SCHLAGER FENCING BIOMECHANICS: DETERMINATES OF IMPACT FORCE

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INTRODUCTION

Schlager swords are used by a subset of fencers interested in reproducing fencing styles from before the 17th century. Anecdotally, it is easier to bruise an opponent inadvertently with excessive force during contact when using these heavier weapons than with the use of modern epees or foils. Sportsmanship in fencing dictates scoring without bruising one's opponent. Thus, minimizing the impact force is desirable and advantageous for the safety of the sport. It is hypothesized that the mechanics of the thrust, specifically, the independent variables of sword speed, vertical angle of attack, and roll, dictate the force of the hit. The aim of this study is to measure the impact force and correlate it with these independent variables.

EXPERIMENT

The sword used is a standard 86 cm schlager. It requires about 40 N of force for a 15 cm bend [1]. In order to study the three independent variables (speed, pitch, and roll) and their associated biomechanics independently, the types of hits asked for of the test fencer (one subject [2]) were as follows:

- Straight lunges of various speeds, to study the effect of velocity.
- Punches (hits imparted by arm extension with no body motion) to study why these blows tend to feel harder than lunges.

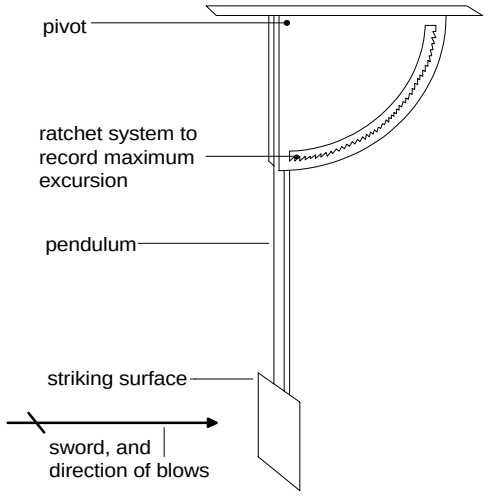

Figure 1.
Apparatus to measure impact force.

- Lunge-throughs, (a lunge aimed at a target a few inches beyond the striking surface).
- Corkscrew lunges and punches, where the sword is rolled as the hit is executed.
- Off-line shots with a negative pitch angle.

An innovative pendulum mechanism was developed to measure impact force (Fig. 1). Impact was made with an aluminum striking surface, which minimized friction between the metal sword tip and the pendulum and contact time. The impact would cause the pendulum to swing, whereby a simple ratchet would record the maximum excursion of the pendulum. This was correlated with the impact force.

To measure the sword speed, angle of attack and the sword roll, data was gathered from a frame-by-frame analysis of a standard 30

frames per second video recording of the experiment [3]. The last 3-8 frames before impact were analyzed for the velocity and roll rate, and the last frame before pendulum motion was analyzed for the static variables such as angle and roll.

RESULTS AND DISCUSSION

The straight lunges (Fig. 2) yielded a direct relationship between impact velocity and the force of impact. Higher force for a higher velocity was of course expected, and so this run sets up a baseline by which to determine what elements of a thrust increase the force.

Punches had a higher impact velocity than the lunges (including the lunge-throughs). For comparable speeds, however, the punches yield less impact force. Lunges included the movement of the whole body towards the target while punches only include the mass of the arm. Hence this less impact force is expected [4].

Lunge-throughs had a higher impact force and on average were faster than lunges. Experienced fencers "pull" or decelerate their lunges at the end of the elbow extension prior to impact. This process does not occur for lunge-throughs and is probable cause for the higher force.

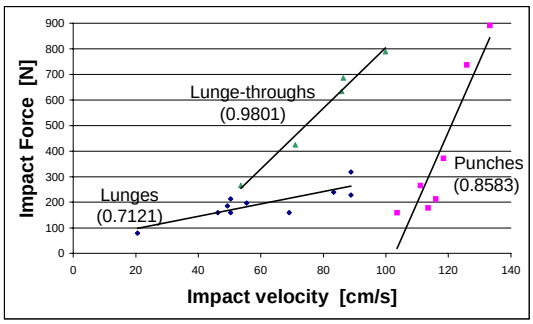

Figure 2. Comparison of impact velocity versus force for the three types of straight hits. (R^2 values indicated)

Off-line shots were found to produce almost identical force to lunges. The effect of pulling a shot, which is seen in lunges, is countered by force absorbed in bending of the wrist.

Corkscrew shots showed an overall slight increase in the force, due to their punching component (which was necessary to maintain a roll rate). Roll rate, however, affects force more so than velocity, based on the correlation between force and a linear combination of normalized roll rate and velocity.

SUMMARY

A direct relationship between impact velocity and the imparted force was realized, with a higher force imparted partway through a full lunge (i.e. lunge-throughs). Punches produced higher overall forces, but off-line shots are safely executed. Roll rate was found to correlate strongly to the imparted force, since the torque generated limits the bend of the sword and a higher force is translated. The conclusions gathered yield sound training protocols for practical schlager fencing.

REFERENCES

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