

# THE KINETIC ANALYSIS OF THE TAEKWONDO AXE KICK

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The purpose of this study was to analyze the kinetics of taekwondo axe kick. Twenty junior high school level taekwondo athletes served as subjects, and their mean age, height, weight and training experience were  $17.1 \pm 1$  years,  $168.8 \pm 5.8$  cm,  $59.9 \pm 6.7$  kg and  $5.8 \pm 1.6$  years respectively. Two Kistler force plates and multifunctional record instruments were used to measure kinetic parameters in each phase of the axe-kick motion. The conclusions described as following: 1. the time to peak anterior-posterior ground reaction force of kicking leg prior to the time to peak vertical force. 2. the peak vertical ground reaction force and impulse of support leg were 1.79 times of body weight and 88.1 N-s during leg-lift phase, and 0.86 times of body weight and 64.9 N-s during leg-axe phase. 3. It's suggested that during the training should emphasize to decrease the response time in order to reduce the total time.

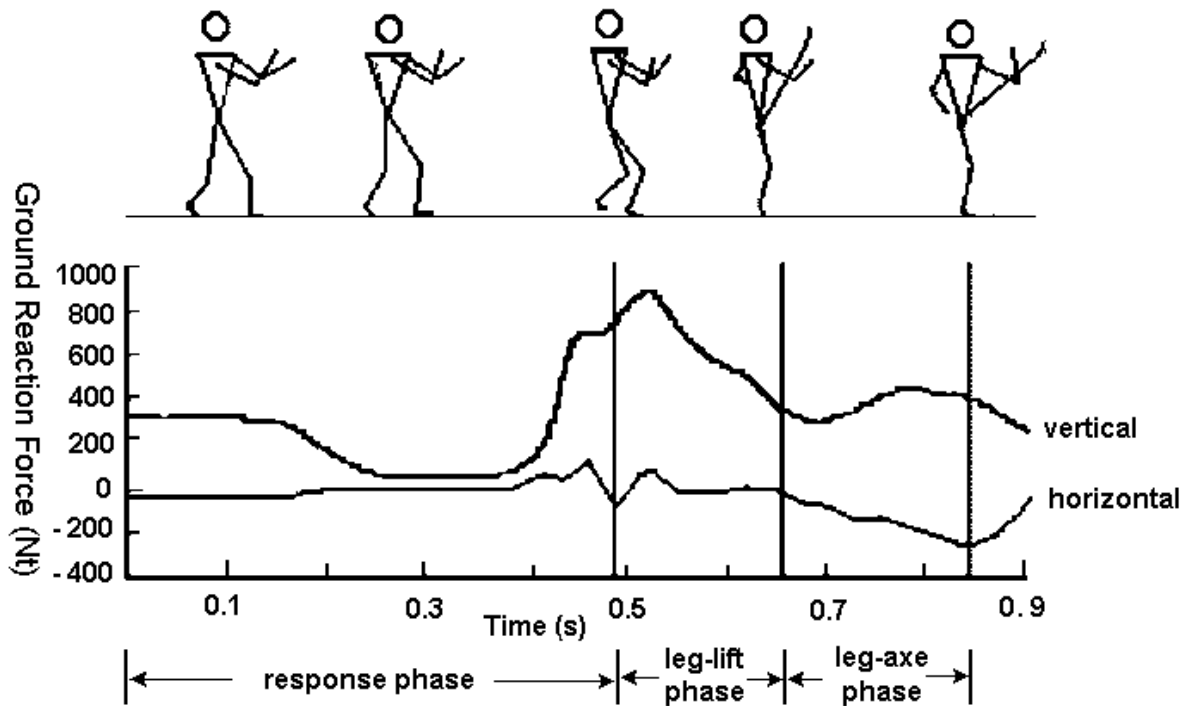
**KEY WORDS:** kinetics, taekwondo, axe kick, GRF

