THE EFFECT OF TARGET HEIGHT ON KINEMATICS OF ROUND KICK IN TAEKWONDO AND HAPKIDO

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Taekwondo and Hapkido are Korean traditional martial arts. The round kick is an important skill in both martial arts. To compare kinematics of round kick in Taekwondo and Hapkido at three different target heights (0.8, 1.2, and 1.6 m), five Taekwondo players and 5 Hapkido players' performances were recorded and analyzed using three-dimensional videography. Although there was no interaction between martial arts type and target height, it was found that two martial arts had different kinematics. The round kick executed by Taekwondo player had shorter kicking time, less medio-lateral displacement of body center of mass, and smaller minimum knee angle. On the other hand, the round kick executed by Hapkido player had greater maximum linear velocity of ankle at impact.

KEY WORDS: martial arts, Taekwondo, Hapkido, round kick

INTRODUCTION: Taekwondo, Korean traditional martial arts, has been in existence for thousands of years as a method of self-defense. Taekwondo having being developed to a competitive sports in 1960, many skills in Taekwondo was modified to win a sports game (Ye, 1981). Thus Taekwondo is a popular sport rather than a martial arts especially with being chosen as the official sport for 2000 Sydney Olympics. Hapkido, which is one of the youngest of the oriental martial arts, has been evolving in Korea over the past 600 years (Myung, 1993). Hapkido is a combination of judo, karate and aikido. As a self-defense, not a sports like other competitive game, Hapkido may still have original form of skills without any modification.
In Taekwondo game, a technical attack movement is performed by both hands and leg, however, in reality, it is composed of 90% kicking and the remaining 10 % of punching attack movements (Kim, 1993). In various kicking skills, round kick is the most effective skill to score point (Lim, 1993). As shown in Figure 1, round kick is a complex movement that includes raising the back leg, drawing the shank back, using the knee joint as an axis, bouncing the shank at a semi-lunar arc and driving the leg back to kick the goal (Kim, 1991). According to Taekwondo competition rule, it must be kicked accurately to the legal area (mid-section the trunk and the front part of the face) to score point. However, kicking target of Hapkido is whole body including lower limb. In addition, although the fast and accurate kick is emphasized Taekwondo, the powerful kick is more important in Hapkido.
The purpose of this study was to investigate the effect of target height on the kinematics of round kick in Taekwondo and Hapkido. It was hypothesized that each martial arts has different biomechanical characteristics with target height.

Figure 1 - Round kick.

METHODS: Five Taekwondo and 5 Hapkido college athletes whose training history was over 4 years were recruited for this study. Subject mean height was 173 cm (range, 168-180 cm) and mean weight was 65 Kg (range, 58-80 Kg). Two high-speed digital video camera (High speed 220) at 100 Hz were used to record the round kick selected for analysis from each subject.
Each subject performed round kick for three different target heights (0.8, 1.2, and 1.6 m) which were assumed levels of hip, trunk, and face, respectively. An APAS (Ariel Dynamics inc., USA) was used to manually digitize body landmarks including: shoulders, elbows, wrists, hips, knees, ankles, and toes. The raw position data was smoothed with a digital filter at a cut-off frequency of 10 Hz. Kicking time, displacement of body center of mass (COM), linear velocity of ankle at impact, minimum knee angle, and maximum angular velocity of knee extension were calculated. The two-way ANOVA with repeated measure was used to evaluate the effect of martial arts type and target height on above kinematics.

