DIFFERENCE BETWEEN TAEKWONDO ROUNDHOUSE KICK EXECUTED BY THE FRONT AND BACK LEG - A BIOMECHANICAL STUDY

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Taekwondo will become an official event in the 2000 Olympic Games. During competition, over 80% of techniques executed were kicks and roundhouse kick was one of the most frequently used kicking techniques. The purpose of this study was to examine the difference between roundhouse kick executed by the front and back leg. Kicking performance of eight subjects was videotaped using two Peak video cameras at 120 Hz. Video materials were digitized by a analysis system (BAS, Germany). Significant differences were found in the movement time ($p < .005$), maximum linear velocity of ankle ($p < .005$) and maximum linear velocity of knee ($p < .005$) between the two kicks. The roundhouse kick executed by the front leg is faster while that the back leg is more forceful. It is suggested that the former might be more effective during fast attack and the later would make the opponent more difficult to block, thus creating new chances to further attack.

KEY WORDS: taekwondo, roundhouse kick, motion analysis, movement time, velocity

INTRODUCTION: Taekwondo, the Korean martial arts, has been adopted as an official sport of the Sydney 2000 Olympic Games, having featured at the 1988 and 1992 Olympics as a demonstration sport. Previous research had been done on the physiological response of human body towards taekwondo training (Cho, & Choe, 1988; Pieter, Taaffe, & Heijmans, 1990; Pieter, & Taaffe, 1992; Shirley, 1992), as well as psychological aspect of taekwondo athletes (Pieter, & Taaffe, 1992). There were also biomechanical studies on taekwondo kinetics (Hwang, 1987; Pieter, F., Pieter, W., & Heijmans, 1987; Pieter, Heijmans, & Taffe, 1989; Pieter, Taaffe, Troxel, & Heijmans, 1989) and kinematics (Hwang, 1987; Sϕensen, Zacho, Simonsen, Dyhre-Poulsea and Klausen,1996; Pieter, 1991; Serina, & Lieu, 1991; Pieter, F., & Pieter, W., 1995). However, there was little research focused on the difference between the roundhouse kick executed by the front and back leg. The purpose of this study was to examine the kinematic difference between roundhouse kick executed by the front and back leg using three-dimensional motion analysis.

METHODS: Eight Chinese male taekwondo players of 1st dan Black belt or above in Bantam Grade (58-64 kg for males) were recruited as subjects in this study. Their mean age, body stature and weight were 26.1±9.48 year, 169.7±6.42 cm and 60.68±8.72 kg respectively. Their training experience was 6.6±3.1 years, with training frequency of 2.9±2.1 hours/week.
Reflective markers were attached to the kicking leg of each subject at 4 joints, which were (1) shoulder: lateral joint line of shoulder joint; (2) hip: greater trochanter of femur; (3) knee: lateral epicondyle of femur; and (4) ankle: lateral malleolus.
Subjects were asked to perform 6 trials of roundhouse kick, of which 3 trials were executed by the front leg and other 3 trials by the back leg. Kicking sequence of the trials was randomized. Subjects prepared in kicking stance and kicked to a training bag at their waist level. A light emitting diode (LED) was placed at the top of the training bag to generate a start-kicking signal at eye level of the subject (see Figure 1). An accelerometer (34100A, 15g, Summit Instruments, USA) was inserted inside the bag to record the time that the kicks reached the bag. Two Peak video cameras at 120Hz and 1/500 shuttle speed were placed on the lateral and postero-lateral side at 5m away from the subject to record the kicking performance. A 1m ×1m ×2m cubic frame was videotaped for calibration purposes.
Movement time was defined as the time duration between starting signals from LED and the attacking signal from the accelerometer. The video materials were digitized and analyzed on a motion analysis system (BAS, Germany). The raw data of motion analysis was smoothed with a digital filter at a cut-off frequency of 6 Hz. Maximum linear velocities of ankle, maximum linear velocity of knee, minimum knee angle, maximum knee angle, minimum hip angle and maximum angular velocity of knee extension were calculated. ROM of knee was

calculated by the difference of maximum and minimum knee angle. The median value of each data from the 3 trial was taken. Paired sample t-test was used to compare the difference between these two techniques. Pearson Product Moment correlation coefficient was used to determine the relationship between ROM and maximum angular velocity of knee. The 0.05 level of significance was used.

