KINEMATICS OF THE SCISSORS KICK IN THE BREASTSTROKE

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This study aimed to clarify the kinematic characteristics of the scissors kick in novice breaststroke swimmers. Six participants exhibited the breaststroke kick and three exhibited the scissors kick. All participants performed two 10-m breaststroke kicks with a board while maintaining a face-down underwater position. The breaststroke kicks were recorded using two synchronized underwater cameras, and three-dimensional analysis was performed on the right-sided kicking movements. The results showed that, with knee flexion, participants who performed scissors kicks showed a significantly greater inversion angle, whereas those who performed normal breaststroke kicks exhibited a change from inversion to eversion before the kick phase. Therefore, it is suggested that the ankle joint may need to be everted while the knee joint flexes to improve the breaststroke kick.

KEYWORDS: swimming, breaststroke kick, motion analysis, novice swimmer.

INTRODUCTION: The breaststroke, a fundamental swimming technique, involves a rhythmic alternation between strokes and kicks. Compared to other swimming strokes, the breaststroke places a greater emphasis on propulsive force generated by the lower limbs rather than the upper limbs (Ungerechts, 1992). The kicking motion plays a pivotal role in providing significant acceleration during breaststroke swimming (Takagi et al., 2004). The swimming rules (Competition Rules 7 Breaststroke 7.5) state that the feet must be turned outward during the propulsive part of the breaststroke kick (World Aquatics, 2024). However, some swimmers encounter challenges mastering the kicking technique during the breaststroke learning process, often resorting to a scissors kick resembling the butterfly kick with both feet or one foot.

Although some studies have focused on the breaststroke kick (Tsunokawa et al., 2015a; Tsunokawa et al., 2015b), none have investigated the kinematic characteristics that cause the scissors kick. Therefore, this study investigated the kinematic characteristics of the scissors kick to clarify the factors that cause it, and to provide teaching material aiding acquisition of the breaststroke kick.

METHODS: Nine male collegiate students participated in this study, three of whom had a scissors kick. The study was approved by the Institutional Ethics Committee of Mie University (approval number 2023-10), and all participants provided informed consent before the study.

The experimental trials were conducted in a short-course swimming pool. Participants began with two 10-m breaststroke kicks as a warm-up, followed by two 10-m breaststroke kicks performed with a board while keeping their faces in the water.

To capture the participants' movements, LED markers (Kirameki; Nobby Tech, Tokyo, Japan) were placed on the right side of each participant at specific anatomical points, including the greater trochanter, center of the femur, fibular head, center of the tibia, lateral condyle, heel, fifth metatarsal, and first metatarsal.

Two underwater video cameras (WAT-2200D; Watec, Yamagata, Japan) were used to record the breaststroke kicks of the right leg, and the recording was synchronously managed using a switcher (ATEM Mini Pro ISO; Blackmagic Design, South Melbourne, Australia) from the participants' right side and rear (capture rate: 60 Hz, exposure time: 1/250 s). The optical angle of the two cameras was approximately 60 degrees.

For motion analysis, the captured images were digitized manually and automatically using a three-dimensional motion analysis system (Frame-DIAS VI; Q'sfix, Tokyo, Japan). The DLT method (Abdel-Aziz and Karara, 1971) was used to calculate the coordinates of the markers attached to the swimmers. The analysis focused on a single kick, ranging from knee extension

to knee extension. The ISB method (Wu et al., 2002) was used to determine joint angles, including extension–flexion of the knee joint and dorsiflexion – plantar flexion, inversion–eversion, and internal rotation–external rotation of the ankle joint. All time data were normalized to 100%.

Descriptive data are presented as means and standard deviations. Non-parametric tests were used due to the limited sample size. Unpaired Mann–Whitney U-test was used to compare knee and ankle joint angles at maximal flexion during normal and scissors kicks. Statistical analyses were conducted using SPSS Statistics (ver. 29.0; IBM, Armonk, NY, USA), with significance set at $P < 0.05$.

RESULTS: Table 1 shows the knee and ankle angles at maximum knee flexion for both the normal breaststroke kick and the scissors kick. The inversion–eversion angle of the ankle joints for swimmers performing the scissors kick was significantly greater than that for swimmers performing the normal breaststroke kick.

Table 1: Knee and ankle joint angles at knee joint maximum flexion.

	Normal (n=6)	Scissors (n=3)	*P* value
Knee angle (deg)	54 ± 5	65 ± 10	0.95
Dorsiflexion(+) / Planter flexion(-) (deg)	15 ± 8	0 ± 10	0.95
Inversion(+) / Eversion(-) (deg)	-4 ± 7	54 ± 11	0.02
Internal rotation(+) / External rotation(-) (deg)	-7 ± 9	9 ± 13	0.26

Figure 1 shows the angular changes in the knee and ankle joints, normalized to 100% time, for the normal breaststroke kick and the scissors kick. In the normal breaststroke kick, the dorsiflexion angle of the ankle joint remained between 30% and 70%, whereas the plantar flexion angle of the ankle joint changed significantly from 40% to 50% in the scissors kick. During knee flexion, the inversion angle of the ankle joint was maintained in the scissors kick, but changed from inversion to eversion in the normal breaststroke kick. The internal rotation–external rotation angle of the ankle changed toward internal rotation with knee extension in the scissors kick but was maintained toward external rotation in the normal breaststroke kick.

