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COMPARISON OF ANGULAR FACTORS TO DETERMINE QUICKNESS IN SEOI-NAGE BETWEEN ELITE AND COLLEGE JUDO ATHLETES

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The purpose of this study was to identify factors to determine the quickness of a Seoi-nage by comparing the kinematic parameters during the *Kuzushi* and *Tsukuri* phases between elite and college Judo athletes. Three-dimensional data were collected on seoi-nage performed by three male elite judo athletes and seven male local college athletes using a three-dimensional motion analysis technique. This study found that the angular velocity of the upper limb of elite judo athletes was much faster than that of the college athletes. The elite athletes performed Seoi-nage with a technique in which they rotated lower body first, and then upper body so that the rotation of the upper limb was minimized in the early part of the turning phase. This finding can help teaching of a quick seoi-nage

KEYWORDS: Nage-waza, quickness, motion analysis, Judo.

INTRODUCTION: Quickness of movements is one of the most important factors to determine the sports performance. Quickness partially depends on the speed of movements that athletes engage in sports situation. Therefore, the analysis of movements is crucial to establish the effective teaching programs for quickness in sports. In case of Judo, the determinants of the quickness have little discussed in either scientific papers or Judo textbooks throughly. Judo coaches have used certain practice routines that are believed to shorten the time of throwing movement (*Nagewaza*); however, there is few scientific evidence that justfy the use of the rotuines. Therefore, we believe that it is crucial to investigate factors to determine the quickness of Nage-waza for better coaching.
In addition, we also need to understand the kinematic characteristics of Nage-waza. In Nage-waza, Judo athletes break the opponent's balance and lead the opponent's center of gravity out of the base of support for preparation of throwing (*Kuzushi*). The previous studies suggest that the kinematics of *Kuzushi* may determine whether Judo athletes were able to quickly put themselves in the right position for Nage-waza (*Tsukuri*)(Imamura, Hreljac, Escamilla and Edwards, 2006). Therefore, the purpose of this study was to identify factors to determine the quickness of a Seoi-nage by comparing the kinematic parameters during the *Kuzushi* and *Tsukuri* phases between elite and college Judo athletes.

METHODS: The subjects were three male elite Judo athletes (medalists in 2010 world judo championships, 24.3 ± 2.1 years of age, 1.66 ± 0.05 m in height, 72.6 ± 6.9 kg in body mass) and seven male college Judo athletes (20.0 ± 1.2 years of age, 1.65 ± 0.04 m in height, 70.6 ± 5.8 kg in body mass). Three-dimensional coordinates data of the segment end points of the subjects performing Seoi-nage in pre-arranged sparring drills (Yakusoku-renshu) were captured by using an 18-camera Vicon MX system (Oxford Metrics Inc., UK) operating at 250 Hz. The subjects wore a pair of spandex pants and specially designed Judo clothes.
Data Analysis: Three-dimensional coordinates data were smoothed by a Butterworth digital filter with cut-off frequencies ranging from 5.8 to 9.3 Hz, which were decided by a residual method. The center of mass (COM) of each segment was estimated by using Japanese athlete's body segment parameters (Ae, 1996). The primary variables were the motion time of Tori, the angular velocity of the line connecting COMs of the right leg and the left leg (leg line), the line connecting the right hip and the left hip (hip line), the line connecting the right shoulder

and the left shoulder (shoulder line) and the line connecting the COMs of the right arm and the left arm (arm line), the ratio of the peak angular velocities of the arm line to the leg line.
The Seoi-nage was divided into turning (front-turn movement) and throwing phases. The turning phase was defined from the toe-off of the pivot foot to the contact of both feet with the mat. Kinematic data were normalized by the time of the turning phase, as 100% time and averaged every 1% time.

RESULTS: Figure 1 shows the motion time of the turning phase in Seoi-nage. The motion time of the elite athletes ranged form 0.56 to 0.61 sec, and the average motion time of college athletes was 0.58 ± 0.05 sec.

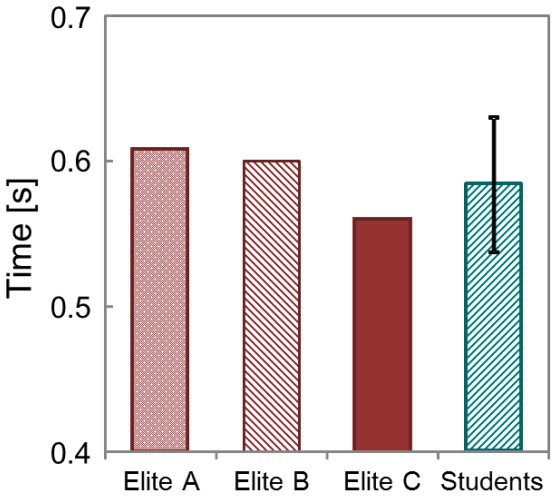

Figure 10: Motion time of the turning phase in seoi-nage.

