DOSE FASTER HOPPING FREQUENCY IMPROVE RESPONSE TIME AND KICKING SPEED IN TAEKWONDO ROUNDHOUSE KICK?

Young-Kwan Kim, Hwi-Jung Jung and Ji-Yong Joo

Dept. of Physical Education, Chonnam National University, Gwangju, S. Korea

The purpose of this study was to investigate the effect of rhythmic hopping frequency on the response time and kicking speeds in Taekwondo roundhouse kick. Eleven elementary and middle-school athletes voluntarily participated in this study. They performed five roundhouse kicks at three different hopping frequencies (normal, 15% faster than normal, and 15% slower than normal) and no hop condition. Results indicated that the 15% slower hopping frequency induced a significantly longer response time than the 15% faster frequency. The 15% faster frequency resulted in faster maximum kicking speed than normal frequency did, while there was no difference in contact kicking speed. Partially the faster hopping frequency would be beneficial to kicking performance.

KEY WORDS: Taekwondo, roundhouse kick, response time, kicking speed, hopping, rhythm.

INTRODUCTION: Taekwondo sparring requires rapid response to an external stimulus and fast kicking velocity for winning a competition. This is because a shorter response time would increase the chance of successful kick and a faster kicking velocity may allow a kicker to give a strong impulse on an opponent.

In Taekwondo sparring most athletes practically use rhythmic hop as a preparatory motion while they are waiting for attacks and dodging in response to an opponent's action. Rhythmic hop consists of repetitive flexion and extension of ankle, knee, and hip joints simultaneously in place at a certain rhythm. Since rhythmic hop mechanically induces a prestretch potentiation of leg muscles (Aura & Komi, 1986; Bosco, Komi, & Ito, 1981) and functional stretch reflex (Melvill-Jones & Watt, 1971) in stretch-shortening cycle, it could be considered to affect the quality of the kicking movement to a certain extent.

Kim and Kim (2014) found that the rhythmic hop did not affect response time statistically but improved the kicking velocity significantly than no hop did. In addition, different instants of detecting an external stimulus in rhythmic hop for the back kick showed significantly different response times. They concluded that rhythmic hop is recommendable for the purpose of kicking velocity, but not for the purpose of response time.

However, there was no study on the effect of different hoping frequency deviated from normal hopping frequency on the kicking performance. Therefore, the purpose of this study was to investigate whether the change in hopping frequency from normal frequency affects the response time and kicking speed in Taekwondo.

METHODS: Eleven Taekwondo athletes consisting of five male athletes and six female athletes (age, 14.4±1.4 years; mass, 43.5±7.8 kg; height, 1.55±0.07 m) voluntarily participated in this study. All of the participants have been practicing Taekwondo for more than four years and all have black belts of the 2nd Dan and above. Prior to experiment, the purpose and procedure of this study was explained to subjects. All subjects signed a consent form according to the rule of institutional review board (IRB) of the university.

Once subjects came to the laboratory, a sufficient time of stretching and warm-up was allowed. When they were ready for an experiment, nineteen reflective markers were placed on major anatomical positions of both legs. After capturing static posture, medial markers (knee and ankle) and toe markers (2^{nd} and 5^{th} metatarsophalangeal joints) were removed to facilitate the kicking motion. The virtual marker of toe was established by the mid-point of the medial and lateral markers (2^{nd} and 5^{th} metatarsophalangeal joints).

Motion capturing system, consisting of five CCD cameras (Osprey®, Motion Analysis Corp., Santa Rosa, CA, USA) with sampling rate of 200 Hz, was used to capture the trajectories of reflective markers. A metronome (YCMTM-2000, Yongchang, Seoul, Korea) was used to set the rhythm of a designated hopping frequency. A hand-held pad (Adist 04, Adidas, Seoul, Korea), having one reflective marker on it, was used as the target. Movement of the marker was used to determine the onset of foot contact to the target. A force-plate (BP400600, AMTI®, Watertown, MA, USA) was used to determine the moment of the toe-off of kicking leg. An assistant held the target with one hand, and with the other hand, held a custom-made red light-emitting diode (LED) close to the target (Figure 1). A custom-made LED was designed to be a trigger for the participants to detect a cue signal for kicking (an external stimulus) and was synchronized with the motion data by the help of analog-to-digital board (NI USB 6525, National Instruments, Austin, TX, USA). The height of the target was adjusted according to the abdominal level of the participant and the distance of the target was the comfortable distance of each subject.

