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# Comparing the weapon speed of French elite para-fencers

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## 1. Introduction

Wheelchair fencing is a duelling sport practiced on a specific wheelchair and with the same three weapons as the able-bodied: foil, sabre, and sword. To participate to the main competitions, athletes must perform with two of the three weapons. While, this sport is now a Paralympic game sport, a lack of performance criteria remains for the athletes.

Rules differences exist between the three weapons (Roi and Bianchedi 2008). With the foil and the sword, the fencer can hit his opponent only with the tip of the blade, whereas, with the sabre, the athlete can hit the opponent with the edge of the blade as well as with the tip. The sabre and the foil are conventional weapons which means that there is a priority needed to score. To obtain the priority, the athlete must attack first, parry, or avoid the attack of the opponent, usually going back. The sword however is non-conventional and the first athlete to hit the other scores.

The specificity of wheelchair fencing is that it is always in close combat. Indeed, the wheelchairs are fixed at a certain distance from one to another. This distance is based on the athlete which has the lowest arm length (Caldwell and Luigi 2018). Therefore, the athletes need to move in their wheelchairs to perform an attack and touch their opponent, and, the faster they are, the more likely they are to strike first, leading to a point in the game. The athletes need to move quickly and to reach a long distance to hit their opponent so it was expected to find a relationship between their mass or arm length and the weapon speed.

It has been observed, on able-bodied fencers, that there were differences in the weapon speed depending on the weapon (Chen et al. 2017) but it had not been applied to para-fencers.

Hence, the objective of this study was to compare the speed of the three weapons used by para-fencers during an attack, and, to define a criterion performance, comparing the relation between the weapon speed and the anthropometric data of the athletes. The sabre was the weapon with the highest maximal speed for the able-bodied fencers (Chen et

al. 2017) so it was hypothesized that it would be the same for the para-fencers.

## 2. Methods

### 2.1 Participants

Eleven para-fencers of the national French para-fencing team volunteered for this study. Their mean  $\pm$  SD age, weight, arm length, and year of practice were respectively  $30.2 \pm 11.3$  y.o.,  $66.8 \pm 9.8$  kg,  $0.65 \pm 0.21$  m and  $18.5 \pm 8.6$  years. All participants had their own fencing equipment, their own wheelchair and weapons. Each athlete was using two different weapons. Therefore, there were eight athletes with a foil, eight with a sabre and six with a sword. This research was authorized by EudraCT / IDRCB n° 2020-A02919-30.

### 2.2 Experimentation

Two participants were facing each other. The wheelchairs of both participants were fixed onto a base plate and were connected by a metal rod as usual, so the distance between the athletes would not change after a motion of the athlete on the wheelchair. One of the participants was asked to perform five attacks at maximal speed of the opponent while the other was not moving. There was no advice on where to exactly hit their opponent on the torso.

Two markers were placed on the weapon of the athlete performing the attack. One at the base of the blade on the hilt, and the other one on the blade at approximately 20 cm from the hilt, not to consider the deflection of the blade. Positions of the reflective markers were captured using a 22-camera optoelectronic motion capture system (Vicon® System, ©Oxford Metrics Inc., UK) working at 200 Hz.

### 2.3 Data processing

The trajectories of the markers were smoothed using a sliding window average method. The trajectory of the marker on the blade was derivated to compute the marker velocity, then smoothed again with the same method. The direction of the weapon was computed using the marker on the hilt and on the blade and the marker velocity was projected on the instantaneous direction of the weapon.

The maximal weapon speed was then computed for the three weapons. Significant differences have been assessed with a one-way ANOVA and a post-hoc analysis. The Cohen's effect size of the ANOVA was reported. Pearson correlation between maximal weapon speed and anthropometric data of the athletes was also computed.

## 3. Results and discussion

The sabre maximal speed was found the highest of all three weapons with a mean maximal speed of 5.13 m/s versus 2.98 m/s for the foil and 2.85 m/s for the sword.

The dispersion (SD) was higher for the sword (1.26 m/s) than for the sabre (0.97 m/s) and the foil (0.40 m/s). The effect size was large:  $f^2 = 0.53$  which confirms the statistical differences found between the speed of the sabre and the other weapons (Figure 1).

The able-bodied fencers wielding a sabre also had a higher maximal weapon speed than the ones wielding a sword or a foil although the speed was not reported. Nevertheless, Chen et al. (2017) reported a maximal foil speed of 2.91 m/s and 2.49 m/s for the sword for elite able-bodied fencers. With a foil maximal speed of 2.98 m/s and a sword speed of 2.85 m/s, the results of this study were close to the ones in the literature on the able-bodied fencers.

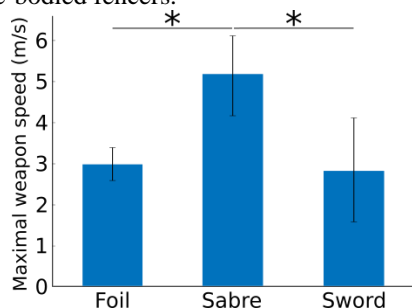


Figure 1 Weapon speed of the three fencing weapons.

Significant differences were highlighted with a \*.

The differences between the weapons (Figure 1) were due to the technique used to hit the opponent. Indeed, the sabre was the only of the three weapons with which it is possible to hit the opponent with the edge of the blade and not only the tip of the weapon. The motion is an edge cut with a motion of the wrist at the end of the attack (Chen et al. 2017), whereas it is a thrust for the foil and the sword.

The dispersion of maximal sword speed was higher than for the two other weapons. This could be due to the inter-variability of the fencing level of the participants, even if they were all on the national French para-fencing team, some of them had more experience, hence the high dispersion in term of year of practice. Differences in the pathologies between the para-fencers also exist, which could also explain the dispersion found in this study.

	Foil	Sabre	Sword
Mass (kg)	0.01 (0.94)	0.12 (0.38)	0.48 (0.09)
Arm length (m)	0.03 (0.66)	0.14 (0.53)	0.13 (0.54)

Table 1 Correlation ( $R^2$  and the p-value associated) of the weapon speed with anthropometric parameters.

The higher correlation was found between the sword maximal speed and the mass of the athlete (Table 1) and it has suggested that the athletes with a lower mass had a slightly higher maximal sword speed. This seemed logical since lighter athletes could possibly move faster than the heavier ones. However, this correlation was not found with the other weapons. This might be because of the low number of athletes, and that the technique to hit was different.

This correlation was not significant, and it was mostly due to the athlete with the lower sword speed. However, it could be seen as a performance criterion if the tendency would be confirmed. And such performance criterion could be of use for coaches, when trying to improve the performance of their athletes. Nevertheless, it needs validation, by increasing the number of athletes in the cohort. However, the speed of the weapons was not significantly correlated with other anthropometric parameters included the subject's height.

#### 4. Conclusions

This study was the first to investigate the performance for para-fencers, and the correlation between the maximal sword speed and the mass of the athlete was presented.

The maximal speed was found the highest for the sabre with 5.13 m/s in average. The maximal weapon speed was equivalent between the foil and the sword but a higher dispersion was found for the maximal sword speed in respect to the other two weapons.

Inter-variability of the fencing level and of the pathology might explain the differences found within the para-fencers presented in this study.

As a search for performance criterion, the correlation between the maximal sword speed and the mass of the athlete was not clear, and there is a need to increase the cohort size, to be able to conclude. The relation between the anthropometry of the athletes and the weapon maximal speed could also be researched further, to provide indications to coaches and recruiters.

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