**INTRODUCTION:** Taekwondo is a competitive game in martial arts, and the kicking leg is the main attack weapon in competition, which is the unique feature to taekwondo (Hon, 1997). Furthermore, it has defined as an official competitive event in the 2000 Sydney Olympic Game. Generally, the emphasis of timing and power in kicking has been addressed. The more velocities and powers of the action, the more advantages of timing and effectiveness can be gained. Although the ground reaction force (GRF) and impulse in kicking could influence the power of action, but there were few information about that. Axe kick is one kind of kicking style in taekwondo (Kim, 1988; Lee, 1992; Chien, 1991; Tsai, 1998). The purpose of the kick is to attack opponent's head, and give it a powerful and downward force. To our knowledge, this type of kick has not been analyzed hitherto by GRF. Previous studies have dealt with punt-style kicking or high front kick in martial art. In these types of kicks, the direction of force on target is the same, and give target an upward force. Furthermore, in addition to the kicking-style analyzed in previous kicking studies, the present study used two force plates under two feet to assess temporal ground reaction force and relative kinetic measurement. In summary, the aim of this study was to investigate the movement time and GRF of kicking leg and supporting leg.

**METHODS:** Twenty skilled taekwondo male athletes of senior high school (their mean age, height, weight and trained experience were 17.1 years, 168.8 cm, 59.9 Kg and 6.6 years respectively) served as subject for this study, and all the subjects provided informed consent to participate. Execution of the motion axe kick analyzed in present study start from a normal standing position (kicking leg behind the support leg) with both feet on two separated force plates. Each subject initiated to response while seeing the light signal. The stick figure sequence of kick leg is shown in Figure 1. The ankle joint of kicking leg is kept fully extension in order to attack the target with the sole of the foot. During the kick, the supporting leg remains almost stationary on the force plate. The kick is performed almost without body rotation. Each subject performed three maximum-effort axe kicks aimed at a practice-used target held to chin level by experiment assistant. The fastest kick from each subject was selected for further analysis. The temporal GRF were simultaneously measured with two force plates (Kistler, 600 Hz).

**RESULTS AND DISSCUSION:** By the developing of the effective skills, the timing effect is more and more important on competitive game. For taekwondo game, the quicker the response time, the more time available that for do defense or offense strategy. Therefore, an elite taekwondo athlete should possess shorter response time. Cho (1996) stated that the response time of axe kick is the shortest kicking among the four different styles (axe kick,

round kick, back kick and hook kick). The reason maybe caused by that the kick is performed without body rotation, and almost is in a single, sagittal plane (contrary to other taekwondo kicking techniques). The movement time is the key point to attack opponent. Thus, the present study was to study the time factor on taekwondo axe kick.



**Figure 1 - The each phase of the kicking relative to GRF of supporting leg.**

In Figure 1, the vertical and horizontal (anterior-posterior) GRF of supporting leg form signal appear to kicking leg attack the target are shown together with a stick diagram of the axe kick performance. According the motion characteristics, we divided total action into two phases: reaction phase and movement phase, and movement phase can be further divided into two phases by horizontal GRF of supporting leg: leg-lifting phase (form the kicking leg off the force plate to negative horizontal GRF of supporting leg appear) and leg-axing phase (form the negative horizontal GRF of supporting leg appear to kicking leg attack the target).

**Table 1 Time Variables in Different Phase**

Variables (N=20)	Mean $\pm$ S.D. (sec)	Ratio	Maximum (sec)	Minimum (sec)
Reaction time	0.531 $\pm$ 0.063	0.60	0.668	0.437
Movement time	0.355 $\pm$ 0.030	0.40	0.436	0.307
Leg-lift phase	0.163 $\pm$ 0.019	0.46	0.208	0.122
Leg-axe phase	0.192 $\pm$ 0.004	0.54	0.265	0.125
Total time	0.886 $\pm$ 0.067		1.060	0.795

Table 1 indicated that the time of leg-lift phase and leg-axe phase are 46 % and 54 % of movement time, respectively. The total attack time is consisted of response time and movement time. In the present study, the averaged response time and movement time of axe kick were 0.531  $\pm$  0.063 s and 0.355  $\pm$  0.030 s, which are about 60 % and 40 % of total attack time. Based on previous study (Cho, 1996), axe kick has maximum total attack time among the four different taekwondo kicking styles (axe kick, round kick, back kick and hook kick). The probable reason about that was caused by longer movement time. Therefore, in spite of being a major weapon of attacking opponent's head, the possibility of re-attacking by

opponent is increased.

