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# Scapula and clavicle kinematics during wheelchair fencing: a preliminary study

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## 1. Introduction

Wheelchair fencing is a duelling sport where athletes sit on wheelchair with a fixed distance between them. As wheelchair fencers suffer many upper limb injuries Chung (2015), studying the kinematics in order to prevent injuries is of particular interest.

To our knowledge, only one study has investigated the kinematics of the upper limbs for wheelchair fencers. In his study, Chung (2015) reported shoulder (humero-thoracic), elbow and wrist angles for athletes performing lunges. He exhibited differences between category A and B regarding shoulder angular velocities when it came to reach distant targets. However, this study did not provide all elements of the shoulder kinematic chain.

Hence, the objective of this study was to provide a first insight of scapular and clavicle kinematics of wheelchair fencers so as to establish the complexity of the models needed to analyse wheelchair fencers kinematics and dynamics in detail.

## 2. Methods

### 2.1 Data collection

Ten elite wheelchair fencers were recruited during the European Championship of Paris 2024 (9 men, 1 woman). Among them, seven belong to the category A and three to the category B. After being informed of the protocol and having signed a written consent form, participants were asked to sit on their own fencing

wheelchair, which was then fixed on a "handifix". Then, participants were equipped with 9 reflective markers on the trunk and the upper limbs placed on: the jugular incisure of the manubrium, xyphoid process, the spinous processes of the seventh cervical, and the eighth thoracic vertebrae, the acromion, the clavicle (lateral part of the pectoralis major attachment) as well as a cluster made of three markers placed on the scapular spine.

After being equipped, participants performed a static pose, arm outstretched. In this position, a scapula locator (Brochard et al, 2012) was used by a trained experimenter to locate three scapular anatomical landmarks of their dominant arm: Trigonum Scapulae, Angulus Acromialis, and the inferior angle of Margo Medialis.

Then, they were asked to perform a fencing movement which started from guard position, and included first an attack without target then a retreat. Volunteers were told to reach maximum distance forward for lunge and maximum distance backward for retreat. Those movements were performed in a motion analysis room equipped with 10 cameras (Vicon, Vero 2.2) with a 100Hz sampling rate.

### 2.2 Data processing

The transformation matrix from local cluster coordinates system to scapula coordinates system was defined from data of the static pose acquisition. It was then used to reconstruct the scapula location and orientation during the fencing motion from the scapula spine cluster position. All marker data were then filtered using a five points sliding average method.

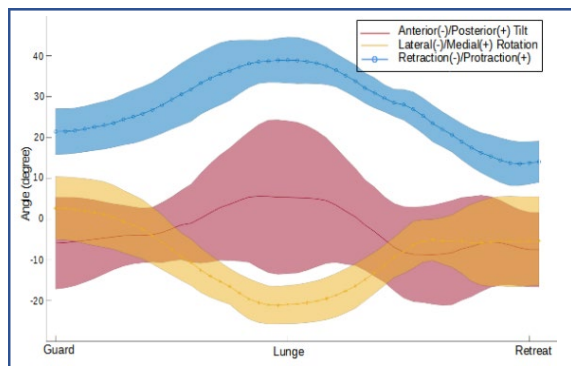
Thorax, clavicle and scapular coordinates systems as well as joint angles were calculated following ISB recommendations. Angular speeds were obtained as projection in the joint coordinate system (Y-X'-Z'') of the angles derivatives. Maximal angular speeds were computed during each movement phase: lunge, retreat and then averaged for each group. Maximal angular positions were computed at the end of each phase and then averaged for each group.

## 3. Results and discussion

During lunge, fencers exhibit similar clavicle elevation compared to high arm abduction reported in the literature (Ludewig et al, 2009) which would drive further studies towards the use of complex shoulder mechanism.

Regarding scapular angles, kinematics of category A fencers are shown in Figure 1. Low standard deviation indicates very similar motion pattern for the seven category A fencers. For both categories, scapular angles for the guard position are very similar to those reported in the literature with intracortical bones for a low abducted arm. On the other hand, lunge motion is characterized by an important protraction as well as a

significant lateral rotation. Those scapular angles, protraction in particular, are very similar to a scapular plane abduction, which implies a change in plane of motion. As the lunge direction did not change during motion, it suggests a trunk rotation. This guess is supported by a previous study that exhibited maximum reach space in the scapular plane for wheelchair fencers (Raud et al, 2023). Moreover, it seems that protraction might be more important for category A fencers, suggesting they would rotate the trunk more than category B fencers, which would be consistent with the functional differences between the two categories. Investigating trunk kinematic could be of interest for further study in order to verify this guess.



**Figure 1.** Scapular angles (means and standard deviations) for Category A fencers.

On the other hand, the retreat motion is characterized by a scapular protraction, a tilt and a lateral rotation similar to the guard position although protraction is less important. All data are summed up in Table 1. Lunge motion is overall consistent with data obtained by Chung (2015) that reported high arm elevations, implying scapula movement through the effect of scapula rhythm.

		Guard		Lunge		Retreat		
		CAT A	CAT B	CAT A	CAT B	CAT A	CAT B	
Y rotation Retraction- Protraction	Clav	Angle	-21,8	-18,2	-37,9	-25,9	-22,8	-21,8
		Speed			-41,6	-28,6	45,8	18,8
	Scap	Angle	21,4	29,2	38,9	39,8	13,7	21,5
		Speed			62,5	48,6	-36,7	-62,7
X rotation Lateral- Medial rotation	Clav	Angle	-4,1	-5,8	-25,9	-24,3	-10,1	-7,7
		Speed			32,5	-58,2	-45,3	-29,6
	Scap	Angle	2,7	-0,2	-21,1	-16,2	-5,3	-1,3
		Speed			-100,9	-118,7	89,3	80,3
Z rotation Tilt	Clav	Angle	-1,6	-1,6	-10,9	-10,2	-2,6	-2,9
		Speed			-23,9	28,0	21,4	36,9
	Scap	Angle	-5,9	-8,4	5,3	15,3	-8,5	-10,9
		Speed			35,4	60,7	-47,1	-67,9

**Table 1.** Angles values and speeds for each category.

Three-dimensional linked-segment model and multiple calibration could be implemented in future studies to reduce the latter and improved results accuracy.

## 4. Conclusions

In this study we propose a feasible method to provide first insights of scapula and clavicle angles of wheelchair fencing. The results, even if they are subjected to soft-tissue artefact, show the requirement of the implementation of a complex kinematic chain model of the shoulder for further and more accurate analysis.

Additionally, investigating trunk kinematic seems also relevant to refine the analysis between categories.

In the future, the method would be improved in order to overcome soft tissue artefacts. For that purpose, musculoskeletal model and multiple calibrations should be considered.

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## Conflict of Interest Statement

No potential conflict of interest was reported by the authors.

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