunk rotation and balance.

From an applied perspective, these findings support the use of individualised, bilateral ROM profiling as part of technical and physical preparation monitoring in elite karate. While functionally expected for a unilateral striking technique, consistent and pronounced left-right asymmetry may also be a useful indicator for prescribing targeted mobility or strengthening work on the non-dominant side, and for injury-risk screening.

Practical Recommendations

On the basis of the patterns identified in this study, several practical recommendations can be offered. First, when teaching and refining ura mawashi geri, coaches should pay particular attention to developing full range of motion at the knee, shoulder and hip on the striking side (the left side in this case), since these joints act as the technique's principal velocity generators. Second, because the comparatively fixed, 'locked' position of the supporting side (the right side) plays an important role in maintaining technical stability, targeted exercises to strengthen the static strength and balance capacity of the supporting limb are recommended. Third, since persistent and pronounced left-right asymmetry may, if it becomes excessive over the course of long-term training, increase the risk of musculoskeletal imbalance and injury on the non-dominant side, periodic bilateral ROM monitoring should be incorporated into sports-medicine and technical-control programmes. Fourth, the three-dimensional ROM profiling approach applied in this single-case study could usefully be extended to other elite karateka and other striking techniques (e.g.,

mawashi geri, yoko geri), contributing to the development of a normative database at the national team level.

Limitations

As a single-case study ($n = 1$), these findings describe one elite athlete's technique during a single testing session and cannot be generalised to the wider karate population. Data were collected without repeated trials, and no direct comparison group (e.g., male karateka, lower-level athletes, or the same athlete performing a different kicking technique) was included. Ground reaction force and temporal (timing) data were not reported here and would strengthen interpretation of the observed ROM asymmetries in future work.

Conclusion

This case study provides a detailed, joint-by-joint ROM profile of an elite female karateka performing ura mawashi geri, revealing pronounced left-right asymmetry at the knee, shoulder and hip alongside small, symmetrical trunk and neck excursion. These results clearly illustrate the unilateral, rotation-dependent demand of the technique and support the value of individualised three-dimensional ROM assessment for technical and physical preparation monitoring in elite karate. Future research should extend this approach to larger samples and multiple trials to establish normative bilateral ROM benchmarks for ura mawashi geri.

References

- Chen, L., Yan, H., Zhu, Y., & Shan, W. (2026). Movement control strategies of the Mawashi Geri Jodan in female karate athletes. *Sports*, 14(4), 134.
- Valdés Cabrera, L. M., Quetglas González, Z., Tabares Arévalos, R. M., & Ruíz Viladón, R. E. (2020). Biomechanical analysis of the Mawashi Geri Jodan kick in Karate-Do. *PODIUM - Revista de Ciencia y Tecnología en la Cultura Física*, 15(1), 111-126.
- Gavagan, C. J., & Sayers, M. G. L. (2017). A biomechanical analysis of the roundhouse kicking technique of expert practitioners: A comparison between the martial arts disciplines of Muay Thai, Karate, and Taekwondo. *PLoS ONE*, 12(8), e0182645.

Kim, Y. K., Kim, Y. H., & Im, S. J. (2011). Inter-joint coordination in producing kicking velocity of taekwondo kicks. *Journal of Sports Science and Medicine*, 10(1), 31-38.

Udara, E. G. D. N., & Chandana, A. W. S. (2021). Biomechanics of roundhouse (mawashi-geri) kicking in karate: A review.

Robalino, J., Cambri, L. T., Cavalcante, A., Franchini, E., Mezêncio, B., & Ferreira, J. C. (2024). Whole-body vibration (WBV) as a conditioning activity for roundhouse kick (mawashi geri) performance in karate. *Journal of Functional Morphology and Kinesiology*, 9(3), 145.