**Table 2 The Selected Variables of Kicking Leg in Response Phase**

Variables (N= 20)	Vertical		Horizontal	
	Mean $\pm$ S.D.	(Max, Min.)	Mean $\pm$ S.D.	(Max, Min.)
Peak GRF (BW)	1.46 $\pm$ 0.28	(2.20, 0.96)	0.59 $\pm$ 0.17	(1.09, 0.38)
The time of peak value	0.095 $\pm$ 0.020	(0.134, 0.071)	0.106 $\pm$ 0.020	(0.139, 0.072)
Impulse (N-sec)	227.7 $\pm$ 44.4	(325.8, 174.5)	69.1 $\pm$ 13.8	(98.6, 50.9)

The averaged impulse in vertical and horizontal direction were 227.7 $\pm$  44.4 Nt-s and 69.1 $\pm$  13.8 Nt-s (Table 2) Based on the Newton's Second Law of motion: Impulse equal to the change of momentum ( $I = m V_2 - m V_1$ ), the take off velocities of kicking leg were be caused by the total impulse, and then influenced the velocities of central mass and force of kicking target. For the peak GRF, the value was normalized by body weight of individual subject. The time of peak GRF value in present study was defined as the time difference between peak GRF occur and kicking leg take off the force plate. Table 2. showed the time of peak value in vertical and horizontal direction were 0.095 $\pm$  0.020 s and 0.106 $\pm$  0.020 s, respectively.

**Table 3 The Selected Variables of Supporting Leg in Leg-lift Phase of Movement Phase**

Variables (N= 20)	Vertical	
	Mean $\pm$ S.D.	(Max, Min.)
Peak GRF (BW)	1.79 $\pm$ 0.22	(2.18, 1.39)
Impulse (N-sec)	104.0 $\pm$ 25.1	(155.9, 70.6)

**Table 4 The selected variables of supporting leg in Leg-axe Phase of Movement Phase**

Variables (N=20)	Vertical		Horizontal	
	Mean $\pm$ S.D.	(Max, Min.)	Mean $\pm$ S.D.	(Max, Min.)
Peak GRF (BW)	0.86 $\pm$ 0.27	(1.40, 0.38)	0.35 $\pm$ 0.08	(0.56, 0.25)
Impulse (N-sec)	64.9 $\pm$ 18.4	(90.6, 20.4)	-20.3 $\pm$ 6.3	(-33.8, -9.9)

Table 3 and Table 4 showed the peak GRF and impulse of supporting leg in movement phase. (In leg-lift phase, we ignored the GRF and impulse of vertical direction because of the unstable frustration of GRF and the approaching zero value impulse value). The vertical impulse of supporting leg in leg-lift phase was 104.0 $\pm$  25.1 Nt-s; and the vertical and horizontal impulse of supporting leg in leg-axe phase were 64.9 $\pm$  18.4 Nt-s and -20.3 $\pm$  6.3 Nt-s. Hong (1997) studied the taekwondo back-kick and found that there is significant positive correlation between vertical GRF of the supporting leg and attacking target force. Which indicated that the greater vertical GRF of the supporting leg, the greater attacking target forces. However the axe kick of present study is different from the back kick. The relationship between the vertical GRF of the supporting leg and attacking target force will need further study.

**CONCLUSION:** The conclusions described as following: 1. the time to peak anterior-posterior ground reaction force of kicking leg prior to the time to peak vertical force. There was a significant negative correlation between the peak anterior-posterior force and movement time. 2. the peak vertical ground reaction force and impulse of support leg were

1.79 times of body weight and 88.1 N-s during leg-lift phase, and 0.86 times of body weight and 64.9 N-s during leg-axe phase. 3. It's suggested that during the training should emphasize to decrease the response time in order to reduce the total time.

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