Figure 1: Experimental set-up for kicking task.

First, normal hopping frequency was determined by a preferred hopping frequency for 20 second. Each subject performed three trials of a 20-second natural hopping and the mean value of three trials was calculated as normal hopping frequency. Then a 15% faster and a 15% slower hopping frequencies than normal hopping were defined as faster and slower conditions of hopping frequency.

Each subject performed five trials of roundhouse kick as fast as possible immediately after seeing a LED blinking at four different conditions (normal, 15% faster, 15% slower, and no hop), respectively. The order of kicking conditions was decided by the counter-balanced design.

The response time was defined as the time interval from the onset of a LED blinking to foot contact to a target. It was divided into ground contact time (a LED blinking to toe-off) and kicking time (a toe-off to foot contact to a target). There were two kicking speed definitions. The maximum kicking speed was the maximum value of resultant linear velocity of the toe and the contact speed was the toe linear velocity at the moment of the contact. One-way repeated measures ANOVA was used to find statistical difference between conditions and performed in SPSS® 18.0. The significant level was set as .05.

RESULTS: The normal hopping frequency of all subjects was 2.87±0.21 Hz. There was no main effect of change in hopping frequency on the response time, ground time, and kicking time (Table1). There was a significant difference on response time between 15% faster frequency (0.762±0.056 s) and 15% slower frequency (0.808±0.079 s). The slower hopping frequency was the longer response time of kicking except no hopping condition. The faster and slower hopping frequencies had same ground times but the faster hopping frequency induced a shorter kicking time than the slower hopping frequency.

Figure 2 indicates the change in maximum kicking speed and contact kicking speed according to changes in hopping frequency. There was no main effect of hopping frequency on maximum kicking speed and contact kicking speed. However, the 15% faster hopping frequency (9.43±1.65 m/s) induced significantly faster maximum kicking speed than the 15% slower hopping frequency (9.12±1.52 m/s) did (p<.05). The contact kicking speed was ranged from 6.0 m/s to 6.34 m/s, which was slower than the maximum kicking speed. The contact kicking speed of faster frequency (6.34±1.32 m/s) was faster than that of normal frequency (6.13±1.02 m/s) but it was no significance statistically.

Table 1
Response Time, Ground Time, and Kicking Time According to Change in Hopping Frequency (unit: second)

Frequency	Response Time		Ground Time		Kicking Time	
	M	SD	M	SD	M	SD
15% Faster	0.762*	0.056	0.222	0.075	0.542	0.111
Normal	0.800	0.099	0.200	0.040	0.605	0.130
15% Slower	0.808*	0.079	0.222	0.020	0.588	0.067
No Hop	0.768	0.050	0.227	0.023	0.545	0.038

* indicates significant difference between two groups (***p*<.05**).

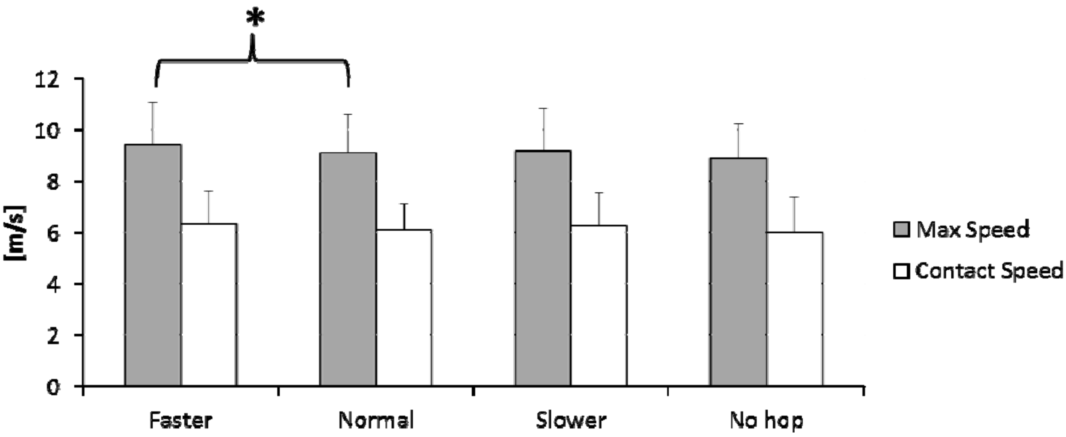

Figure 2: Comparison of maximum kicking speed and contact speed according to hopping frequency. * indicates significant difference between two groups (*p*<.05).

