

Unveiling the Significance of Kinematics in the Saber Fencing “Box”

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ABSTRACT

This research paper delves into the critical role of kinematics specifically in the realm of the motion of the hand within the saber fencing “box”. Saber fencing is a dynamic martial art that demands swift and precise movements to achieve success. By analyzing the intricate relationship between the first continuous increase velocity and acceleration of the hand and performance outcomes, using Kinovea, this study aims to emphasize the importance of understanding and optimizing kinematic principles within the “box” area of the fencing strip. The findings presented herein illuminate how only focusing on the hand in the “box” can profoundly impact a fencer's ability to optimize their strategy within this confined space, ultimately enhancing their competitive edge in saber fencing.

INTRODUCTION

In the exhilarating world of saber fencing, two opponents engage in a dynamic battle of strategy, skill, and precise movements. Within the confines of the fencing strip, fencers must navigate a designated area known as the “box” while adhering to specific rules and regulations. The “box” refers to a rectangular area on the fencing strip, spanning 14 meters long and 2 meters wide. It is marked by colored lines that delineate the boundaries within which the fencers must remain during the bout. The “box” serves as a designated space wherein the intricacies of footwork, blade work, and tactical maneuvering come into play. One key principle within the “box” is the concept of “right of way.” This principle determines which fencer earns the point or scoring opportunity in the event of a simultaneous hit or near-simultaneous actions. According to the FIE’s, the international fencing governing body’s, rule book in the “box”, “any attack properly executed must be parried, or completely avoided, and the phrase must be continuous” (FIE p. 34). Meaning if one fencer launches a valid continuous attack, they will have “right of way”, and their opponent must parry or successfully evade the attack before mounting a counterattack to score a point. Therefore, the fencer who has established “right of way” has the advantage in scoring. The agreed upon method of gaining “right of way” is to move faster with the feet; however, this paper moves to challenge that notion.

This research paper attempts to demonstrate that, as supported by the FIE rule book, if a fencer’s hand generates the first continuous increase in velocity and acceleration in reference to their opponent, they will be awarded the touch every time. By analyzing the kinematics of a fencer’s hand and the significance of it on “right of way”, we hope to provide valuable insights that will allow for further methods and strategies to be developed.

METHODS

To ensure a diverse range of scenarios, 10 different saber fencing bouts of both genders and different age groups were selected from the USA Fencing YouTube channel. These bouts were specifically chosen to represent different styles of fencers, varied attack strategies, and a mix of offensive and defensive actions. Each bout featured distinct fencers and different referees officiating the matches.

From the selected bouts, specific touches where scoring actions in the “box” occurred were identified. These touches were strategically chosen to provide a comprehensive representation of various types of attacks, preparation steps and hand actions. The aim was to include a range of scenarios that would enable meaningful analysis of the kinematic parameters of the hand and their correlation with the referee's decision.

Kinovea, a video analysis software, was employed to track the hand movements in the selected touches. Each touch from the 10 different scenarios was imported into Kinovea for analysis, allowing for precise frame-by-frame examination and tracking of the fencers' hand movements.

Using Kinovea, the hand movements of each fencer involved in the touch were manually tracked. This meticulous process involved carefully placing markers on only the hand throughout the duration of the touch. The manual tracking ensured accurate representation of the hand movements for subsequent kinematic analysis.

Once the hand movements were accurately tracked, the kinematic equations were applied to calculate the acceleration and velocity profiles of each fencer's hand in the selected touches. The kinematic equations facilitated the determination of the change in position, velocity, and acceleration over time for precise kinematic analysis.

Utilizing the data extracted from Kinovea, graphs depicting the velocity and acceleration profiles of each fencer's hand were generated for each touch. These graphs provided a visual representation of the changes in velocity and acceleration for each fencer's hand during the touches. Subsequently, the generated graphs were correlated with the referee's decision to identify any consistent patterns or trends between kinematic parameters and scoring outcomes.

To account for variations in referee judgment, the 10 selected bouts contained 10 different referees. This approach aimed to introduce a broader perspective on how kinematic parameters of the hand correlate with the referee's decision across different scenarios and officiating styles. The diversity of referees ensured a more comprehensive evaluation of the relationship between the hand and scoring outcomes.

The graphs of velocity and acceleration, generated for each touch, were compared with the respective referee's decision for scoring. The focus was on identifying consistent trends where the fencer with the first continuous increase in velocity and acceleration aligned with the referee's judgment of the scoring fencer. Through rigorous correlation analysis, the validity and effectiveness of the kinematic analysis in relation to scoring outcomes were evaluated across the different referee scenarios.

By incorporating 10 different unique bouts this study aimed to provide a robust analysis of the correlation between kinematic parameters and the referee's decision. The diverse range of scenarios and officiating styles allowed for a comprehensive evaluation of if a continuous increase in velocity and acceleration of the hand influenced the scoring outcomes in saber fencing.