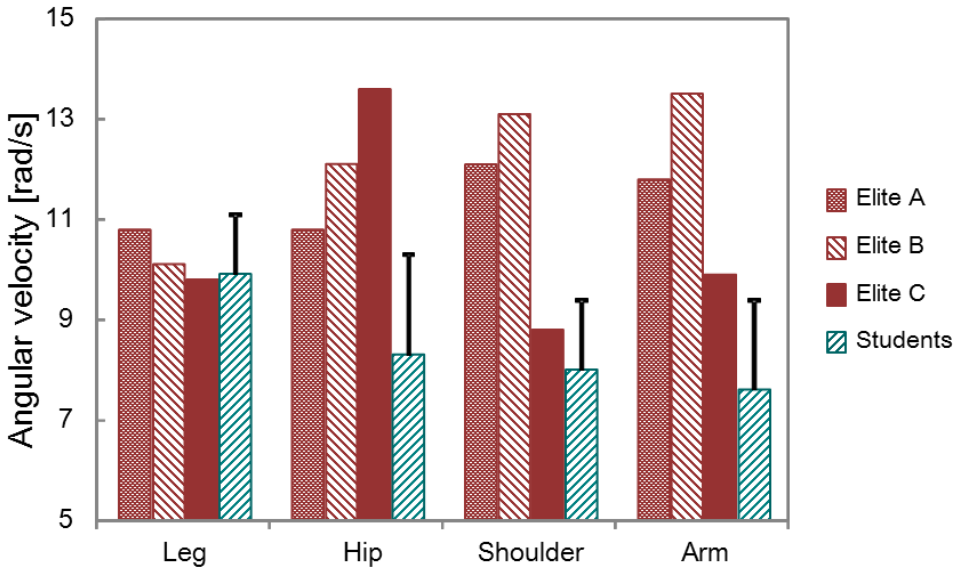

Figure 2: Peak angular velocity of body part lines in the turning phase.

Figure 2 shows the peak angular velocity of the body part lines in the turning phase. The peak angular velocity of the arm line of the elite athletes ranged from 9.8 to 10.8 rad/s, and the average peak angular velocity of the arm line of college athletes was 9.9 ± 1.2 rad/s. The peak angular velocity of the hip line of the elite athletes ranged from 10.8 to 13.6 rad/s, and the average peak angular velocity of the hip line of college athletes was 8.3 ± 2.0 rad/s. The peak angular velocity of the shoulder line of the elite athletes ranged from 8.8 to 13.1 rad/s, and the

average peak angular velocity of the shoulder line of college athletes was 8.0 ± 1.4 rad/s. The peak angular velocity of the arm line of the elite athletes ranged from 9.9 to 13.5 rad/s, and the average peak angular velocity of the arm line of college athletes was 7.6 ± 1.8 rad/s. The ratio of the peak angular velocity of the arm line to the peak angular velocity of the leg line of elite athletes ranged from 1.01 to 1.34, and the average ratio of the peak angular velocity of the arm line to the peak angular velocity of the leg line of college athletes was 0.77. Although peak angular velocities of the elite athletes were greater in hip and arm lines than those of college athletes, there were no differences in the angular velocities of leg and shoulder lines.