DISCUSSION: Almost athletes habitually perform rhythmical hopping as preparatory motions in Taekwondo sparring. Rhythmic hop was purposed to be ready for next movements such as attacking an opponent and dodging opponent's attack with controlling breathing and rhythm. However, the biomechanical effect of rhythmic hop was not well known to people. This study investigated the effect of hopping frequency on kicking performance.
Results demonstrated that there was no main effect of hopping frequency but there were significant differences between two groups for a couple of comparisons. The 15% faster hopping frequency reduced response time significantly than the 15% slower hopping frequency. All hopping conditions revealed no difference in response time statistically in comparison with no hop condition, which was agreed with Kim and Kim (2014) study.
Kim and Kim (2014) insisted that the rhythmic hop has advantage in kicking speed. This study demonstrated only difference in maximum kicking speed between 15% faster hopping and normal hopping frequencies. Biomechanically the rhythmic hop produced continuous fluctuations of centre of mass (CM) of a subject, which induced a certain level of mechanical energy (i.e., the sum of kinetic energy and potential energy). The faster hopping frequency

having higher level of mechanical energy would be beneficial to enhance the maximum kicking speed with utilizing a high level of mechanical energy.

The rhythmic hop stimulates the stretch-shortening cycle of elastic component of muscles continuously (Aura & Komi, 1986; Bosco et al., 1981), which utilizes the stored elastic energy of muscles. Farley, Blickhan, Saito and Taylor (1991) investigated the variation of hopping frequency on a treadmill and in place and found different results between the higher frequency and the lower frequency than preferred hopping frequency. In this study, the faster hopping frequency tends to reduce a response time and to induce faster maximum kicking speed such a simple spring-mass system. The slower hopping frequency, however, showed disadvantage in response time. This would be because of the improper utilization of storage and recovery of elastic energy in optimizing the cost of generating muscular force (Blickhan et al., 1991). The optimal hopping frequency for maximizing kicking performance might not be the preferred hopping frequency (normal hopping frequency) but the normal hopping frequency would be the point minimizing the cost of generating muscular force in order to keep longer durations of hopping motions in Taekwondo sparring.

There are a couple of limitations in this study. The number of subject (eleven subjects) would not be sufficient to find strong statistical power so that more subject across diverse levels of skilled athletes are required to induce a general conclusion. In addition, elite adult athletes are required to verify this results in future study.

CONCLUSION: This study identified the effect of hopping frequency on kicking performance in Taekwondo sparring. Results indicated that the 15% faster hopping frequency than normal frequency (i.e., preferred frequency) would be beneficial to maximum kicking speed. The 15% slower hopping frequency would deteriorate the response time in comparison with the faster hopping. Coaches should remember followings in sparring. In order to enhance athlete's kicking speed, an athlete should increase his/her hopping frequency than preferred normal frequency. And coaches carefully watch the rhythm of hopping of an athlete and should not let his/her hopping frequency down below his/her normal hopping frequency because of slower response to an external stimulus.

REFERENCES:

Aura, O., & Komi, P. V. (1986). Effects of prestretch intensity on mechanical efficiency of positive work and on elastic behavior of skeletal muscle in stretch-shortening cycle. *International Journal of Sport and Medicine*, 7, 137-143.

Bosco, C., Komi, P. V., & Ito, A. (1981). Prestretch potentiation of human skeletal muscle during ballistic movement. *Acta Physiologica Scandinavia*, 111, 135-140.

Farley, C. T., Blickhan, R., Saito, J., & Taylor, C. R. (1991). Hopping frequency in humans: a test of how springs set stride frequency in bouncing gaits. *Journal of Applied Physiology*, 71, 2127-2132.

Kim, Y.-K., & Kim, Y.-H. (2014). Effects of rhythmic hop on response times and kicking velocities. *Korean Journal of Sports Biomechanics*, 24, 367-373.

Melvill-Jones, G., & Watt, D. G. D. (1971). Observation on the control of stepping and hopping movements in man. *Journal of Physiology*, 219, 709-727.

Acknowledgement

This research project was supported by the Sports Promotion Fund of Seoul Olympic Sports Promotion Foundation from Ministry of Culture, Sports and Tourism.