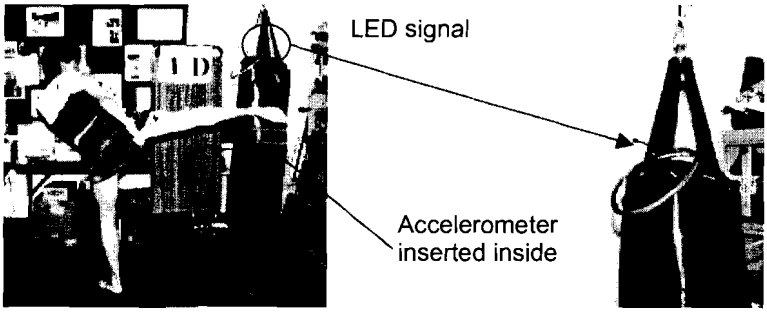

Figure 1 - Experimental setup.

RESULTS: There were significant differences in the movement time ($p < .005$), maximum linear velocity of ankle ($p < .005$) and maximum linear velocity of knee ($p < .005$) between the two kicks. No significant difference was found in minimum knee angle, maximum knee angle, minimum hip angle, angular velocity of knee extension, and ROM of knee between the two techniques (see Table 1).

Table 1 Comparison of Roundhouse Kick Executed by Front and Back Leg

Parameters (n=7)	front leg	back leg	degree of freedom	t value
movement time	0.73±0.10s	0.83±0.09s	7	-4.348*
maximum linear velocity of ankle	18.83±5.81 m/s	26.26±8.86 m/s	7	-4.559*
maximum linear velocity of knee	9.0±3.49 m/s	14.56±6.04 m/s	7	-4.777*
minimum knee angle	1.70±0.35rad	1.68±0.36rad	7	0.177
maximum knee angle	2.88±0.24rad	2.87±0.14rad	7	0.539
minimum hip angle	1.76±0.40rad	1.71±0.40rad	7	0.867
maximum angular velocity of knee extension	15.94±5.38rad/s	15.22±5.80rad/s	7	0.393
ROM of knee	1.18±0.40rad	1.12±0.36rad	7	0.528

*$p < .005$

The movement time of the roundhouse kick executed by the front leg was 12% shorter than that of the back leg. The maximum linear velocity of the roundhouse kick executed by the back leg was greater than that of the front leg by 39.46% and 61.78% for the ankle and knee respectively. All subjects attained greater maximum linear velocity of ankle and knee in the roundhouse kick executed by the back leg. Individual subjects' maximum linear velocity of ankle and knee are shown in Figure 2 and Figure 3. Typical patterns of linear velocity of ankle and knee in both kicks are shown in Figure 4 and Figure 5, respectively. Maximum velocities were reached prior to impact in all trials.

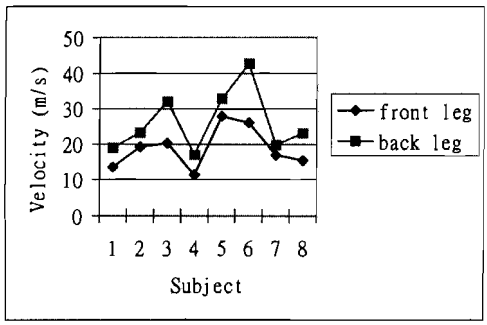

Figure 2 - Individual subjects' maximum linear velocity of ankle.

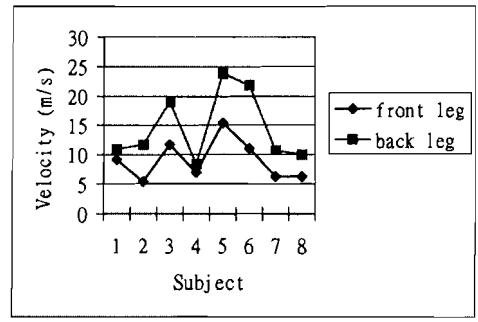

Figure 3 - Individual subjects' maximum linear velocity of knee.

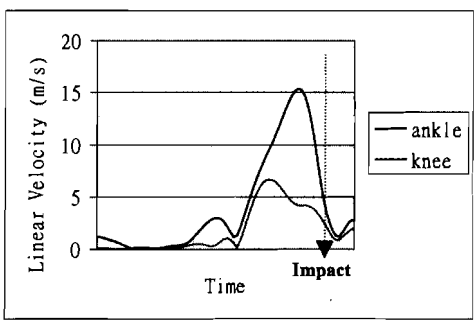

Figure 4 - The linear velocity of ankle and knee in roundhouse kick executed by the front leg.

