A KINEMATIC ANALYSIS OF ROUND KICK IN TAEKWONDO

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The purpose of this study is to provide kinematic analysis of the round kick in Taekwondo. The round kick is an important component required in the performance of Taekwondo. In order to accomplish this skill, it is necessary to accelerate the movement of the leg to a high velocity. In order to determine the mechanism involved in this maneuver, kinematic analysis of the motion will be used. This study analyzed the round kick motion through application of the 3D-video analysis system. The data determined that the muscles of the thigh initiate the round kick, transmitting force from the hip, through to the shank and finally to the foot. Before kicking the target, the knee-joint flexes to increase the velocity of leg and then the lower limbs extend. These are the requirements for a rapid and powerful kick.

KEYWORDS: kinematic analysis, Taekwondo, round kick

INTRODUCTION: Taekwondo is a popular sports event in which both arms and legs are used. This form of martial art originally came from Korea. The kick is a very important factor in performance of Tae kwon do. The round kick is the most common one that is used. Many highly skilled athletes consider that the most important objective of the kick was to maximize the horizontal velocity of the foot. Although many coaches and scholars have studied the technique of the kick in Taekwondo, it has not been common practice to analyze the kick mechanism with biomechanical methods.
Some coaches intuitively think that maximum segment velocities should be maintained prior to impact. However, considerable research does not support this view. The data has suggested that 'slowing down' of the proximal segments produces optimal velocity at the distal end of a lever. The purpose of the present study is to examine the relative activity of the leg during the round kick in Taekwondo performance.

METHODS: The subjects selected for this study included eight of the most highly skilled Taekwondo athletes, who had been either provincial or national champions. Four were male and four were female, and their ages ranged from nineteen to twenty-one. For descriptive data of the subjects, see Table 1.

Table 1 Individuals-subject-data

Subject	Sex	Age (years)	Height (m)	Body mass (kg)	Thigh length (cm)	Shank length (cm)	Foot length (cm)
1	Male	21	179	67	44	35.5	26
2	Male	19	180	71.5	39.5	41	26
3	Male	19	167	58	37	35	25
4	Male	21	181	69	44	37	26.5
5	Female	18	173	53	41.5	37.5	25
6	Female	19	166	54	41	35	24.5
7	Female	20	166	59	40	37	24.5
8	Female	19	160	50	35.5	35	24
Average	--	19.5	171.5	60.2	40.3	36.6	25.2
SD	--	1.069	7.874	8.035	3.023	2.049	0.884

Two Panasonic DP200 camcorders were used to record the round kick selected for analysis from each subject. The vertical view of the testing environment is shown in Figure 1. The time and date were displayed in the lower left corner of the frame, and comments of the camera operator identifying the subject's name and experimental condition were recorded on the sound track of the videotape beforehand, to ensure that corresponding video A and video B could be identified.

Figure 2 is the reference frame of the motion. A tree-shaped reference structure (PEAK Inc.) containing 25 markers of known coordinates, which encompassed the space of movement of the round kick action, was constructed and recorded to permit calibration of the field of movement. After the filming of the reference structure it was removed. Axes x, y, and z defined the reference frame, with its origin at the first marker of the reference structure (Figure 2). A total of ten trials were selected, representing each subject's "best" round kick, as judged by coaches. These were recorded for analysis.

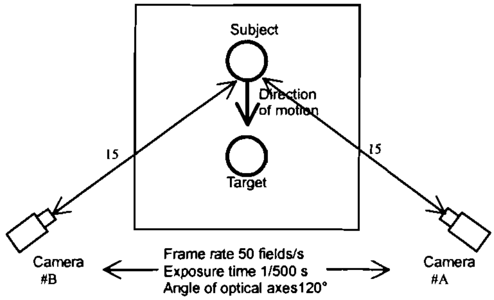


Figure 1- Vertical view of the testing environment.

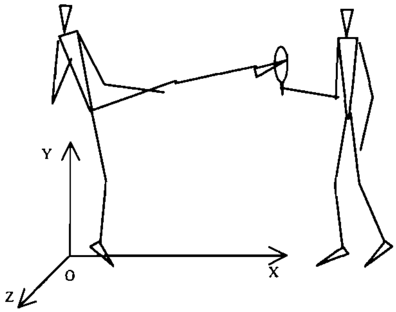
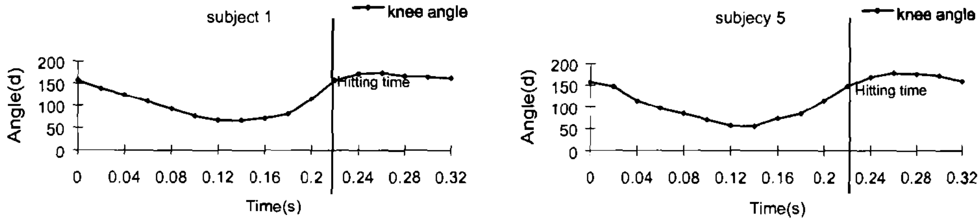


Figure 2 - Reference frame of the motion.

A Peak Motus 3-D system was used to digitize the tape records provided by this experiment. The segmental endpoints of the kicking leg were digitized separately from the whole body data. The five endpoints of each subject involved in this digitizing processes were: the hip joint, the knee-joint, the ankle-joint, the heel, and tip of the toe of the kicking leg. The 3-D coordinates of the digitized points in time were obtained with Direct Linear Transformation (DLT) procedures. The angular displacement and velocity data were then graphed for each of the round kick analyzed.

