BIOMECHANICAL ANALYSIS OF THE LUNGE TECHNIQUE IN THE ELITE FEMALE FENCERS

Bai Ming Zhang, Danny P. K. Chu and Youlian Hong
Sports Science Department, Hong Kong Sports Development Board, Hong Kong

The objective of this study is to profile the lunge technique of four female elite epee fencers. The motion was filmed with a video camera (50Hz) during a trial competition against Jiang Su Team. Data were collected and analysed using a Peak Performance System. The lunge in attacking technique was analysed. The kinematic parameters included stride length of lunge, reaction time, horizontal velocity of the centre of gravity and time to reach the target were determined. The centre of gravity and the Made of all four athletes were found to move simultaneously. The findings contradicted the belief of the athletes that the blade leads the movement of the body.

KEY WORDS: fencing, kinematics, lunge.

INTRODUCTION: Fencing, the art of offence and defence with a sword, is experiencing a renaissance today. It is a sport that requires the utmost in physical and mental agility. The lunge is the quickest way to close the distance to one's opponent. One must think of the lunge as beginning with the tip of one's foil. It is as though someone has grasped the tip of the foil and is pulling it rapidly forward, causing a rapid extension of the foil arm with the body following (Curry, 1984). Thus the athletes believe that the blade leads the movement of the body. The execution of the lunge involves flexion and extension of elbow, knee, and hip to provide forward propulsion of body mass and balance of the body in the guard position. One of the crucial characteristics in fencing is the ability to act and react to the opponent's sudden and unexpected movements. The control of the attack is highly dependent on the fencer's agility, speed, as well as to catch the opportunity when the opponent is unprepared. The objective of this study is to profile the lunge technique of four Hong Kong female elite epee fencers.

METHODS: The motion was filmed with a JVC GY-X1 video camera (50Hz) during a trial competition against Jiang Su Team which was the champion team in the 8th All China Games. The distance between the plane of motion and video camera was about 5 m. Representative motions of the 'on guard' of the fencing lunge were selected for analysis. The representative motions were chosen, independent of the success of the attack, by the coach and the motions selected were the typical technique of the fencer. On average, four trials for each fencer were performed. A Peak Performance System was used to calculate the joint angles, displacement, velocity of the centre of mass (CG) and the reaction time of attack. Reaction time of attack was defined as the period between initiation of the CG and the foil until the sudden increase of velocity in the centre of gravity and the foil. The times of sudden increase of velocity were determined from the velocity time graph of the CG at the point of intersection. The body landmarks included toe, heel, ankle, knee, hip, shoulder, elbow, wrist, hand, neck, ear, and guard of epee.

RESULTS:
Definition of Terms
Max. stride length: The maximum distance between the toes during the lunge.
Max. front knee angle: The maximum acute angle of knee in front leg.
Max. back knee angle: The maximum acute angle of knee in back leg.
Max. angle between trunk and horizontal line: The maximum acute angle between the trunk line and horizontal line.
Max. angle between upperarm and horizontal: The maximum acute angle between the line joining the shoulder and arm and the horizontal line.
Max. hori. CG velocity: The maximum horizontal velocity of body mass centre during the lunge.

Time to reach target: The time between the start forward movement of blade and reached the maximum forward displacement.

Table 1 Kinematic Data of Attack

Subject	1	2	3	4
Body height (CG)	164	158	158	159
Max. stride length (CG)	223.0±10.0	206.4±14.1	230.2k35.7	237.6k17.5
Max. front knee angle (°)	174.3k4.8	166.9k0.7	178.0k0.7	172.2k5.9
Max. back knee angle (°)	176.7k2.6	177.3±1.5	174.9k2.7	177.2k2.5
Max. angle between trunk and horizontal line (°)	50.8±15.3	46.9±11.4	64.4±4.4	68.6k9.4
Max. angle between upper arm and horizontal (°)	-7.5±10.9	4.1k11.2	6.4k4.1	0.6k5.4
Max. hori. CG velocity (CG/s)	305.6k10.8	345.0k44.2	311.2k67.8	304.7±61.2
Time to reach target (s)	0.54k0.14	0.70k0.13	0.59k0.14	0.54k0.08

Table 1 shows the kinematic data of attack. The maximum stride length was the largest in subject 4 and smallest in subject 2. The maximum angle between trunk and horizontal line in subject 4 was the largest and smallest in subject 2. A negative angle between the upper arm and horizontal was found in subject 1. The maximum horizontal CG velocity in subject 2 (345.0k44.2CG/s) compared to the lowest value 304.7k61.2CG/s in subject 4. The maximum horizontal blade velocity was found to be highest in subject 1 and smallest in subject 2.

