BIOMECHANICAL ANALYSIS OF STRAIGHT AND FLEXURAL LEG SWINGS OF THE CHINESE MARTIAL ARTS JUMPING FRONT KICK

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INTRODUCTION: Fighting skills have a certain relationship with distance. In Chinese martial arts, there is a proverb for leg technique: 'Kick when far; using knee when near.' This traditional fighting theory also applied in Chinese martial arts routines to express the different levels of players' fighting thought. The Front Slap Kick belongs to the kick of slapping which asks the kicker to slap the back of his foot with his palm. It is separated into kicking with a straight leg swing (SLS), which merely focuses on the kick, and kicking with a flexural leg swing (FLS), which has both functions of kicking and using the knee.

The Jumping Front Kick (Figure 1) is a required movement in the routines of the Wushu event in the Asian Games which contains four phases: run-up, takeoff, flight, and landing. In the flight, a front slap kick should be completed in the air. According to the Rules of Wushu, the front slap kick in the jumping front kick is a way of kicking with a straight leg swing, but it is illustrated as kicking with a flexural leg swing in the textbook of Wushu. Kan (1991) has the same contradictory description in his book, too.

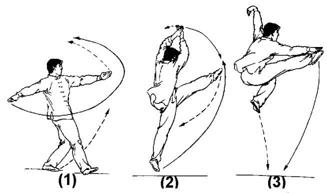

Figure 1 The Movement of the Jumping Front Kick. (Kan, 1991)

Cheng & Hong (1994) found that there were two different kicking technical features in the jumping front kick, kicking with a straight leg swing and kicking with a flexural leg swing, when players kicked. But they did not discuss the biomechanical differences between the two kicking skills. Nor did the other research about the jumping front kick analyze the fact that there were two different kicks (Chen, Tang, Lee, Huang, & T. Chen, 1997). So, the biomechanical analysis on the two kicking styles not only explained the different fighting thought levels of kicking in Chinese martial arts, but also offered a reference for similar movements in the martial arts. Park (1990) expressed that kicking with a flexural leg swing could cause a fast lower extremity velocity. Cheng (1995) showed that the horizontal velocity of the kicking toe with a straight leg swing was faster than the flexural leg swing, but kicking with straight leg swing was better than a flexural leg swing on the fighting effect and expression of consciousness. The kicking movements in the above two studies conducted on the standing leg on the ground, so the effect of kicking might be influenced by the standing leg (Liu, Chuang, & Lang, 1996; Cheng, 1995).

The research on the comparison of the differences in biomechanical character showed that kicking with a straight leg swing was faster than a flexural leg swing. On the other hand, Hwang (1987) indicated that the velocities of the toes of elite athletes were faster than those of beginners when kicking a target. In this research we would like to compare the difference between elite Chinese martial arts players and beginners when kicking without a target. The study would focus on analyzing the biomechanical characteristics of the kick after jumping in the air for two different Jumping Front Kicks and discuss their differences.

METHODS: Ten elite male Chinese martial arts players with six flexural leg swing and four straight leg swing techniques, and ten male PE major students (beginner) with four flexural leg swing and six straight leg swing techniques were selected as subjects for this study. The subjects' information is listed in Table 1.

Table 1 Mean and Standard Deviations of Subjects' Information and the Basic Kinematical Parameters of Movement Performance of Subjects.

Group	Style	H (cm)	W (kg)	Age (years)	Age of learning (years)	Normalized flight height	Vertical velocity at takeoff (m/s)	Horizontal velocity at takeoff(m/s)
Elite Player	FLS n=6	167.3 (3.7)	62.0 (4.9)	19.9 (2.7)	3.1 (2.2)	1.77 (0.04)	2.12 (0.42)	3.02 (0.07)
	SLS n=4	168.0 (7.0)	62.5 (3.3)	20.3 (3.4)	3.2 (2.4)	1.80 (0.05)	2.17 (0.52)	2.95 (0.52)
Begin-ner	FLS n=4	176.8 (3.6)	74.0 (6.8)	26.6 (7.1)	0.4 (0.2)	1.63 (0.16)	2.56 (0.26)	2.41 (0.57)
	SLS n=6	174.0 (6.0)	73.0 (9.3)	20.9 (0.7)	0.5 (0)	1.64 (0.13)	2.50 (0.39)	2.80 (0.27)

