FRONT-TURN MOVEMENT IN SEOI-NAGE OF ELITE JUDO ATHLETES

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The purpose of our work was to investigate the control of the front-turn movement (*Mae-mawari sabaki*) for seoi-nage of elite judo athletes to obtain findings for effective coaching. Three-dimensional data were collected on seoi-nage performed by six elite judo athletes using a three-dimensional motion analysis technique. The most distinguishing feature of the present study results is that the decrease in the trunk inclination angle closely related to the decrease in the moment of inertia of the body in the turning phase. This study found that elite judo athletes performed seoi-nage by turning their body while quickly raising their trunk so that the moment of inertia of the body about the vertical axis was minimized.

KEYWORDS: nage-waza, yakusoku-renshu, motion analysis.

INTRODUCTION: Seoi-nage in judo is categorized in group one of the Gokyo no waza (five groups for teaching judo)**.** Seoi-nage is also frequently used by many judo athletes during practice and competition. Therefore, it has been described and explained in many books of judo skill (Nomura, 1999; Sato, 2005). Although the books have given us great knowledge about the structure of the technique and helped us to improve the skill, the descriptions are usually experiential and therefore diverse, potentially causing confusion for coaches as well as athletes. Research on judo is expected to obtain science-based knowledge to understand the diverse descriptions, some of which (Otaki, 1988; Tsuge, Matsushima, Takeuchi, & Nakamura, 1994) are very scientific and valuable. To the best of the authors' knowledge, however, no investigation has yet been carried out to clarify the control of the front-turn movement in seoi-nage.

The success of nage-wazas (throwing-techniques) is determined by their speed, and highly advanced nage-wazas are often completed before the opponents respond to it. Some authorities stated the importance of "speed" of nage-wazas in many technical books (Kurihara, 1970; Jeon, 2001). However, they did not describe how to perform seoi-nage in a short time and with quickness. The only information that recent studies have implied was that seoi-nage's speed may relate to appropriate trunk position (Ishii, Kanamaru, Ae, Okada, & Komata, 2011), which is not enough to understand seoi-nage and improve the quickness of athletes. Therefore, the purpose of this study was to investigate the control of the front-turn movement in seoi-nage of elite judo athletes to obtain findings for effective coaching.

METHODS: Six elite judo athletes (medalists in world championships or junior world championships, three males and three females (23.8 ±3.0 y, 1.613 ±0.052 m, 63.33 ±10.70 kg) participated in the study. Three-dimensional data of the subjects performing seoi-nage in pre-arranged sparring drills (yakusoku-renshu) were collected using an 18-camera Vicon MX system (Oxford Metrics Inc., UK) operating at 250 Hz. Furthermore, we positioned the cameras so as not to block the marker by the Uke. The subjects wore a pair of spandex long pants, a long-sleeved shirt, and specially designed lapels and sleeves that imitate judo clothes.

Three-dimensional coordinate data were smoothed by a Butterworth digital filter at cut-off frequencies ranging from 15 to 35 Hz, which were decided by a residual method. The primary variables computed were the body and segment centers of mass, trunk inclination angle, and the moment of inertia about the vertical axis passing through the body's center of mass.

The seoi-nage was divided into distancing, turning (front-turn movement) and throwing phases. The turning phase was defined as from the lifting of the pivot foot to the contact of both feet with the mat. Kinematic data were normalized over the entire seoi-nage movement phase, as 200% time, and then averaged every 1% time. The turning phase was from 90% to 140% time on average. The relationship between the trunk inclination angle and the moment of inertia about the vertical axis passing through the body's center of mass was evaluated by Pearson's correlation coefficient.

RESULTS: Figure 1 illustrates the change in the moment of inertia about the vertical axis passing through the body's center of mass in seoi-nage. The body's moment of inertia gradually increased from the start of the distancing phase and reached the maximum at the end of the distancing phase. The body's moment of inertia quickly decreased to 1.56 ±0.34 kgm^2 in the turning phase. The standard deviation of the moment of inertia became small in the latter half of the turning phase. The time from the pivot foot contact to both feet contacting was 0.26 s for male subjects.

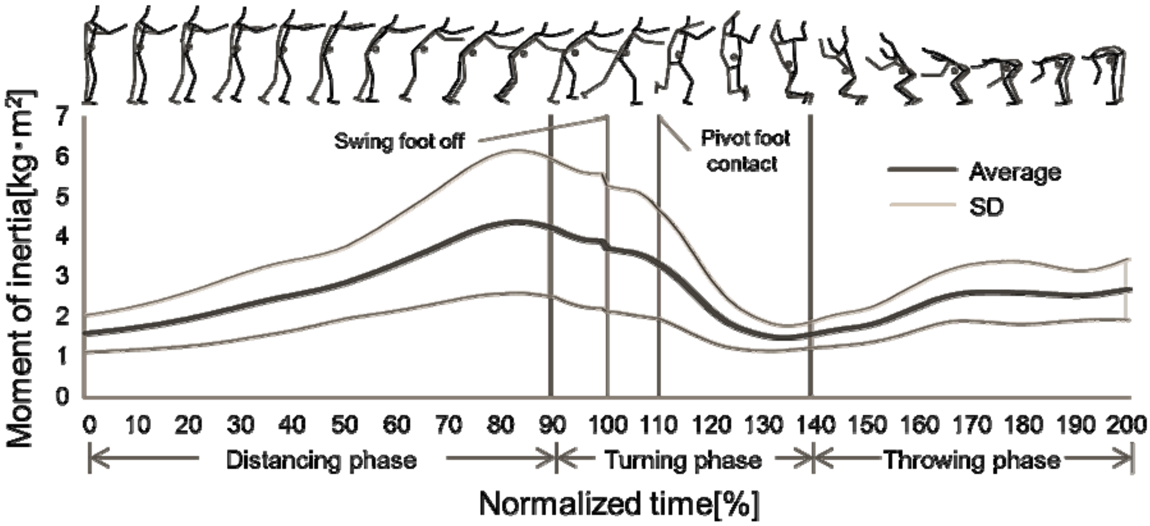

Figure 4: Change in the moment of inertia about the vertical axis passing through the body's center of mass.