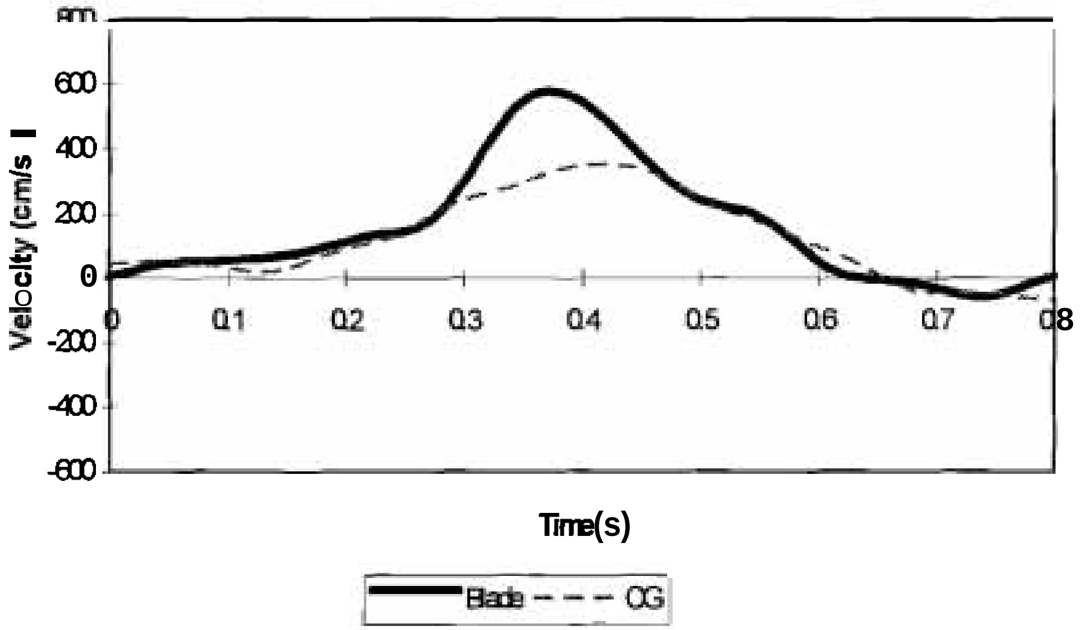

Figure 1 - Foil and CG hori. Velocity Vs Time (Subject 3)

