A BIOMECHANICAL ANALYSIS OF THE CHINESE WUSHU SANDA SIDE-KICK AS PERFORMED BY ELITE MALE WUSHU SANDA COMPETITORS

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This study was designed to clarify the underlying principles of Wushu Sanda in order to improve the quality of the Wushu Sanda side-kick. The research involved critical review of reference materials, interviews and 3-D video biomechanical analysis. The findings have important applications for improving the quality of both Wushu Sanda instruction and Wushu Sanda coaching; additionally, they provide an important theoretical reference in the field of martial arts.

KEY WORDS: wushu sanda, side kick.

INTRODUCTION: The "side kick" is one of the most important kicking techniques in Chinese martial arts (Liu,1983). It is a flexible, powerful, very high speed, long-distance technique. It can be used for both defense and attack, and it is a primary means for gaining points in a Wushu Sanda competition. The side kick is also known as the "vanguard leg".
For the past several years, Chinese martial artists have competed in multiple international contests, notably with Thai kick-boxers and American boxers and wrestlers. The Chinese martial artists have consistently won a majority of these competitions and have demonstrated exceptional skills. The success rate of the Chinese competitors appears to be largely due to the effective use of the side kick (Huang and Chen, 2002), (Song, 2002), (Zhou, 2002).
This research examines, analyzes and compares the similarities and differences of the side kick as performed by four elite male Wushu Sanda athletes. By biomechanical analysis of foot placement, displacement and velocity, this study adds depth and precision to the only previous study on the Wushu Sanda side kick (Ye, 2003). This new information and the associated numerical analyses have important applications to both coaching and training. Additionally, this information provides an important theoretical reference.

Figure 1 .Side kicking (Liu Hailong and Author)

METHOD:

Research Subjects: We selected four representative Wushu Sanda athletes. These athletes included: from the Shandong Province Team: Liu Hai Long and Liu Xian Wei; from the Beijing Sports University Team: Li Jie; from the Guang Zhou Sports Institute: Pan Xian Hua. The general physical characteristics of the four subjects are outlined below. See Table 1.

Table 1 General Characteristics of Research Subjects

Name	Age	Ht (cm)	Wt (kg)	Training (yrs.)	Achievments
Liu Hai Long	23	177	80	10	2001-2003 Chinese All-Wt. Wushu Sanda King
Pan Xian Hua	24	179	75	9	2003 Chinese Wushu Sanda Champion
Li Jie	28	183	70	10	2003. Wushu Sanda King
Liu Xian Wei	24	172	65	8	2003 Wushu Sanda King

Procedure: The All China Sports University Martial Arts Competition was held in Chengdu at the Chengdu Sports University. Using two JVC Gr-DVL9800 video cameras the four athletes were filmed before the competition began.
The film speed was 50 frames/second (sufficient for biomechanical analysis of sports activities); the time lapse between frames was 0.02 seconds. The 2 cameras were positioned at a height of 1.5 meters. The 2 primary light axes formed a 90 degree angle with convergence on the filmed subjects' front center. Camera A was positioned at the athlete's front left; camera B was at the athlete's front right. Before filming, 3-D parametric calibration was completed with a DLT calibration device. Then filming began. Using three dimensional video analysis and 21 joint human model systemization, we obtained more than 4,000 bits of digitized data which were filtered and rounded to obtain graphical displacement curves and velocity curves.

Data Analysis: Omitted.

RESULTS AND DISCUSSION: For sake of convenience and in accordance with the primary characteristics of the side kick, this paper divides the side kick into five phases and six temporal "instants".

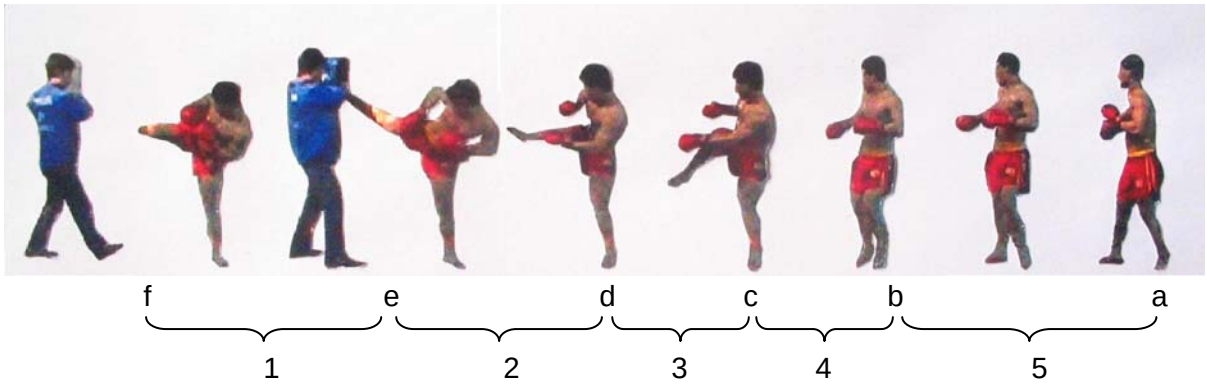

Fig 3: The movement of kick side: 1 the "step up" 2 lifting the knee to maximum height 3 the rotation of the innominate 4 the side kick 5 the recovery
a. step up phase b. kicking foot leaves earth to kick c. lifting knee to maximum height d. plantar metatarsals aimed at target e. plantar metatarsals contact the target f. recovery