RESULTS and DISCUSSION

The results of the analysis demonstrated a consistent trend across all 10 scenarios, indicating a strong correlation between the first fencer to achieve continuous increase in velocity and acceleration of their hand and the referee's decision to award them the point. In each of the 10 bouts analyzed, the fencer who exhibited continuous increase in velocity and acceleration first was consistently deemed the scoring fencer by the respective referee. Figure 1 represents only 1 of the 10 scenarios considered and contains the most complicated action out of the 10. In Figure 1, both fencers accelerate, decelerate, then proceed to reaccelerate all within 1033 ms. In addition, both fencers were making circular motions with their hands while decelerating. Figure 1 demonstrates that the findings of the study are consistent independent if the fencers are making circular motions with their hands, or if they accelerate multiple times within one touch. In this touch, William Morrill's hand had the first continuous increase in acceleration vectors, as he started accelerating at 800 ms, while Taylor Chon's hand started accelerating at 833 ms. This touch was scored in William Morrill's favor, indicating the referee's decision aligned with the kinematic analysis.

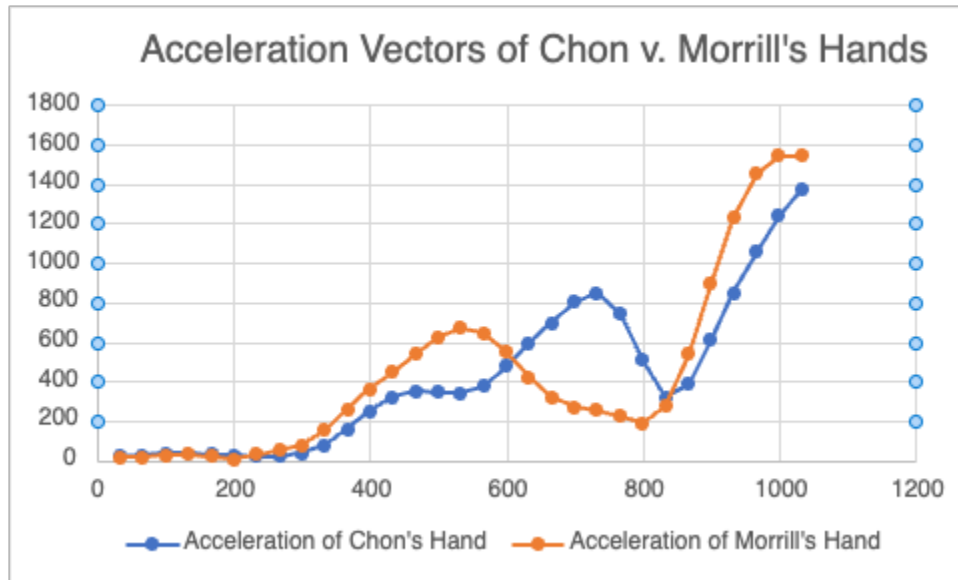


Figure 1. Depicts the acceleration vectors of the second touch from the 2022 October NAC CMS Gold Medal Final between Taylor Chon and William Morrill. Time (ms) is on the x-axis and acceleration (m/s²) is on the y-axis.

The consistency of the results across the diverse range of scenarios and the involvement of multiple referees underscore the robustness of the correlation observed. The findings strongly support the notion that continuous increase in velocity and acceleration of the hand play a significant role in determining the scoring outcome in saber fencing.

The results of the analysis not only demonstrated a consistent trend but also provided strong evidence to support the hypothesis that the fencer whose hand had the first continuous increase in velocity and acceleration would be awarded the point by the referee. In all 10 scenarios examined, the hypothesis was proven correct, as the fencer with the earliest and continuous increase in hand velocity and acceleration was consistently recognized as the scoring fencer by the referee.

Overall, these findings emphasize the critical role of kinematic parameters of the hand in saber fencing and provide valuable insights for fencers and coaches seeking to optimize their performance. These findings can lead to new strategies and methods of teaching saber fencing, as a focus on the feet is no longer necessary. If a fencer is able to focus on and train their ability to generate continuous increases in velocity and acceleration of their hand, they will be able to optimize their performance potential and succeed further in the sport of fencing.

LIMITATIONS

It is worth noting that while the correlation between continuous increase in velocity and acceleration and the referee's decision was consistently observed in this study, other factors such as technique, height, arm length, and the referee's experience may impact the decision. In addition, the bouts used for analysis all occurred from 2022-2023 and were all from USA Fencing. Therefore, this study may not represent sport internationally as a whole. However, within the scope of this analysis, the focus on the fencers whose hand had the first continuous increase in velocity and acceleration proved to be a reliable predictor of scoring outcomes.

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