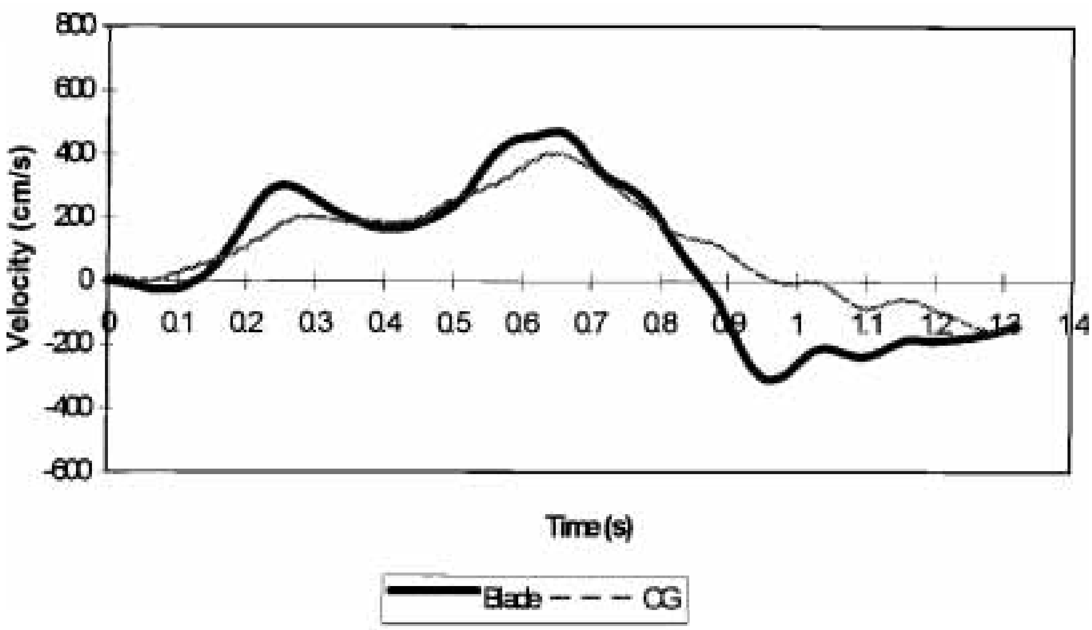

Figure 2 - Blade and CG **hori.** Velocity **Vs** Time (Subject 2)

Figure 1 shows single peak curves. The blade and CG velocities increased slowly until there was a sharp peak and then the velocity curves decreased with time. Figure **2** shows double peak curves. There was a small peak before the main peak.

DISCUSSION: The lunge distance was larger in subject 1, **3** and **4** than subject **2.** The reason may due to the relatively small front knee angle **(166.9"** ±0.7°) when compared to the other fencers **(172.2"+ 5.9" - 178.0"** ± **0.7").** The maximum extension of the back knee offourdifferent athletes were quite similar ranging from **174.9"** ± **2.7"** to **177.3"** ±1.5°.
The forward trunk inclination angles of subject 1 and **2** were greater than the other two subjects. The angle of forward **trunk** inclination was above **24".** Three of the subjects showed positive angles between the upper arm and horizontal after completion of the lunge. This is the result of forward flexion of **trunk** of these three subjects with small stature. Only one of the subjects had a negative angle between the upper arm and horizontal line **(-7.5")** after the completion of lunge. Although the body height of this subject was highest **(164** cm) among the four subjects, strictly speaking, she belonged to the small stature class. Therefore, the angle between the upper arm and horizontal should be increased to positive. The elbow angle of one of the athletes was **177.3"** which was close to the ideal position **(180").** Other athletes had angles that were much less than **180".** This indicates the extension of the elbow was not enough.
The velocity of CG during the lunge was greatest in subject **2.** However, the blade velocity was slow. This could be explained by subject **2** concentrating on the total body movement during attack. On the other hand, subject 1 and **4** has slow CG velocities and the velocity of blade was fast due to rapid arm movement. The technique of subject **3** was in-between the above two.
Regarding the lunge, it was found that the CG and blade moved simultaneously for all four athletes. These findings contradict the belief of the athletes that the foil leads the movement of the CG. However, the simultaneous movement enhanced unison and smoothness of transition. Thus, power from the waist and the legs could effectively be transferred to the foil. The reaction time of attack of the athletes was found to be **0.3** second. The reaction time of

attack could be treated as the delay action before attack. This was dangerous since in this period the motion of the blade was slow. Therefore, fencers should try to reduce the delay time so that the explosive power of attack could be improved.
The foil velocity time curve of three athletes shows a smooth single peak curve (Figure 1), indicating that their movement was smooth and continuous. On the other hand, the remaining athlete had a double-peaked curve (Figure 2). There was a small peak prior to the maximum velocity achieved by the foil. This small peak appeared to have an undue effect on the final peak. This small peak indicated that extra energy would be expended throughout the lunge. Therefore, the maximum velocity and the continuity of movement would be affected. The reaction time of attack of the athletes in this situation was 0.5s. This would reduce the blade velocity and broke the continuum of the lunge technique. Also, the first peak was a sign of attack to the opponent. No matter what style of technique was employed, the movement of body and blade was synchronised.

CONCLUSIONS: The reaction time of attack of the athletes with the double peak velocity curve was 0.5s. This will reduce the blade velocity and broke the continuum of the lunge technique. This delay time was a dangerous period since during this period the blade was slow.
The displacement of the CG and the blade of all four athletes was found to move simultaneously. These findings contradict the belief of the athletes that the foil leads the movement of the centre of gravity.

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