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KINEMATICS OF JUDO BACKWARD BREAKFALL: COMPARISON BETWEEN NOVICE AND EXPERIENCED JUDOKAS

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This study aimed to investigate the kinematic differences in judo backward breakfall between novice and experienced judokas. Eleven experienced and 13 novice judokas volunteered to participate in the study. Three-dimensional kinematic data were collected while participants performed five sets of backward breakfalls. We documented head-, neck-, trunk-, hip-, and knee-angle–time-curve profiles during judo breakfalls. The results showed significant differences in knee- and trunk-angle time curves, whereas no significant differences were found in head, neck, and hip kinematics between the novice and experienced judokas. These results suggest that motion of the lower extremity requires more attention during the learning of breakfall technique by novice judokas.

KEY WORDS: Injury Prevention, Martial Arts, Motion Analysis, Head Injury

INTRODUCTION: The previous study of Miyazaki (2010) reported that approximately 50% of mild traumatic brain injuries associated with judo occurred when judokas were thrown backward by opponents. Furthermore, the number of head injuries was relatively higher in novice judokas or judokas who had recently started practicing judo at a higher level. When judokas are thrown backward, they execute a backward breakfall technique to avoid their head from hitting the floor. Therefore, it is reasonable to hypothesize that the risk of head injury can be predicted by the skill level of the breakfall and that the incidence of head injuries in novice judokas can be decreased by improving their skill.

For novice judokas to attain proper breakfall skills, it is crucial for judo coaches to understand the biomechanics of judo breakfalls. According to judo manuals, the backward breakfall is characterized by curling up the neck and trunk to prevent the head from hitting the floor and using the hands to decrease the pressure exerted on the body. It is assumed that experienced judokas are able to coordinate their joint motion properly and smoothly, whereas novice judokas may fail to perform some of the important components of the breakfall, which may be related to a higher risk of head injury. However, there is little scientific evidence available for discriminating between good and poor judo backward breakfall skills. Therefore, this study aimed to investigate the kinematics of judo backward breakfall and compare them between novice and experienced judokas.

METHODS: We recruited 11 experienced and 13 novice male judokas from the University for this study. The novice judokas had no competitive or recreational judo experience outside of physical education classes, but all had attended 10 sessions of 90-min judo classes offered at the university. The experienced judokas were on the university judo team and had at least 5 years of competitive judo experience at the time of the study. The mean (±standard deviation) age, height, weight, and judo experience of the experienced judokas were 19.9 ± 1.8 years, 164.2 ± 4.5 cm, 70.1 ± 8.8 kg, and 11.1 ± 4.0 years, respectively, whereas mean age, height, and weight of the novice judokas were 21.4 ± 0.9 years, 169.2 ± 6.2 cm, and 68.6 ± 10.6 kg, respectively. After explaining the purpose and risks of the experiment, we obtained written informed consent from all participants. The study protocol was approved by the Ethics Committee of Ryotokuji University.

We attached 31 reflective markers (diameter, 1.9 cm) on the body landmarks of each participant for motion analysis. The experimental protocol required the participants to perform 10 sets of backward breakfall motions (Figure 1) following practice trials. The participants wore tight-fitting spandex shorts and head gear for safety. As the starting position, they adopted a half-squatting posture with both hands holding parallel bars and shifted their bodyweight backward. Then they executed the backward breakfall onto a urethane matte. Only the last five trials were used for analysis.

We obtained three-dimensional marker trajectory data (60 Hz) using an eight-camera Mac3D motion analysis system (Motion Analysis Corp., Santa Rosa, CA, USA). The marker trajectory data were low-pass filtered through a Butterworth filter at a 6-Hz cutoff frequency. To calculate the flexion angles of the head, neck, trunk, hip, and knee, we used the modified method of Miyashita et al. (2008), wherein the angles were established by two corresponding triangles between the markers to define the body segments (Figure 2). The cardinal angles of each intersegment angle were set at 0° with the subject standing in an upright position. Head, neck, trunk, hip, and knee flexion angles were represented as positive values in this study.

We analyzed the data between the moment when the athletes hit the floor and the end of the breakfall motion. We defined the end of the breakfall motion as the lowest resultant velocity of the top head marker. For analysis, the kinematic data were averaged and normalized into 100 frames to facilitate intergroup comparison.

For statistical analysis, we first calculated the regression formulae for the normalized angle–time curves of each intersegment. We then tested the difference in the coefficient of regression between the two groups to determine the difference in the overall trend of normalized angle curves during the backward breakfall motion. Statistical significance was set at $p < 0.05$ in this study.