These phases are 1. the "step up" (from the instant the kicking leg first leaves the earth in the "step up" movement until the instant it leaves the earth to kick), 2. lifting the knee to maximum height (from the instant the kicking foot first leaves the earth to kick to the instant the kicking knee is at its maximum elevation), 3. the rotation of the innominate (from the instant the kicking knee is at its maximum elevation to the instant the plantar metatarsals are aimed at the target), 4. the side kick (from the instant the plantar metatarsals are aimed at the target to the instant the plantar metatarsals contact the target), and 5. the recovery (from the instant the plantar metatarsals contact the target to the instant the knee returns to flexion).

From this study with 4 elite athletes we arrived at the following data and interpretations.

1. Regarding the "step-up" phase, increased velocity improves the overall side kick. Increased velocity helps to control the attack distance and it can increase the kinetic energy of the attack. Liu Hai Long's "center of gravity" speed at the "step-up" phase is 140.20 cm/sec.
2. In the "lifting-knee" phase, the support leg maintains an appropriate measure of extension (approximately 171.51±7.99 degrees). This measure is important because it not only establishes a "conserved force" and provides an opportunity for follow-up movements, but also it supplements the required balance for both attack and defense movements. The supporting leg's external rotation not only improves the "angle" for human balance but also establishes an important directional force for kicking.
3. In the instant the kicking knee is at its maximum elevation (when lifting the knee to the front of the body) the angle of the innominate is 57.19°+12.58°, less than 90°. When lifting the knee to the side of the body, the angle of the innominate is 97.07°+ 5.37°. When lifting the knee to the front of the body, the movement path is relatively short and the average attack speed is fast; the drawback is a relatively small impulse (or impact). When lifting the knee to the side of the body, the path to impact is longer and impact force is relatively greater; the drawback is that the time required to perform this maneuver is relatively greater.
4. In the process of lifting the knee the four athletes all demonstrated contra-lateral shoulder depression toward the lower abdomen simultaneously with the elevation of the kicking knee, i.e. "reciprocal motion". Liu's and Pan's shoulder depression speeds were the fastest. They both attained a peak velocity of approximately 270cm/sec. The depression of the opposite shoulder simultaneously with the lifting of the kicking knee is critical and requires careful attention.
5. In the process of lifting the knee, the knee should first make a slight counter-movement to the opposite direction of the intended attack, then return to the direction of the attack. This counter-movement is critical to increasing the force of the kick.
6. The choice of lifting the knee to either the front of the body or the side of the body should depend on the opponent's situation. During the simultaneous elevation of the knee and rotation of the innominate, it is advantageous to tightly link these components to increase the kick velocity.
7. During the "side kick section", the thigh propels the lower leg from flexion to extension towards the target to apply force. This is according to the kinetic chain principle of joint mechanics. It is important to avoid throwing the lower leg into unneeded directions.
8. During the "side kick section" the support leg demonstrates a distinct "sliding step". The significance of the sliding step is as follows: 1. to adjust the attack distance to increase the side kick's absolute attack force; 2. to provide a "supplementary measure" to improve balance and return the center of gravity to the supporting leg. The sliding step requires aggressively fast speed.
9. The height of the side kick, the athlete's anterior-posterior center of gravity, and side kick style all may influence the side kick's result. The four athletes in this study demonstrated a side kick impact height of 163 cm-178 cm.
10. In the "recovery section" the kicking leg returns along its original path. Not only does this provide a very quick defense, it is also very useful for quickly delivering the second attack. In this study, Liu Hai Long's "recovery phases" were the most optimal: his innominate and knee angles were, respectively, 75.326°and 59.675°. In the "step-up phase", Li Jie would benefit from increasing his "step-up" speed; Liu, Pan and Li, in the "knee-lift" phase, would benefit from increasing knee flexion (i.e. decreasing knee extension) of the supporting leg, and in the "recovery phase" they would benefit from both following the original path of movement and recovering more quickly from the side-kick.

CONCLUSION: The data analysis indicates Liu Hai Long's side kick is the most optimal of the research subjects. This also sheds light on why he was able to win the Sanda King competition for three consecutive years in China, defeat the Thai Kick Boxing King and

defeat the American Full-Contact Boxing Champion. Obviously there are numerous factors influencing the performance of the side kick. The implications of this study are that both a grasp of the inherent logic as well as a proficiency in kinetic chain control are essential to implement scientific training to improve the side kick technique. Due to time and monetary constraints, this study is not comprehensive, however, there are plans to continue with related biomechanical and kinesiological studies when funds and appropriate conditions become available.

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