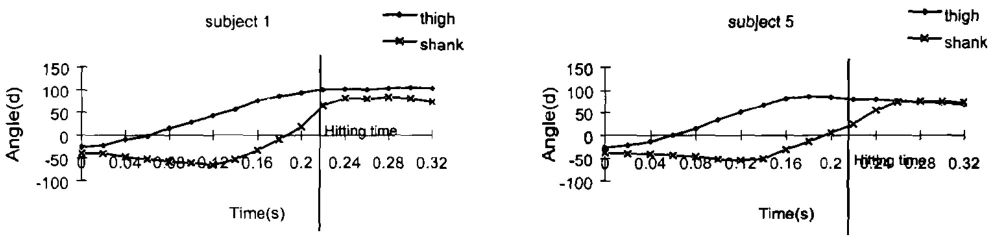
RESULTS: The data determined that whether within the trials of one subject, or between trials of different subjects, the kinematic curves were very similar. The curves reported in this study are typical of all other trials of each subject, and single trials are reported rather than ensemble averages of several trials to avoid distorting the curves too much because of slight plane differences in them. Subject 1 and 5 (a male and a female, respectively) were chosen randomly to be examples. The kinematic curves of subject 1 and 5 are shown in Figure 3-5. There are two graphs identified as A and B in each figure. The point of hitting the target for each of the curve is indicated on the figure.

The kinematic data refers to only two subjects tested but it must be emphasized that this is representative of the technique used by all subjects in the present study.



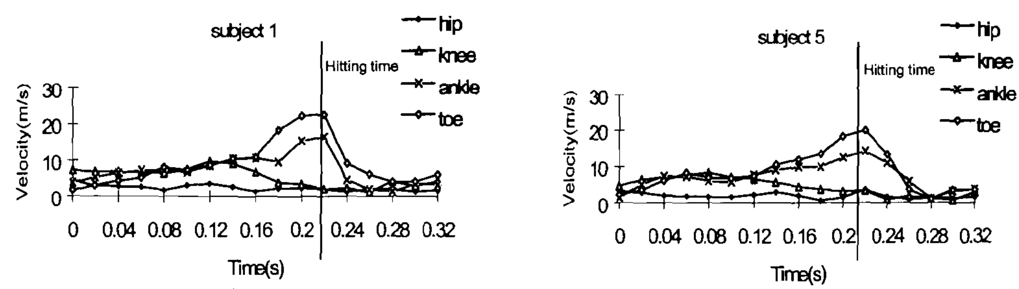
(A) (B)

Figure 3 - Knee angle vs. time. Knee angle was the angle between thing and shank of kicking leg. Graph A and B is the curve of subject 1 and 5 respectively.



(A) (B)

Figure 4 – Angular position vs. time of the leg segments. The angle was between segment and YZ plane. Thigh and shank were shown respectively. Graph A and B is the curve of subject 1 and 5 respectively.



(A) (B)

Figure 5 - Velocity vs. time of the leg endpoints. The velocity of hip, knee, ankle, and toe were shown respectively. Graph A and B is the curve of subject 1 and 5 respectively.

DISCUSSION: In Figure 3, 4 and 5, the curve of subject 1 and 5 are very similar. There was marked similarity in the motion of the leg of highly skilled subjects in round kick. There are few obvious differences in the performance of the highly skilled male and female in this skill.

In Figure 3, the curve of the knee angle shows a gradual decrease at first, and then it increases to 170, at the point of hitting the target. This indicates that the leg flexes at first and then extends to kick the target. These results are compatible with the reports given by other scholars on the subject. In the curves, the decrease and increase of the knee angle are both steep. This demonstrates that the flexion and extension of the knee are both at a high degree of angular velocity.

In Figure 4, the trends of curves are different in the thigh and shank of kicking leg. Initially, the curve of the shank decreases and the curve of thigh increases. The shape of the curves indicate that the thigh swings forward and the shank bends backward. When the thigh swings to about 60° to YZ plant, the thigh brakes and knee extends. Then the lower leg kicks out at the target, and the shank to YZ plant angle increases rapidly. This is compatible with the movement of knee in Figure 3.

The velocity curves of endpoints are shown in Figure 5. There is a great difference in these curves, and the timing at the peak velocities can be seen for each of the endpoints. In both subjects, the curve of hip shows a constant slope, and it maintains a low velocity in whole motion. The peak velocities of ankle and toe occur at almost the same instant, near the point of contact. However at this time, the velocity of knee has been reduced to a low level. This indicates that the thigh has lost velocity prior to the hitting the target. The shank's swing completes the last phase of round kick. After the point of contact, the velocity curves of all joints exhibit sharp drops. That indicates a rather rapid loss in velocity.

Increase the velocity of round kick is obtained as the shank flexes backward. According to theory of rotational inertia, $I = m R^2$, the whole round kick can be regarded as a rotation of leg around the axis of hip. The flexed shank reduces the radius of gyration of leg, which means that in addition, it reduces the rotational inertia. In the same way, according to the law of rotation, $\Sigma M = I\beta$, the smaller is the rotational inertia, the faster is the rotation under the same strength of hip-joint muscle. In other words, the leg kicks more rapidly.

CONCLUSION: In the round kick of Taekwondo, initially, the thigh accelerates to swing forward. At the same time, knee-joint flexes and the shank bends backward to increase the angular velocity of rotation. In this way, the radius of gyration is decreased in order to get the superior velocity of rotation in the same momentum. This is the mechanism that is required for performance of a rapid and powerful kick.

Examining the curve of velocities, the curve of hip shows a constant slope, and it maintains a low velocity in whole motion. However, the curves of knee, ankle and toe exhibit an obvious change. The knee-joint attains peak velocity first, followed by the peak velocities of the ankle and tip of the toe, which occur at almost the same instant when the ankle and the tip of the toe are close to the point of contact. Undoubtedly, this pattern reflects the characteristics of a skilled performance.

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