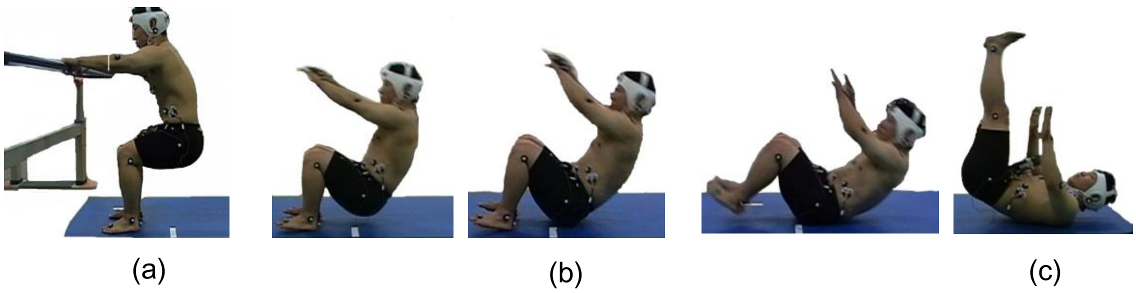

Figure 1: Judo backward breakfall phases: the starting position (a) and the start (b) and end (c) of the breakfall phase

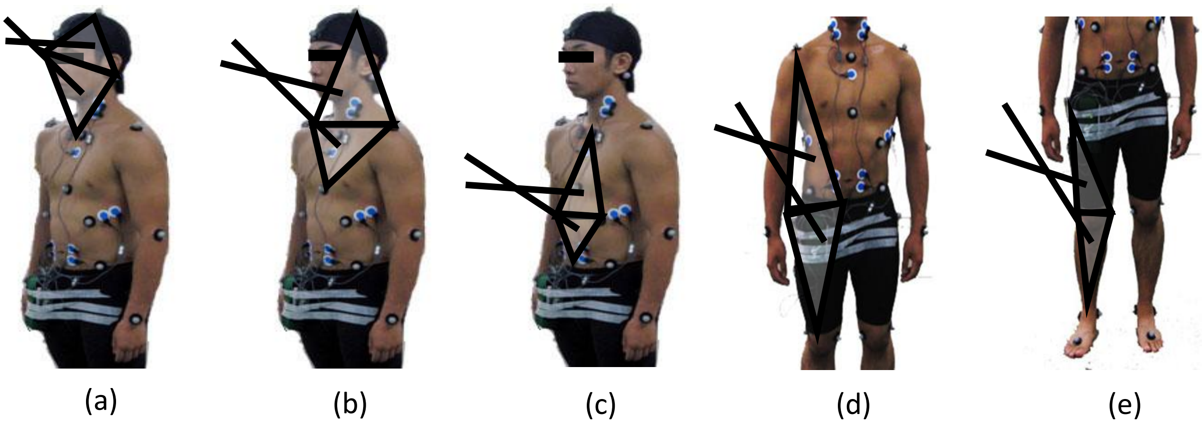

Figure 2: Definitions of the intersegment angle calculations modified by Miyashita et al. (2008): (a) head, (b) neck, (c) trunk, (d) hip, and (e) knee

RESULTS: Figure 3 illustrates the normalized intersegment angle data for the neck, trunk, hip, and knee in the novice and experienced groups. The results demonstrated significant differences in the regression formulae for knee flexion (to = 7.235, df = 196, P < 0.001) and trunk flexion (t_o = 2.637, df = 196, *P* < 0.05) angle curves between the two groups.

