

KINEMATIC ANALYSIS OF THE SUPPORTING LEG BETWEEN DIFFERENT WEIGHT DIVISIONS IN THE ROUNDHOUSE KICK OF TAEKWONDO

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The purpose of this study was to compare kinematic differences in the supporting leg between two weight divisions in the Taekwondo Roundhouse Kick. Collegiate Taekwondo athletes participated in the study and differences in maximum joint angles and ranges of motion on the supporting leg during executing the Roundhouse Kick were examined. The results showed significantly larger ($p < .05$) ankle displacement and less inversion/eversion in the heavy division group during performing the Roundhouse Kick. It is inferred that the strategy adopted by the heavy division group has the tendency of using ankle displacement for achieving a stable ankle angular motion in the supporting foot.

KEY WORDS: revolution, range of motion, martial arts.

INTRODUCTION: Taekwondo, which is known for its kicking techniques, has become an official event in the Olympic Games from the year 2000. Competitors can score points by their feet and fists in the game, but most of the Taekwondo athletes usually get points by the feet kicking on the torso and head. One of the most used kicking techniques is the Roundhouse Kick which is also called Bandal Chagui (Lee, 1983). The characteristics of the Roundhouse Kick are rapid execution speed (Falco, 2009) and ease for counter-attack. In the performance of the Roundhouse Kick, a successful motion is not only dependent on the kicking leg but on the supporting leg. The supporting leg plays an important role in the Roundhouse Kick because of being the rotation axis of the body and adjusting the trunk orientation during kicking. In addition, Taekwondo athletes between different weight divisions have considerable diversity on the kicking patterns (Tang, 2001). There is virtually no study focusing on the kinematics of the supporting leg. Thus the purpose of this study was to run a kinematics analysis of the supporting leg between different weight classes during performing the Roundhouse Kick performance.

METHODS: Subject: Four collegiate athletes who have practiced Taekwondo for over 7 years voluntarily participated in this study. No subjects reported any acute injuries or disorders when the experiments were carried out. Experimental procedures were explained in detail before collecting kinematic data. Basic subject information is shown in Table 1.

Procedure: Roundhouse Kick movements were collected by a 3-D capture system with eight cameras at 200 Hz sampling rate. The marker set included nine reflective markers placed at the scrum and Anterosuperior iliac spine (ASIS), middle points of the thigh and shank, greater trochanter, lateral knee joint, lateral malleolus, fifth metatarsal-phalangeal joint, and calcaneus of the supporting leg. The dominant leg was identified by placing a ball on the ground and the dominant leg was the one that kicked the ball. After warming up, each subject was asked to practice the Roundhouse Kick so that they could be used to perform these movements further in the laboratory environment. Each subject then performed five Roundhouse Kicks by the dominant leg as fast as possible. Between each trial, the participant took a break of 30 seconds to avoid muscle fatigue. In addition, distance between the supporting foot and kicking foot was 60% of the leg length measured from the trochanter to lateral malleolus. The choice of this separated distance was based on the average of the preferred distance of all the subjects. In this study, subjects were asked to place the kicking leg at the posterior position and the supporting leg at the anterior position. The kicking target was held at the height of the subject's umbilicus and the distance of Roundhouse Kick was defined as 1.5-fold leg length from the anterior of supporting leg.

Table 1
Basic information of the subjects

	Light weight (n=2)	Heavy weight (n=2)
Body weight	64.2±2.89	71.8±1.77
Body Height	169.2±1.04	173.8±1.13

Note: Light weight: 58-68kg; Heavy weight: 68-80kg.

Data analysis: Kinematic data of the supporting leg was processed with Visual 3D. Movement of the Roundhouse Kick was defined to have three phases. Phase 1 was defined from propelling the kicking foot (with ankle plantar flexion) to maximum kicking knee flexion. Phase 2 was defined from maximum kicking knee flexion to kicking the target including trunk and pelvis rotation. Joint angles on the supporting leg were calculated for flexion, extension, forward rotation, backward rotation, inversion, eversion, dorsiflexion, plantar flexion during the Roundhouse Kick.