Note. *H = height; W = weight; Normalized flight height = the highest flight height of the body center of gravity above the standing height of the body center of gravity; velocities means the velocity of the body center of gravity.*

One Peak high speed camera was set up at the National Taiwan Normal University outdoor track perpendicular to the plane of the action to record the movements of the Jumping Front Kick performed by subjects. The camera was operated at a speed of 120 fields per second and a shutter speed of 1/2000 s. The distance between the camera and the plane of action was 20 m. The vertical distance from the ground to the center of the camera lens was 1.2 m. Each subject had 10-15 minutes of warm up exercise and was introduced to the experimental task during a practice session. The purpose of the practice session was to allow each subject to become comfortable with the experimental task and data collection conditions. Each subject wore his own Chinese martial arts shoes and performed three Jumping Front Kicks. Each subject was asked to select a trial which he felt the most successful to him. The trial representing the best by each subject was selected for analysis. Seventeen body landmarks served as the source for the digitized points. A 1.4 meter stick positioned in the plane of the action was videotaped to determine the conversion factor from digitizing to metric units. The 17 body landmarks were digitized field by field with the Peak Performance system. These raw data points were scaled to metric units through the use of the video camera aspect ratio and the digitized coordinates of the 1.4 meter stick within the plane of interest. Each horizontal and vertical spatial coordinate of the digitized body landmarks was filtered with a fourth-order Butterworth Digital Filter with an optimum cutoff frequency selected by the Peak System.

Because of the different flight times from subject to subject, we described the important event in the normalized timing (NT) that was calculated by way of the time of descriptive event to takeoff over the time of the highest body center of gravity to takeoff. The selected variables for kick leg were tested by completely randomized design two-way ANOVA at α=0.05 significant level.

RESULTS: Figure 2 were the stick figures that depicted the different kick styles of movement behavior. They clearly showed significant conspicuous to tell the difference between them. The style of kicking with a flexural leg swing was shown to flex the knee after takeoff, therefore the knee joint went ahead to perform the attack intention during the midstream of the kick (Figure 2(1)). After the knee attack phase, they started to extend the knee joint to do a kick. But the stick figure of kicking with a straight leg swing showed the behavior had no complexity of performance, it was just a simple kick (Figure 2(2)).

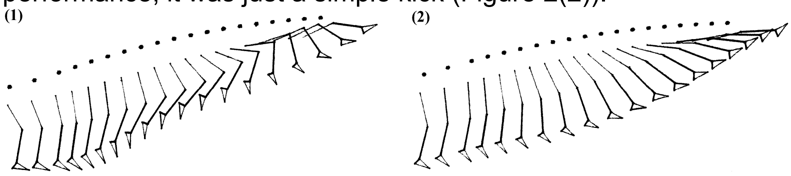

Figure 2 *The stick figures of two styles of kick performed by two elite Chinese martial arts players. (1) showed one subject kicking with a flexural leg swing, and (2) showed another subject kicking with a straight leg swing.*

We made the comparison between two styles of kick on maximum angular velocity of extending knee joint and normalized timing which are listed in Table 2. It showed that there were significantly larger angular velocities and longer normalized timing in kicking with a flexion swing.

Table 2 *Mean Values and Significant Level for Angular Velocity of knee and the Normalized Timing.*

Group	Style	Max. angular velocity of flexion knee?ldeg/s?s	NT of Max. angular velocity of flexion knee	Max. angular velocity of extension knee?ldeg/s?s^{+}	NT of Max. angular velocity of extension knee
Elite Player	FLS	757(185)	0.20(0.06)	1040(384)	0.79(0.09)^
	SLS	187(98)^	0.15(0.05)	150(95)	0.44(0.10)^ $^{\#}$
Begin-ner	FLS	825(46)$^{\#}$	0.12(0.12)	966(265)	0.99(0.21)
	SLS	451(202)^$^{\#}$	0.30(0.33)	300(164)	0.93(0.33)$^{\#}$

( ): Standard deviation $^{+}$Style, p<.05 ^$^{\#}$ Simple main effects, p<.05

The flexural leg swing was significantly faster than the straight leg swing in maximum vertical velocity of the knee joint. There was no significant difference between flexural leg swing and straight leg swing in maximal toe velocity and maximal ankle velocity. However, there was a significant difference in time to the maximal toe velocity and time to the maximal ankle velocity between the flexural leg swing and the straight leg swing (Table 3). In addition, the beginners had significantly greater maximal ankle velocity (9.58$\pm$0.62m/s) than the elite Chinese martial arts players. Figure 3 also indicates that the flexural leg swing had two maximal values of ankle and toe vertical velocities, and the maximal velocity of the knee appeared between the two peaks of toe and ankle. But the peak velocities of toe and ankle in the straight leg swing were always concurrent with the maximal velocity of the knee.

