KINEMATIC ANALYSIS OF AN ELITE LEVEL FENCER

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INTRODUCTION

Though fencing is one of the oldest competitions and one of the original Olympic sports, there exists a paucity of in-depth research of fencing despite the breadth of studies that have been conducted by sports biomechanists. Additionally, less has been researched concerning the characteristics and abilities of internationally elite level fencers.

Investigators have conducted studies of the forces involved in the movement of fencing and have concluded that ground reaction forces are affected by starting position of the front leg and that heel-toe lift offs have greater forces than toe-heel lift offs. (Szilagyi, 1993). Adrian and Cooper (1989) reported that the skilled fencer as compared to the unskilled fencer propels oneself forward with greater horizontal force and less vertical force during the lunge attack. Researchers have also studied asymmetries in flexibility, strength, and muscle cross-sectional area and found differences only in dominant limb strength and muscle CSA as compared to the nondominant limb (Margonato, Roi, Cerizza, & Galdabino, 1994; Nystrom et al., 1990; Sapega, Minkoff, Valsamis, &Nicholas, 1984). Reaction times have been studied too with prompting of different stimuli and with varied levels of fencers (Harmenberg, Ceci, Barvestad, Hjerpe, & Nystrom, 1991; Roberts & Sanderson, 1980; Sliwa, Chlebicka, & Cysewski, 1992).

Introductory research concerning kinematics of fencing has been accomplished mostly in examining the lunge attack. Researchers have focused on describing the lunge in terms of displacement, velocity, and time (Klinger, Adrian, & Dee, 1985; Szilagyi, 1992). However, data from those studies were not collected under competition settings and few variables were examined. It appears that there is a need to present a more complete kinematic analysis of an elite level fencer in a competitive environment.

The purpose of the study was to describe the kinematics of an elite male fencer over a series of successive bouts. Specifically, the lunge and movement patterns preceding the lunge were examined.

METHODOLOGY

The study received approval from the University Advisory Committee on Human Experimentation before any data collection took place. The participant was a 32-year-old male, right-handed, and at the time of data collection was the top fencer in the international points standing and went on to represent Russia in the 1996 Olympics.

The Peak5 (Peak Performance TechnologiesInc., Englewood, Co) two dimensional videography equipment was used to record the participant's fencing trials. The camera, set at 120 hz, was set up perpendicular to the participants, 8 m from the center of the fencing strip and remained immobile during filming. Half inch reflective markers were placed on the lateral plane of the right leg and medial side of the left leg at the fifth metatarsal, heel, ankle, knee, hip, and shoulder for referencing each landmark on the coordinate system. The view of the camera was able to record only the middle 5m of the 14 m strip. Peak 5 video motion measurement software computed the kinematic analysis of the fencer's movements and smoothing of the values was accomplished with the Butterworth digital filter.

Filming included four bouts of the subject fencing against top ranked U.S. fencers. The lesson and bouts persisted for four to five minutes each with approximately five minutes of rest between each bout for the fencer. The lunge and preceding jump lunge footwork patterns were selected for analysis, The jump lunge is footwork that is used in preparation for the attack rather than the advance (where the fencer marches down the strip), and the lunge is the principal attack in saber fencing. The fencers were asked by the coach to fence as if in a competition and received no further instructions. As such, the number of lunges and preceding footwork patterns that were captured on film varied between bouts (2 -6 attacks per bout).

RESULTS AND DISCUSSION

Table 1.

Kinematic variable means and (standard deviations) for the attacks in the four bouts

	Lunge distance (m)	Mean hip vel.(m/s)	Vertical hip disp.(m)	Trunk angle deviation	Mean trunk angle
Bout 1	1.24(.39)	1.97(.31).	040(.01)	5.98°(3.6)	17.46°(2.5)
Bout 2	.716(.18)	1.57(.28)	.190(.12)	5.99(1.7)	16.340(1.4)
Bout 3	1.45(.16)	2.17(.60)	.255(.03)	5.38°(2.5)	15.23°(1.9)
Bout 4	.752(.12)	1.75(.24)	.241(.01)	2.04°(.54)	16.86°(3.0)

Table 2.

Linear acceleration mean and (standard deviation) for the attacks in the four bouts

	Mean Hip (m/s/s)	Peak Hip (m/s/s)	Mean Knee (m/s/s)	PeakKnee (m/s/s/)
Bout 1	6.32(.53)	10.47(1.3)	10.82(2.0)	21.65(4.8)
Bout 2	6.52(.90)	15.63(5.6)	9.24(2.0)	23.5(5.9)
Bout 3	7.98(.84)	19.63(2.7)	11.28(1.2)	23.63(2.2)
Bout 4	6.43(1.3)	13.75(1.6)	7.32(.60)	14.6(4.4)

In fencing, distance and time are two very important factors. When a fencer attacks, he or she must be able to accelerate quickly to move closer to the opponent before the opponent has the opportunity to create more distance between the two. However, because both fencers can manipulate the temporal and spatial factors involved, there can be great variability in the kinematics of the attack during an actual fencing bout. The attacking fencer must be able to adjust the length or speed of the lunge as the distance between the fencer varies. Additionally, these athletes must be able to maintain the power and strength to move and accelerate during the bout and in successive bouts to be an effective fencer.

