NECK AND TRUNK KINEMATICS AND ELECTROMYOGRAPHIC ACTIVITY DURING JUDO BACKWARD BREAKFALLS

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The purpose of this study was to demonstrate the neck and trunk angle time curves as well as electromyographic (EMG) activities during a judo backward breakfall in both experienced and novice judokas. Six experienced and four novice judokas volunteered to participate in the study. Three-dimensional kinematic and EMG data were collected while participants performed five sets of backward breakfalls at their own speed. We demonstrated neck/trunk angle time curves and muscle activation profiles during judo breakfalls. The results showed that there were no significant differences in the variables between experienced and novice judokas, which suggests that even short-term judo practice improves backward breakfall skills and may help prevent injury.

KEY WORDS: judo breakfall, biomechanics, EMG.

INTRODUCTION: According to a previous report, about 60% of mild traumatic brain injuries (MTBI) in judokas (judo athletes) are caused by backward breakfalls. In response to being thrown backward, judokas perform backward breakfalls (Figure 1) by curling up their body with neck and trunk flexion and using their hands to prevent their head from hitting the floor. Therefore, reduction in the number of MTBI would be achieved by performing skilled backward breakfalls achieving correct neck and trunk flexion.

Figure 1: Judo backward breakfall.

A previous report stated that MTBI more frequently occurred in novice judokas, which suggests that poor breakfall skills may be related to the occurrence of MTBI. Although it is a relatively simple skill and is easy to learn, we do not fully understand the biomechanics of the neck and trunk during a breakfall in either novice or experienced judokas. Therefore, the purpose of this study was to investigate the neck and trunk angle waveforms and electromyographic (EMG) activities during backward breakfalls and compare these variables between novice and experienced judokas.

METHODS: Six experienced male judokas (19-22 y; 166.0-177.8 cm; 65.5-79.3 kg; years of judo experience 7-12 y) and four novice male judokas (19-21 y; 163.2-174.3 cm; 50.0-86.2 kg) participated in the study. All the novice judokas had attended at least 10 sessions (15 sessions maximum) of judo classes at Ryotokuji University in the past 2 years. The mean period of absence from judo training in the novice judokas was 15 months (6-22 months). Prior to their enrollment in the study, all participants gave written informed consent. The study protocol was approved by the Ethics Committee of the University.
For motion analysis, we attached 31 reflective markers (diameter, 1.9 cm) on bony landmarks of the participants as follows: top of the head, front of the head, rear of the head, mastoid process, left/right acromion process, elbows, wrists, upper sternum, left/right 10th rib, xiphoid process, left/right anterior superior iliac spine (ASIS), greater trochanters, medial/lateral knees, medial/lateral ankles, toes and heels (Figure 2). We computed the neck and trunk flexion angles reached during the judo backward breakfall. To calculate the neck and trunk flexion angles, we used a modified method of Miyashita et al., (2008), in which the angles were established by two corresponding triangles between the markers to define the body segments. To calculate the neck flexion angle, we formed one triangle using the two

acromion process markers and the markers at the top of the head. The other triangle was formed using the two acromion process markers and lower sternum (xiphoid process) marker. To calculate the trunk flexion angle we formed one triangle using the two rib markers and upper sternum marker, whereas the other triangle was formed using the two rib markers and the middle point of the ASIS markers. We then calculated the normal unit vectors projected from each corresponding triangle and the inner products of the two unit vectors. The cosine angle of the inner products was defined as each joint angle. The cardinal angles of the neck and trunk flexion were set as 0º when the participant stood in an upright position.

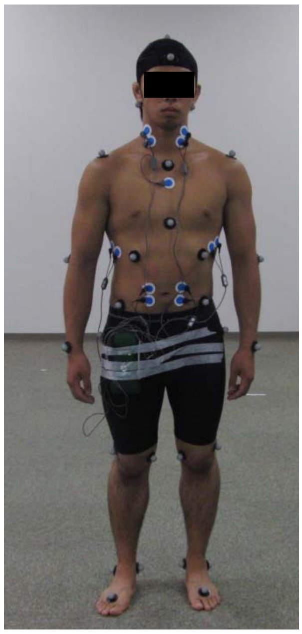

Figure 2: Placement of reflective markers and EMG electrodes.

The experimental protocol required participants to perform five sets of backward breakfalls. First, the participant adopted a squatting posture with both hands holding parallel bars as the starting position. Then, the participants executed the backward breakfall at their own speed onto a urethane mat.

We obtained three-dimensional (3D) marker trajectory data for the breakfall motion (60 Hz) using an eight-camera Mac3D motion analysis system (Motion Analysis Corp., Santa Rosa, CA, USA). The marker trajectory data were then low-pass filtered through a Butterworth filter at a 6-Hz cutoff frequency.