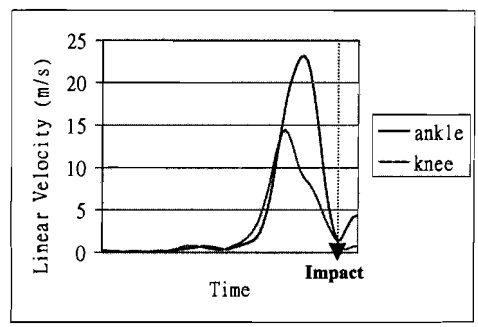

Figure 5 - The linear velocity of ankle and knee in roundhouse kick executed by the back leg.

The correlation of the ROM and angular velocity of knee was 0.895 ($p < .005$) and 0.792 ($p < .05$) for the front leg and back leg respectively. It was interesting to find that there were two different types of kicking style: type 1 and type 2. Typical examples are shown in Figure 6 and Figure 7. In type 1 kicking style, there was prominent knee flexion (from A to B) followed by rapid extension (from B to C) to kick (see Figure 6). In type 2 kicking style, the leg remained rather straight throughout the whole kicking process with was only slight knee flexion near the end of kick (see Figure 7). There were 5 subjects performing type 1 kicking style and 2 subjects performing type 1 kicking style. One subject performed the roundhouse kick executed by the front leg in type 1 kicking style and that of the back leg in type 2 kicking style.

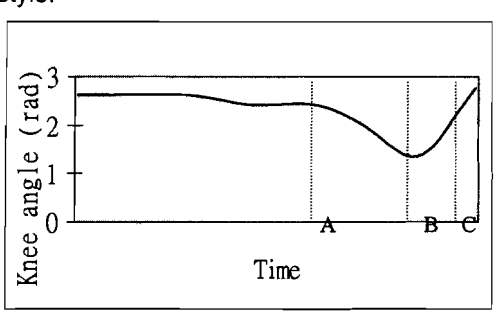

Figure 6 - Type 1 kicking style.

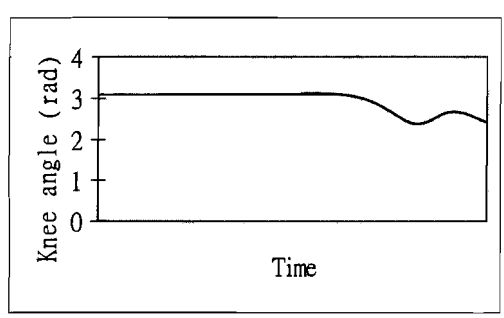

Figure 7 - Type 2 kicking style.

DISCUSSION: The different distances between the initial kicking position and the training bag can explain the differences in movement time. The front leg was nearer to the training bag, thus less time was required to reach the bag. Since the roundhouse kick executed by the front leg is faster, it might be more effective during fast attack. It must be kicked accurately to the legal area (mid-section of the trunk and the front part of the face) to score point in competition.

The roundhouse kick executed with the back leg showed greater velocity. This result supports the findings of Serina and Lieu (1991) who suggested that the addition of a spin to kick execution would result in greater velocities. The roundhouse kick executed by the back leg requires the waist to turn more than that of the front leg. The turning of waist causes trunk rotation which can be taken as a small spin before kicking. The greater velocity results in greater momentum (p=mv). This forceful kick would make the opponent more difficult to block the kick, thus creating new chances to further attack. According to the WTF rules of competition, when a contestant is knocked down as a result of the opponent's attack on a part of the trunk protector which is not a part of a legal area, such a technique shall be regarded as a point (WTF, 2000). Thus, the roundhouse kick executed by the back leg may even win a point directly if it is powerful enough to knock the opponent down.

Similar to the results of previous research, maximum velocities were attained immediately prior to reaching the target. Hwang (1987) observed that maximum foot speeds were reached prior to target in all front kicks. Suwat (1996) also found that the linear velocity of ankle in Thai roundhouse kick reached the maximum velocity at 48μsec prior to the point of impact. Practically, it is difficult for human to reach maximum velocity exactly at the point of impact. Such a slow down in velocity may be due to the reflex contraction of hamstring to protect the knee joint before the leg is fully extended.

The high correlation between the ROM of knee and angular velocity of knee extension suggests that increasing knee flexion before extending to kick can generate greater angular velocity. The two different kicking styles should have different ROM, and may involve different muscular activities. Further studies on EMG together with motion analysis are needed before a conclusion can be made.

CONCLUSION: This study has investigated the difference in roundhouse kick executed by the front and the back leg by 3D motion analysis. Since the roundhouse kick executed by the front leg requires less time than the that of the back leg, it might be more effective in fast attacking legal area to score point during competition. The roundhouse kick executed by the back leg, on the other hand, generates greater momentum (p = mv), which would make the opponent more difficult to block and thus create new chances to further attack. It may even win a point directly if it is executed powerful enough to knock the opponent down.

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