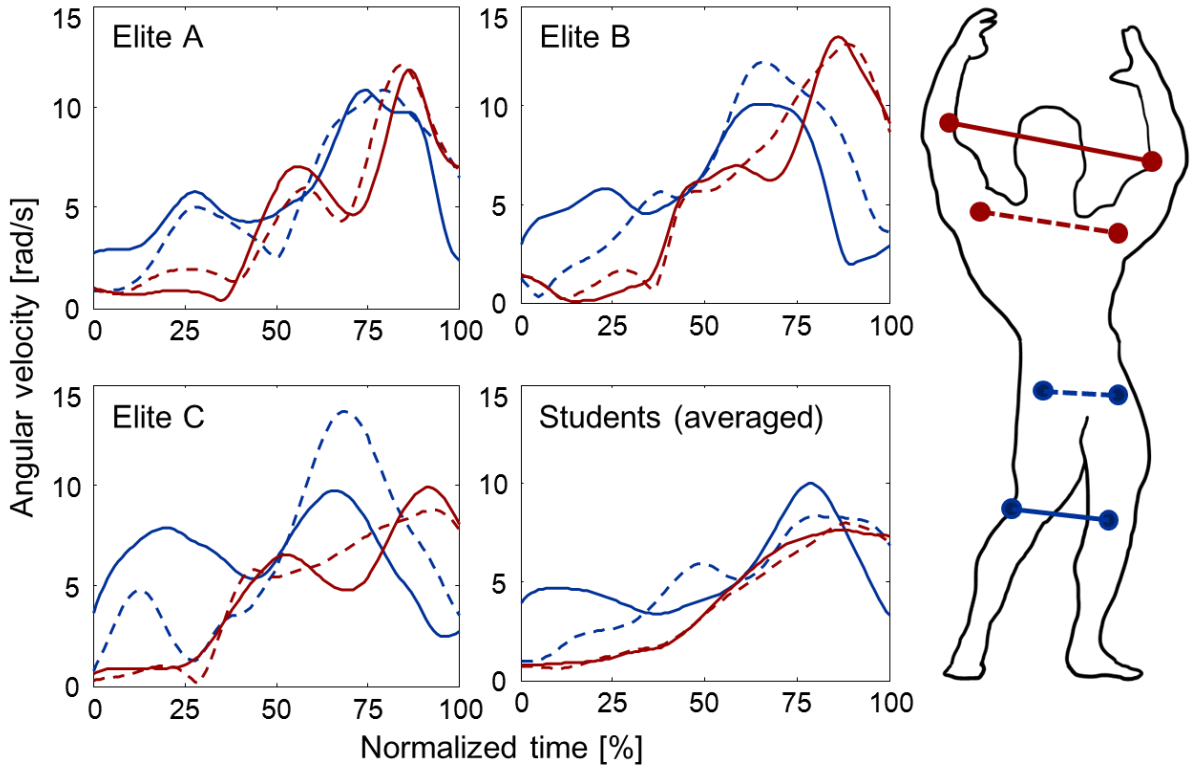

Figure 3: Change in the angular velocity of body part lines in the turning phase.

Figure 3 illustrates the change in the angular velocity of body part lines in the turning phase. The angular velocity of the leg line of elite athletes increased just after the start of the turning phase to 20-25% time and reached the maximum around the 65-75% time. The angular velocity of the hip line of elite athletes changed as the similar pattern to the leg line. The angular velocity of the shoulder line and the arm line of elite athletes quickly increased from 25-35% time and reached the maximum around the 80-100% time. The angular velocity of shoulder line and arm line of college athletes gradually increased from the start of the turning phase and reached the maximum around the 75-90% time.

DISCUSSION: Previous investigations demonstrated that the time from the pivot foot contact to both feet contacting was 0.35 s on average for two college judo-athletes, 3rd grades (Hirosaki, Suganami, & Hirose, 1989), while the result of the elite athletes was 0.26 s, approximately 0.1 s shorter(Ishii, Ae, Kobayashi, Suzuki, 2012). However, the result of the present study indicated that there were no difference in the motion time between elite athletes and college athletes. We can say that the quickness of the movement in Nage-waza is not always equal to the motion time of the front-turn movement. Some investigates pointed out elite athletes turned leg quickly and rotated hips quickly (Jeon, 2001, Hosokawa, 2005, Yoshitaka, 2005, Suzuki, 2005), these seem to be observational and empirical descriptions. The peak angular velocity of body part lines of college athletes were relatively smaller than

those of the elite A. There was a significant difference in the magnitude of the peak angular velocity of the arm line between elite athletes and college athletes. It is likely that the factors relating to the quickness for Seoi-nage is the angular velocity of the arm line. The angular velocity of the shoulder and arm lines of elite athletes were in relatively higher level from the start of the turning phase to 25-35% time. It is inferred that at the start of Seoi-nage the elite athletes does not give the opponents clear visual and somatosensory inputs. However, since the angular velocities of the body part lines were very large in the final part of Nage-waza, the opponents may feel that the motion of elite athletes was so quick.
Until now, many judo coaches implement a kakari-renshu with instruction to shorten the motion time vaguely, but this may not improve actual quickness of Nage-waza of athletes.

CONCLUSIONS: This study found that the angular velocity of the upper limb of elite judo athletes was much faster than that of the college athletes. The elite athletes performed Seoi-nage with a technique in which they rotated the lower body first, and then upper body so that the time and range of rotation of the upper body was able to minimize in the early part of the turning phase. This finding helps coaches to design better practice routines to improve the quickness of Nagewaza.

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