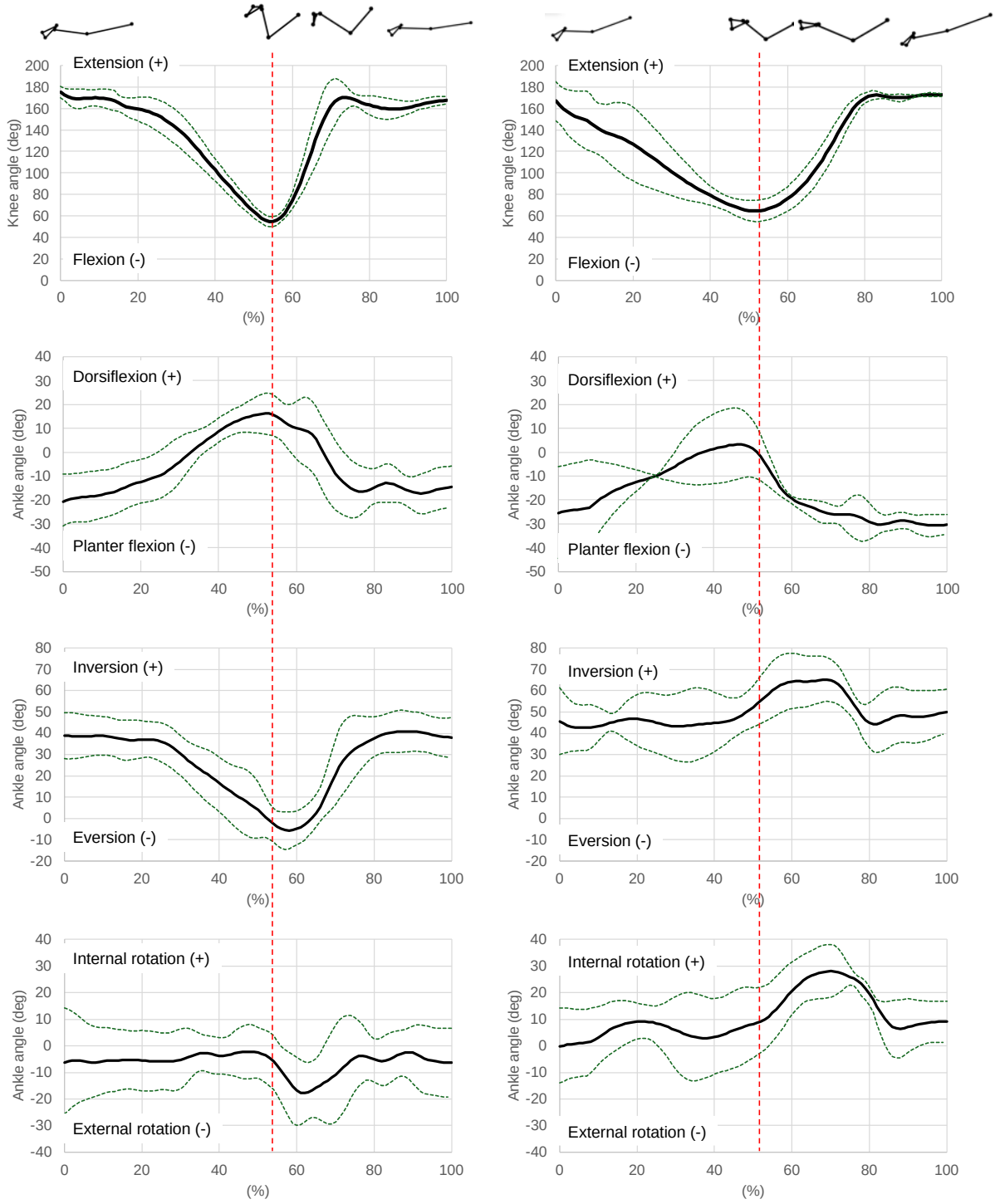

Figure 1: Knee and ankle joint angle changes for the normal breaststroke kick (left) and scissors kick (right) normalized to 100% time. Red dotted lines indicate the timing of maximal knee flexion.

DISCUSSION: The present study quantitatively evaluated a specific kicking technique, the scissors kick, commonly observed in the kicking motion of novice swimmers during breaststroke swimming. In the normal breaststroke kick, ankle dorsiflexion and eversion angles increased with knee flexion. Conversely, in the scissors kick, the inversion and internal rotation angles of the ankle joint were maintained, although the dorsiflexion–plantar flexion angle of the ankle joint increased with knee flexion. At the maximum knee flexion point, the normal breaststroke kick exhibited the ankle eversion angle, while the scissors kick maintained the

ankle in an inverted position. Thus, although both the normal breaststroke kick and scissors kick move in dorsiflexion with knee flexion, the scissors kick has a small dorsiflexion angle, and no eversion or external rotation movements were observed.
During the kicking motion (propulsive phase), the eversion and external rotation angles peaked in the normal breaststroke kick. Since the breaststroke kick requires the foot to rotate outward during the propulsive phase (World Aquatics, 2024), the peak eversion and external rotation angles in the normal breaststroke kick were observed immediately after the kicking motion, indicating that the correct breaststroke kick was performed. In comparison, in the scissors kick, the plantar flexion angle increased, and the inversion and internal rotation angles peaked, during the kicking motion, indicating that the feet rotated inward in the propulsive phase. Therefore, it can be inferred that the ankle joint needs to move in the direction of eversion along with knee joint flexion to acquire the kicking technique in breaststroke swimming. Additionally, during the knee extension phase, it is necessary to move the ankle in the direction of dorsiflexion, placing the foot in an externally rotated position.

CONCLUSION: This study compared the normal breaststroke kick and the scissors kick to elucidate the kinematic characteristics of the kick during breaststroke swimming. Although the inversion and internal rotation angle of the ankle joint were maintained in the scissors kick, the eversion angle of the ankle joint during the normal breaststroke kick increased with knee flexion. Therefore, it is suggested that the ankle joint may need to be everted while the knee joint flexes to improve the breaststroke kick.

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