We attached two surface electrodes on both sides of the sternocleidomastoid, external oblique and rectus abdominis muscles on areas of the skin prepared using a standard procedure (Figure 2). All EMG data were collected at 1,000 Hz using an eight-channel Tele MyoG2 system (Noraxon U.S.A. Inc., Scottsdale, USA) and were fully rectified, followed by band-pass filtering with cutoff frequencies of 10 and 350 Hz. For each trial, the EMG data collected during the breakfall trials for each muscle were normalized to the peak EMG amplitude. The kinetic and EMG data were electrically synchronized and normalized into 200 frames. To represent the muscle activation pattern during the breakfall, we subdivided the entire breakfall into five temporal phases and found the average percentage of the peak EMG amplitude during each phase. The averaged EMG data of both sides were used for statistical analysis.

We used the coefficient of multiple correlation (CMC) to quantify the similarity between the mean neck and trunk flexion angle time courses between the novice and experienced judokas (Mackey, Walt, Lobb, & Stott, 2005). In addition, for percentage of peak EMG amplitude data, we used inverse sine transformation and performed a two-way analysis of variance (ANOVA) (group × subdivided phase). This was followed by multiple comparisons using the Tukey method to examine the differences among muscle activation level and the phase. Statistical significance was set at 0.05 in this study.

RESULTS: Figure 3 illustrates the mean neck and trunk flexion angle curves during the breakfall technique for novice and experienced judokas. The CMC in the neck and trunk flexion angle-time curves were 0.989 and 0.954, respectively.

Figure 4 illustrates the mean percentage of peak EMG amplitude observed in each target muscle during the breakfalls, for the novice and experienced judokas. The result of a two-way ANOVA demonstrated that there was a significant difference in the percentage peak EMG amplitude of the sternocleidomastoid (F=25.665, df=4, p=0.004), external oblique (F=10.423, df=4, p <0.022) and rectus abdominis (F=98.049, df=4, p <0.001) muscles between the temporal phases, but not between experienced and novice judokas (p >0.05).

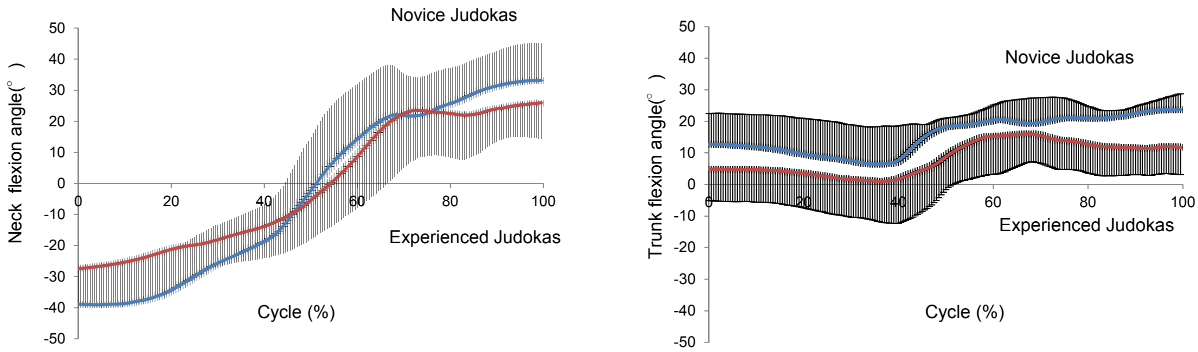

Figure 3: Mean neck and trunk flexion angle time curves during backward breakfalls.