RESULTS AND DISCUSSION: Kicking time, defined as a time from kicking foot take-off to impact, significantly increased with target height (Figure 2). The reason might be caused by the increased distance between initial foot position and target. Although it was not significant, kicking time of Taekwondo was shorter than that of Hapkido. Since the timing and speed of kicking motion is critical in Taekwondo game, players might be trained to perform fast movement. The displacement of body center of mass, defined as a displacement from a position at supporting foot touch-down to a position at impact, was analyzed in three-dimension. Anterior-posterior displacement of COM, ranged 21.51~25.70 cm, was not affected by martial arts type and target height, while vertical displacement of COM, ranged 8.50~17.85 cm, increased with target height. It is obvious that both martial arts players kicked to target without any backward moving of initial position for adjustment, although target was higher. Furthermore, medio-lateral displacement of COM in Taekwondo, ranged 0.66~2.48 cm, was much smaller than that in Hapkido, ranged 9.60~10.46 cm (Figure 3). This little displacement of COM in Taekwondo may due to little movement of trunk to prepare a faster defense posture against an opponent's counterattack. It was interesting to find that there was a significant difference between Taekwondo and Hapkido for the linear velocity of ankle at impact. Linear velocity of ankle at impact in Taekwondo, ranged 11.97~13.98 m/s, was slower than that in Hapkido, ranged 14.73~15.51 m/s (Figure 4). This result may indicate that the powerful kick is less critical or effective than a less powerful but accurate kick and/or a quick performed kick with adequate timing such as a perfect counter-kick. Since Hapkido is self-defense, not a sport like other techniques, a powerful kick might be required to knock the opponent down. The three-dimensional components of linear velocity of ankle are shown in Figures 5 through Figure 7. Anterior-posterior velocity of ankle decreased with target height, while vertical velocity of ankle increased with target height. There were significant differences between Taekwondo and Hapkido for both medio-lateral and vertical velocity of ankle. While medio-lateral velocity of ankle in Hapkido was faster than that in Taekwondo, vertical velocity of ankle in Hapkido was slower than that in Taekwondo. The faster vertical velocity but slower medio-lateral velocity of ankle in Taekwondo might be related to the fact that the movement plane of the shank was steeper than that in Hapkido.
Minimum knee angle in Taekwondo was smaller than that in Hapkido (Figure 8). It is obvious that Taekwondo players flexed their knee more than Hapkido players. According to the law of rotation, more flexed knee decreased the radius gyration of leg which reduce the rotational inertia, can produce more rapid kick under the same strength of hip joint muscles. Although there was no significant difference, maximum angular velocity of knee extension in Hapkido showed greater value than that in Taekwondo (Figure 9).

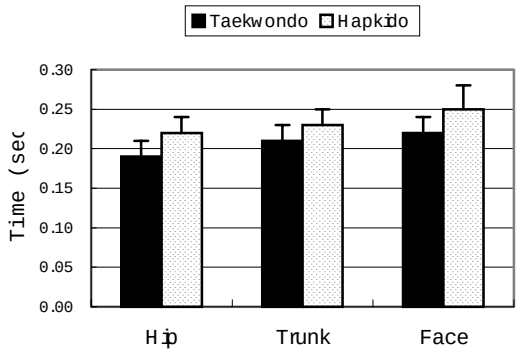

Figure 2 - Kicking time.

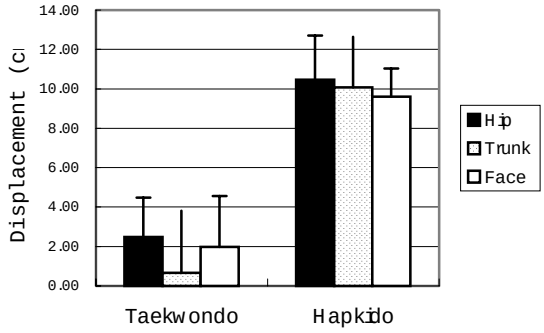

Figure 3 – Medio-lateral displacement of COM.

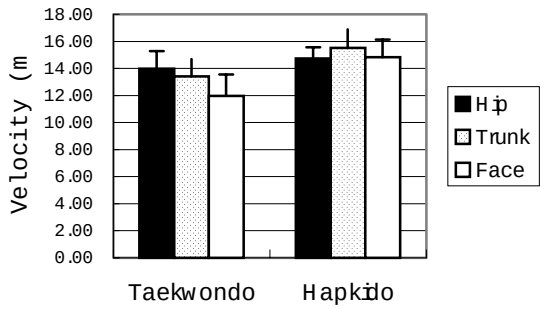

Figure 4 - Linear velocity of ankle.