Examining the data revealed that no general trend developed across bouts or within bouts concerning an ideal lunge length or lunge velocity. One trend that did appear to develop across and within the bouts was that the fencer controlled his stability very well. Minimal displacement of his hip during his footwork supported that trend. It appeared that he kept his center of gravity stable which would aid him in movement. Further, he maintained his trunk angle steady across bouts, experiencing minimal sway in his trunk. His posture lent him an aggressive stance, like a boxer, and his minimal sway contributed to a stable body that may have contributed to him being an effective fencer.

This study differed from past kinematic analysis of fencing in that it aimed to capture the sport in a competitive atmosphere. The current results were compared to past fencing analyses which examined the lunge attack in practice and psuedocompetition settings (Klinger et al., 1985; Szilagyi, 1992). The fencer in this study compared favorably to both previous studies. Examining the data from the first bout, the fencer's average lunge distance was greater than the lunge in the non-competitive setting in the Klinger et al. study. But the competitive setting lunge length (1.0 to 1.5 m) in that study corresponded favorably to the current study. In some instances, Klinger et al. reported higher velocities (2.3 to 4.0 m/s) in the competitive setting when compared to within trial data and average bout data in the current study. This may be attributable to the fact that in the current study, the average velocity represented the entire movement analyzed (preceding movements and the lunge) as opposed to the past study which examined only the lunge. Apparently, only the non-competitive settings from Klinger et al. showed less lunge length (.6 to 1.0 m) and velocity (1.2 to 2.5 m/s) as compared to the current study, even though data collected in the current study were collected during actual bouts.

Similar results were also found when comparing the current data to findings in another study (Szilagyi, 1992). That researcher reported the lunge distance under simple reaction conditions ranging from .99 m to 1.066 m depending on the preceding footwork. The elite fencer in the current study on average had a longer lunge length as compared to this. The average velocity of the lunge as reported by Szilagyi compared favorably to the current study. Szilagyi reported lunge velocities ranging from 1.184 m/s to 1.638 m/s depending on the footwork preceding the lunge. Again, the fencer in the current study had lunge velocities that fell within, above, and below this range. Though Szilagyi did include preceding footwork patterns as part of the lunge analysis, it is important to note that data was not collected during an actual bouting situation, which makes further discussions problematic.

Results indicated that mean hip acceleration remained somewhat constant across bouts. Data from bout 4 indicated that the fencer accelerated less quickly than bouts 1-3, which may imply a fatiguing of the muscles. Further analysis of additional bouts after bout 4 would be needed to help depict a trend of decreasing acceleration, to help show a trend of fatigue.

Because fencing relies on an interaction of time and distance between two bodies and the distance varies, lunge length or velocity may not be the best variables to examine when looking at effective performance as the amount of distance needed can change. Rather, acceleration may provide some insights to the sport. An analysis of the acceleration of the fencer revealed that he generally decelerated during his preparation phase before the lunge then quickly accelerated during the lunge. Peak acceleration of the hip generally occurred at the completion of the lunge, with the lead foot making contact with the ground. Peak knee acceleration generally happened during a period of mid lunge to heel strike of the lead leg. Kinematic results of acceleration from the hip and knee marker showed that a wide range of accelerations took place from bout to bout. Taking this in account along with the variability of the lunge length suggested that there is no single type of lunge attack. It may be that as the distance between fencers changed, the fencer interpreted the information and adjusted accelerating appropriately when executing a lunge attack. It may be that a fencer's ability to accelerate may be a determining factor of successful performance. A highly skilled fencer may have the training and technique to accelerate much more quickly than a novice fencer, which would result in better performance.

CONCLUSIONS

In the future, more analysis of actual competition fencing bouts is needed. Fencing is a sport where the principal action, the lunge attack, can be quite variable. However, mastering balance during the footwork actions through control of the trunk or vertical displacement may play a substantial role in effective fencing, Further studies involving possible relationships between balance and ability to accelerate quickly are needed. Comparisons of unskilled fencers versus skilled fencers or top ranked fencers versus middle ranked fencers in strength, power, and acceleration during the lunge may yield useful information in terms of successful performance. Furthermore, investigations are required in foot-eye reaction times, as this may present data on the fencer's ability to decide, act, and accelerate with the lunge attack.

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