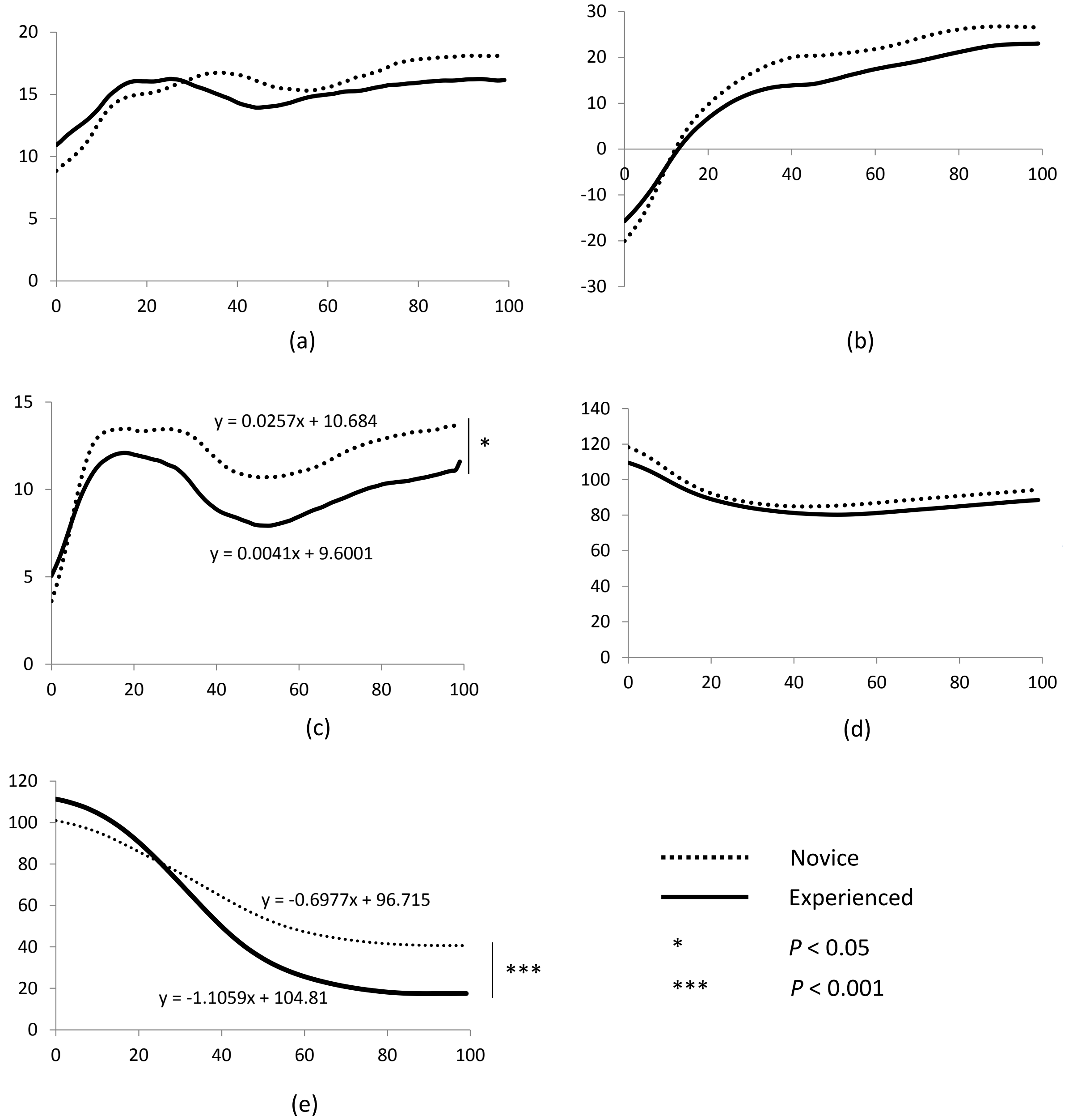

Figure 3: Intersegment angle–time curves during judo backward breakfall: (a) head, (b) neck, (c) trunk, (d) hip, and (e) knee

DISCUSSION: The primary result of the current study was that the experienced judokas demonstrated a greater change in knee angle, especially during the early phase of the breakfall, compared with the novice judokas. Both the experienced and novice judokas started by extending their knees until approximately 60% of the phase, followed by remaining stable until the end of the phase. However, the experienced judokas demonstrated faster-paced knee extension compared with the novice judokas. We speculate that the rapid knee extension observed in the experienced judokas in the early phase may contribute to the velocity control of backward falling by increasing the distance from the rotation axis to the center of mass of the shank and foot segments. Although further analysis is required to elucidate the roles of knee kinematics in the backward fall, judo coaches may need to pay more attention to knee kinematics when teaching breakfall to novice judokas.

Our results also showed that the trend of trunk kinematics through the breakfall phase was statistically different between the novice and experienced judokas. It appeared that the trunk flexion angle in the novice judokas may have increased over time, whereas the angle was less time-dependent in the experienced judokas. However, differences in trunk kinematics among the novice judokas require careful interpretation. The difference in change in trunk flexion was small between the groups and may be less important than the difference in knee kinematics.

There were no significant differences in the kinematic patterns of the head and neck between the novice and experienced judokas. The heads of both experienced and novice judokas were in a slightly flexed position at the beginning. Consequently, the increase in the angle with flexion occurred up to approximately 20% of the phase, following which the angle remained stable or showed slight flexion during the remainder of the phase. In contrast, the neck flexion angle peaked at approximately 40% of the phase and remained stable or slightly flexed during the last phase of the motion. In this study, all the novice judokas had experienced at least 10 × 90-min sessions of judo class, including backward breakfall practice, although they had performed no judo for several months before the study. Therefore, short-duration judo practice may be sufficient for judokas to maintain neck and head kinematics during backward breakfall.

In the future, we need to investigate the direct relationships between the kinematics variables of judo backward breakfall and the head acceleration control both in the backward breakfall and in the "being thrown "situation. In addition, we need to analyze the kinematics of upper extremity, which may contribute to decrease the momentum of the backward rotation during the movement. Finally, the force applied to the head during the breakfall task is likely to be much lower than that applied while being thrown in judo practice or in a judo match. Further investigation is needed of more challenging situations requiring breakfall tasks.

CONCLUSION: We investigated the kinematic pattern of the judo backward breakfall in novice and experienced judokas. The results showed that there were significant differences in knee and trunk kinematics between the two groups. The result suggests, not only neck and trunk motion, that knee motion also needs more attention during the learning of breakfall technique by novice judokas.

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