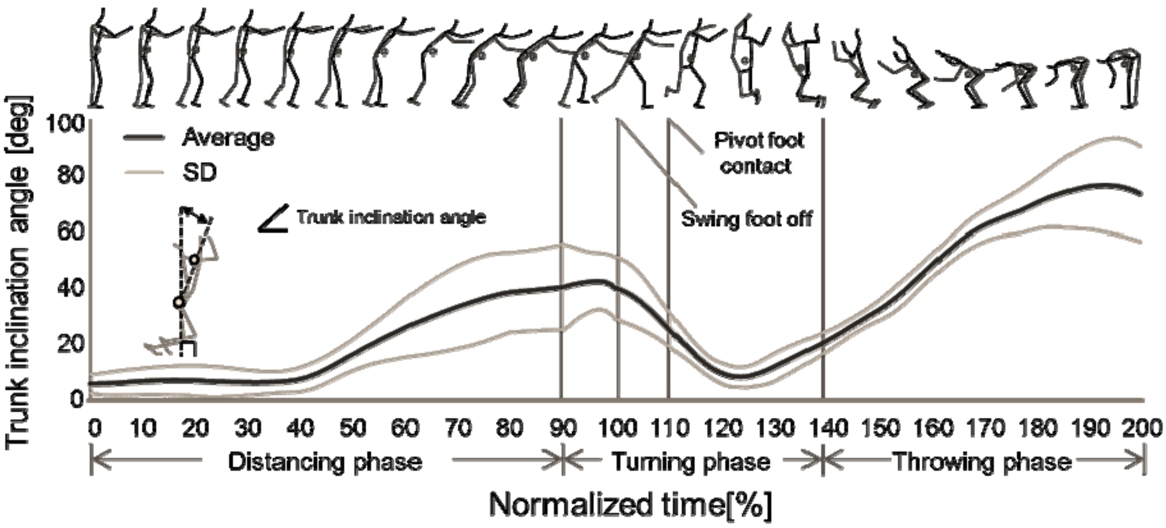

Figure 2: Change in the trunk inclination angle.

Figure 2 depicts the change in the trunk inclination angle in seoi-nage. The trunk inclination angle gradually increased from the middle of the distancing phase and reached the maximum in the early part of the turning phase. After the instant of toe-off of the swing foot, the trunk was quickly extended until the middle of the turning phase. In the throwing phase, the trunk was quickly inclined forward again to put the opponent on their back. The standard deviation of the trunk inclination angle become small from the latter half of the turning phase to the former half of the throwing phase. This result was similar to those of previous investigations in which the trunk inclination angle at the end of the turning phase was very small (Ishii et al., 2011).

Figure 3 illustrates the relationship between the trunk inclination angle and the body's moment of inertia in the averaged data. With the decrease in the trunk inclination angle, the body's moment of inertia decreased in the turning phase. The correlation between the trunk inclination angle and the body's moment of inertia was very high (r=0.900, P<0.0001).

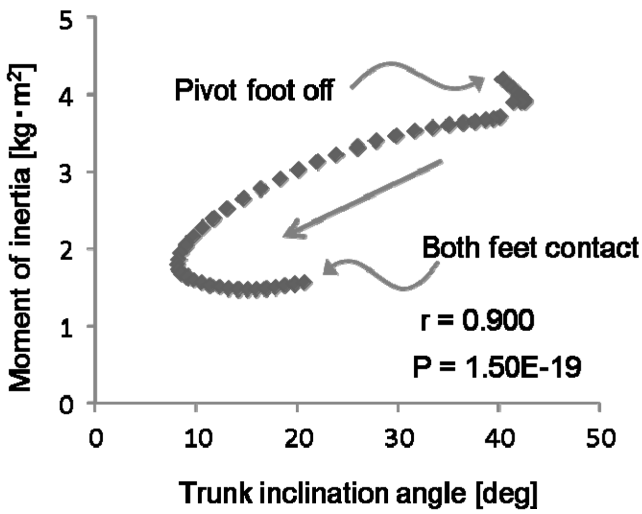

Figure 3: Relationship between the trunk inclination angle and the moment of inertia.

DISCUSSION: Previous investigations demonstrated that the time from the pivot foot contact to both feet contacting was 0.35 s on average for two collegiate judo-athletes, 3rd grades (Hirosaki, Suganami, & Hirose, 1989), while the result of the present study was 0.26 s, approximately 0.1 s shorter. It is likely that the front-turn movement for the elite subjects in the seoi-nage is much faster than that of the collegiate judo athletes. An elite athlete in competition has to perform their seoi-nage before an opponent elite athlete completes a defensive movement. The results of the present study suggest that the elite judo athletes seemed to rapidly decrease the moment of inertia after the toe-off of the swing foot until the middle of the turning phase to fulfill this task. The most distinguishing feature of the present study is that the decrease in the trunk inclination angle closely related to the decrease in the moment of inertia in the turning phase. This agrees with the finding that the speed of seoi-nage may be associated with the trunk position.

CONCLUSIONS: This study found that elite judo athletes performed seoi-nage with a technique in which they turned their body while quickly raising their trunk so that the body's moment of inertia was minimized. This finding can help learning of a quick seoi-nage by focusing on the trunk position.

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