Table 3 *Mean Values and Significant Level for Velocities of Toe and Knee.*

Group	Style	Max. Velocity Toe?am/s?s	Vertical Max. of Velocity Toe?xm/s?s*	Horizontal Max. of Velocity Knee?xm/s?s^{+}	Vertical NT of Max. Vertical of Velocity of Knee
Elite Player	FLS	9.64(0.60)	8.68(1.31)	5.37(0.61)	0.49(0.06)
	SLS	8.76(1.13)	7.96(0.59)	4.24(0.45)	0.53(0.10)
Begin -ner	FLS	8.53(0.98)	10.04(0.72)	5.12(0.40)	0.57(0.17)
	SLS	8.95(0.94)	9.20(1.28)	4.55(0.38)	0.50(0.11)

( ): Standard deviation $^{+}$Style, p<.05 *Group, p<.05

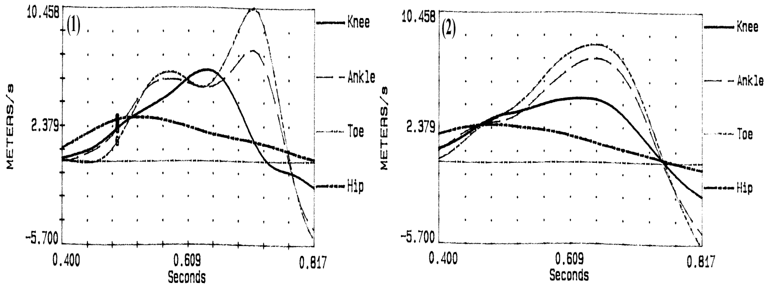

Figure 3 *The lower extremity's vertical velocities of two styles of kick performed by two elite Chinese martial arts players. (1) showed one subject kicking with a flexural leg swing, and (2) showed another subject kicking with a straight leg swing.*

CONCLUSIONS: The results indicated that the flexural leg swing technique might have advantages during actual combat situations which matched the fighting theory of Chinese martial arts. So the research suggested that the rules of Wushu on the Jumping Front Kick should be changed to match the textbook of Wushu and fit for the theory of Chinese martial arts. The data indicated that there was no difference in the lower extremity's velocity when performed the flexural leg swing and straight leg swing. This might be because the Jumping Front Kick did not have the standing leg. The data also indicated that the beginners' lower extremity velocity is faster than that of the elite players. This might be the reason the elite Wushu players did not emphasize power, but rather coordination.

REFERENCES:

Chen, C. Y., Huang, C., Tang, J. P., Chen, T. Y. (1997). Biomechanical Analysis of the wushu Jump-Slap-Kick. In *Book of Abstracts from the XVIth Congress of the International Society of Biomechanics* (p. 91*).* Tokyo.

Cheng, S. Y., Hong, D. M. (1994). A Qualitative Analysis of "Flying Kicks" in Chinese Martial Arts. *Chinese Martial Arts Research* **6**, 3-14.

Cheng, S. Y. (1995). *A Biomechanical Analysis of Straight Leg Swing Kick & Flexor Kick Under Various Leg Position of Single Hit Foot & Cross-Tap Foot.* Unpublished Masters Dissertation. National College of P.E. & Sports, Taiwan.

Hwang, I. S.(1987). Analysis of the Kicking Leg in Taekwondo. In J. Terauds et al. (Eds.), *Biomechanics in Sport III & IV* (pp. 39-47). Del Mar, CA: Academic.

Kan, K. (1991). Chinese Wushu Practical Guide (pp. 500-780). Taipei: Wu Chou.

Liu, Y., Chuang, L., Lang, D. (1995). Comparison and Biomechanical Analysis of the Chinese Martial Arts Forward Snap Kick and Forward Heel Kick. *Chinese Martial Arts Research* **8**, 45-72.

Park, Y. J. (1990). A Biomechanical Analysis of Taekwondo Front-Kicks. Microform Publications. Eugene, OR: University of Oregon.