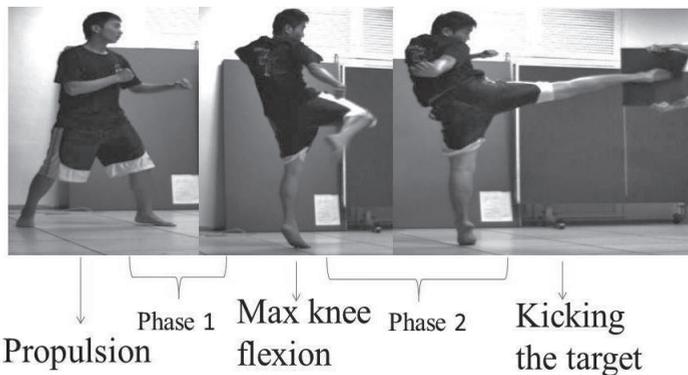


Figure 1: Definition of the three phases of the Roundhouse Kick

Statics analysis: The t-test was used to compare the difference between two weight divisions. All the joints angular data were calculated by SPSS 17.0 software package. The significant level was set at $p < .05$.

RESULTS: Table 2 and 3 present kinematic data of the Roundhouse Kick performance in phase 1 and phase 2, respectively. In phase 1, maximum joint angles of the supporting leg were calculated. Maximum ankle inversion angle in the light division group was significantly lower than that of the heavy division group. In the maximum angle of knee flexion, the light division group was significantly larger than that of the heavy division group. In phase 2, the range of ankle forward/backward rotation and eversion/inversion showed significant difference between two groups. In the light division group, the range of ankle forward rotation was lower than the heavy group. Contrarily, the range of ankle eversion/inversion of light group was higher than heavy group. Finally, there was significantly difference in the range of hip internal/external rotation between the two groups.

Table 2
The maximum angle of the supporting Leg in phase 1

	Light(S.D)	Heavy(S.D)
Ankle Dorsiflexion	88.12±9.13°	89.78±10.85°
Ankle Inversion	36.29±17.60*	44.86±8.03*
Knee Flexion	55.68±1.73°*	41.55±1.64°*

Note: * denote significant difference ($p < .05$) between groups.

Table 3
The range angle of the supporting Leg in phase 2

	Light(S.D)	Heavy(S.D)
Ankle For/backward Rotation	3.82±1.57°*	7.40±1.00°*
Ankle E/Inversion	4.22±1.18°*	2.02±1.11°*
Knee Fle/Extension	8.52±5.63°	6.12±4.04°
Hip Fle/Extension	10.73±3.88°	14.18±4.55°
Hip Ex/Internal Rotation	20.03±5.52°*	12.55±1.69°*

Note: * denote significant difference ($p < .05$) between two group. For/Backward: Forward and Backward. Fle/Extension=Flexion and Extension.

DISCUSSION: Both the supporting leg and the kicking are important factors influencing athletes' ability to perform the Roundhouse Kick. Athletes need rapid rotation movement by using the supporting leg to raise the power or velocity of the kicking leg (Chang, 2008). A good rotational movement of the supporting leg may help athletes to kick more effectively. The contribution of the rotation on the supporting leg is the increase in the attack distance and reduction of the area directly facing the opponent (by using the other lateral side of the torso to face the opponent). The less exposure of the frontal plane of the upper body, the less area can be kicked. The main finding of the study was that the heavy division group have more range of ankle for/backward rotation which could prevent injury on the supporting leg. A previous study has demonstrated that the low extremity sustained the body weight and rotation torque (Kellis, 2004), but this probably had negative effect on the supporting leg. In the range of ankle eversion and inversion, the heavy division group has significantly higher values indicating that movement in the heavy group is more stable in phase 2 during kicking. This is because extra ankle eversion/inversion will increase the shaking variance at the foot. Our study indicated larger range of the knee flexion/extension in the light division group, possibly producing more momentum from the supporting to kicking leg, which is similar to the results of Wu (2008). A larger push-off movement of the supporting leg lead to greater impact force. But the theory needs further examination on the relationship between the range of knee joint movement and impact force.

CONCLUSION: The purpose of the study was to examine the kinematics variables of four Taekwondo athletes. The present study indicated that there were higher range of ankle forward/backward rotation and less range of ankle eversion/ inversion, which may increase the stability of the supporting leg. In future studies, the kinetics and ground reaction forces should be included in the analysis in order to demonstrate whether the impact force can be influenced by the variable such as knee range of motion.

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