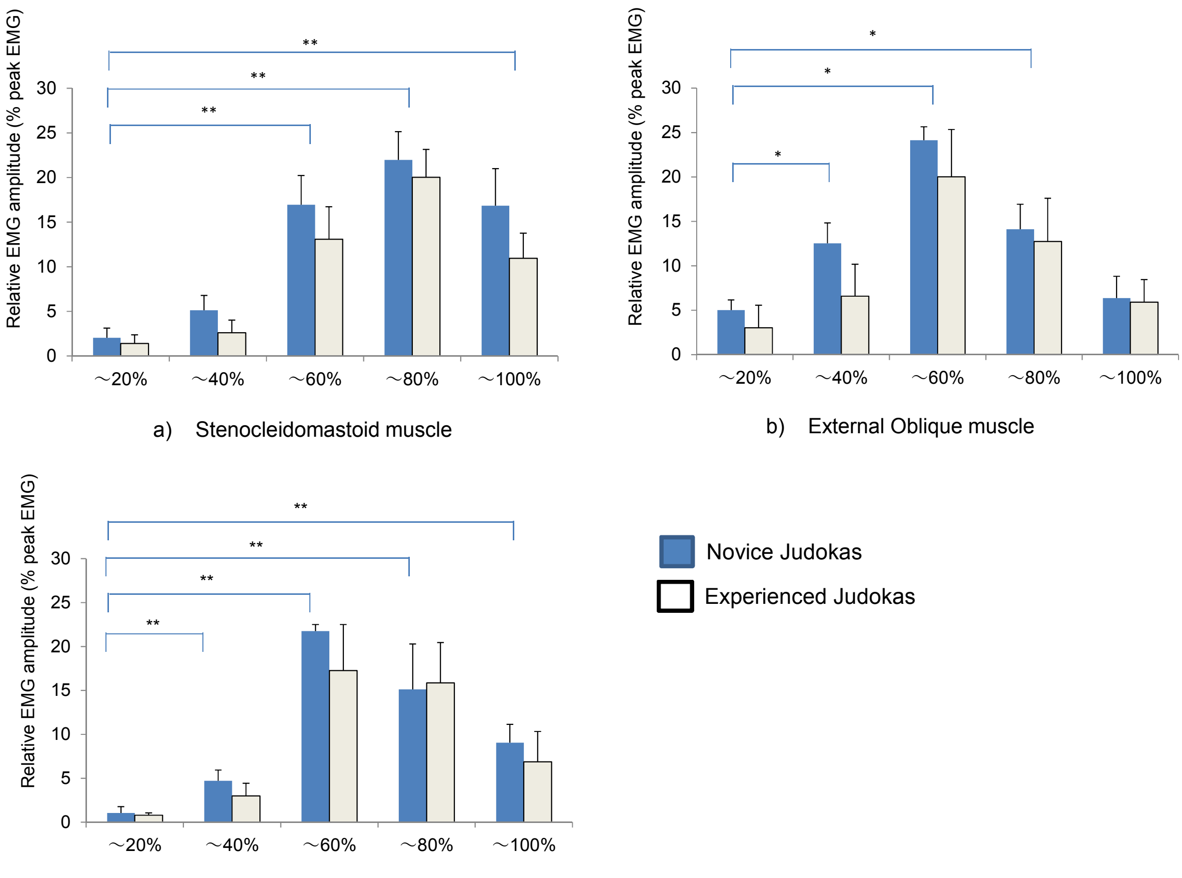

Figure 4: Muscle activation pattern of neck and trunk muscles during backward breakfalls; (* *p* <0.05, ** *p* <0.01); EMG electromyography.

DISCUSSION: The current result suggests that even short-term judo practice may improve backward breakfall skill in novice judokas. In this study, there were no significant differences in the kinematic pattern of neck and trunk between the novice and experienced judokas. Both groups used not only neck but also trunk flexion to prevent their head from hitting the floor during a backward breakfall. On the basis of visual observations of the angle curves, the neck flexion angle increased from the beginning of the motion to approximately 60% of the phase, whereas the trunk flexion angle started at a slight flexion position and then further increased from 40%–60%. The neck and trunk flexion angles remained stable during the last phase of motion. In addition, the EMG data revealed that the muscle activation profiles are

similar between the two groups. In both groups, the external oblique muscle appeared to be more activated during the earlier phase, whereas the sternocleidomastoid muscle appeared to be more activated during the later phase of the breakfall.
Our result also demonstrated retention of the backward breakfall skill after only short-term judo practice. Lo et al. (2003) reported that forward breakfall skill training for only 10 min successfully reduced the impact force to the floor; however, the retention was so poor that the healthy subject who received intervention did not retain the short-term learning after 3 weeks. In this study, the novice judokas had experienced at least 10×90-min sessions of judo incorporating backward breakfall practice, even though on average, no judo practice had been undertaken for several months. This short duration of practice may be sufficient for judokas to retain breakfall skill. It is important to note that the force applied to the head during the breakfall task would likely be much lower than that applied when being thrown in judo practice or a judo match. Therefore, we are not able to conclude that in a real judo situation novice judokas would benefit from the backward breakfall skill and subsequent prevention of head injury. Further investigation of neck and trunk biomechanics is needed in more challenging situations requiring breakfalls.

CONCLUSION: We demonstrated the neck and trunk angle curves and EMG activities of the neck and trunk muscles during judo backward breakfalls. We also found that there were no significant differences between novice and experienced judokas in neck and trunk flexion angle-time curves and EMG activation patterns during the breakfalls.

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Acknowledgement: Financial support was provided by a grant from the Kozuki Foundation for Sports and Education. We also would like to acknowledge Enago (www.enago.jp) for the English language review.