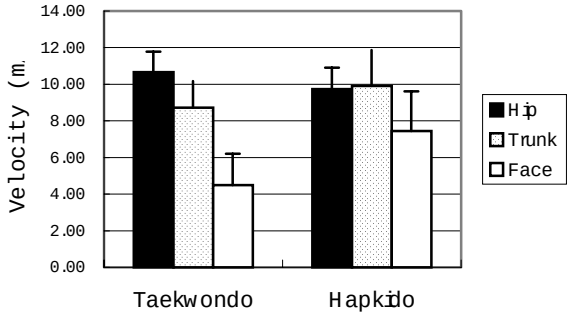

Figure 5 - Anterior-posterior velocity of ankle.

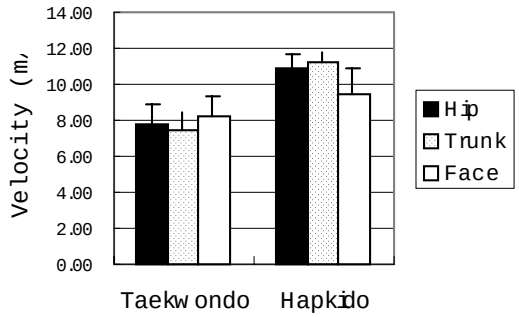

Figure 6 - Medio-lateral velocity of ankle.

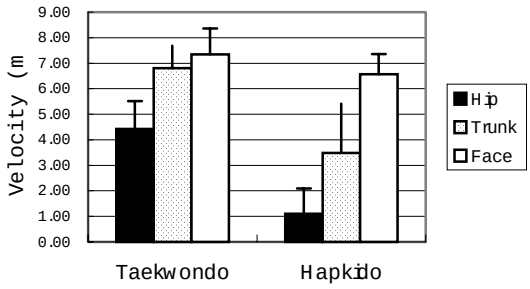

Figure 7 - Vertical velocity of ankle.

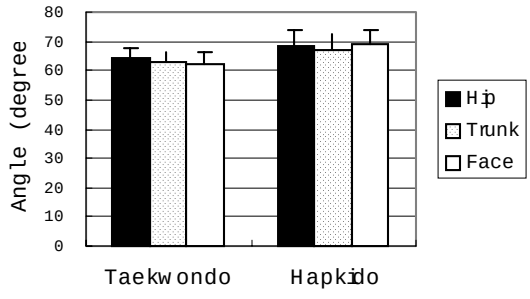

Figure 8 - Minimum angle of knee.

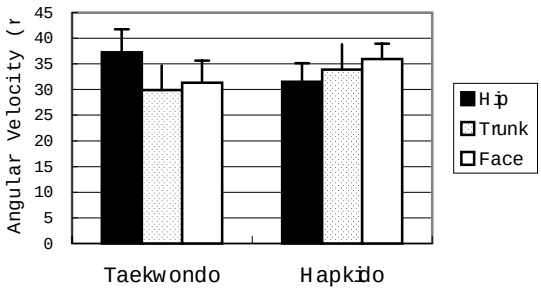

Figure 9 - Maximum angular velocity of knee.

CONCLUSION: Although it was expected that Taekwondo and Hapkido had different biomechanical characteristics with target height, i.e., Taekwondo was superior for face level target and Hapkido was superior for hip level target, there was no interaction between two

dependent variables. However, it was found that two martial arts had different kinematics. The round kick executed by Taekwondo player had shorter kicking time which might be due to less medio-lateral movement of body and the reduced rotational inertia by more flexed knee. Taekwondo players might be trained to perform fast and accurate attacking legal area to score point in competition. On the other hand, the round kick executed by Hapkido player had faster linear velocity of ankle which might be due to greater medio-lateral movement of body. Hapkido players might be trained to perform powerful attacking to knock the opponent down.

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