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Comprehensive analysis of archery performance: a case study

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1. Introduction

Archery is an Olympic sport where archers aim at targets 70 meters away outdoors or 18 meters indoors, with the objective of achieving the highest score by hitting the center of the target. Callaway, Wiedlack, & Heller (2017) delineated archery shooting movements into seven phases. The aiming and the follow-through phases are particularly emphasized in the literature.

Success in archery relies on strength and endurance of upper body muscles, stable posture, and strategic timing (Callaway et al., 2017; Zawi & Mohamed, 2013).

Muscle activation patterns differ for the drawing and bow arms during the aiming and follow-through phases. Higher performance is associated with specific muscle activations, while others may hinder performance (Ertan, 2009; Simsek, Cerrah, Ertan, & Soylyu, 2018). Postural stability, key in precision sports (Mononen, Kontinen, Viitasalo, & Era, 2006; Zawi & Mohamed, 2013), affects archery performance. Reduced movement speed of center of pressure (CoP) enhances accuracy during aiming (Sarro, Viana, & De Barros, 2021) and follow-through phases (Spratford & Campbell, 2017). Various temporal strategies have been identified, with shorter aiming phases correlated with higher performance (Sarro et al., 2021).

Furthermore, individual archers employ distinct muscular and temporal strategies (Vendrame et al., 2022), underscoring the relevance of identifying performance determinants both individually and collectively.

Therefore, the aim of this case study is to propose a precise and reproducible protocol to identify which performance determinants in archery are individual or common to all archers.

2. Methods

2.1 Population

One voluntary French nationally ranked archer (19 years old), participated in this study.

2.2 Protocol

Measurements were conducted indoors at the CREPS Nancy, with standard targets placed 18 meters away from the archer. Before starting the protocol, the archer performed a 15 minutes warm-up following his usual routine. The archer completed 10 rounds of 6 arrows each, maintaining his typical pace throughout.

2.3 Measurements

The aiming phase and the follow-through phases were identified using a camera recording at 20Hz. The duration of the aiming phase was calculated for each arrow using the camera.

EMG activity of eight muscles, defined as performance determinants in other studies, was recorded at 2000Hz using surface EMG (Noraxon system). Electrodes were placed on the extensor digitorum (ED), flexor digitorum superficialis (FDS), middle deltoid (MD), posterior deltoid (PD), and upper trapezius (UT) on the drawing side, and on the ED, FDS, and MD on the bow arm side, following the recommendations of the SENIAM project. Prior to the first round, MVC measurements were taken against static resistance. For each arrow shot, EMG activity was measured for both phases. The data were then filtered and rectified using a 4th order Butterworth bandpass filter with a 20-500Hz frequency range. The data were normalized according to the MVC.

Kinetic data were recorded using an AccuPower AMTI force platform at 1000Hz. The Y-axis is for the shooting direction and the X-axis is perpendicular to it. Velocity of CoP displacement on the X (VX) and Y (VY) axes, overall velocity of CoP (V) calculated with $\sqrt{VX^2 + VY^2}$, range of CoP displacement on the X (RX) and Y (RY) axes, and the surface area of CoP displacement (S) were calculated throughout each of the studied phases. Maximum velocity of CoP displacement (Vmax) was calculated for each phase. EMG, kinematic data, and camera were synchronized with Noraxon software.

2.4 Data analysis

Among the 60 arrows shot, the top 10 scores and the bottom 10 scores formed two groups: high score (HS) and low score (LS). Average EMG signals of the eight muscles for each of the two phases were compared between the two score groups. The analysis was identical for RX, RY, VX, VY, V, Vmax, and S.

3. Results and discussion

Results shown are preliminary and for only one participant. Only the aiming phase is presented in this results section.

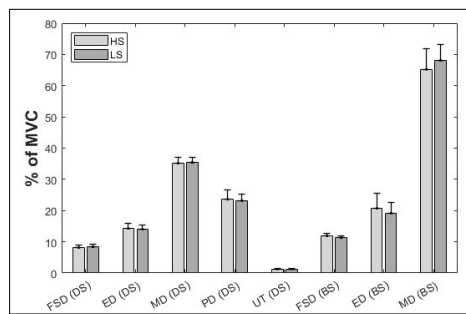


Figure 1. Muscular activations for the participant in the aiming phase. DS: draw side and BS: bow side

The muscle activation (Figure 1) and postural control data (Table 1) are descriptive and do not allow for interpretation. No visual differences in muscle activation are apparent. For postural control variables, only the means of S and Vmax might potentially be different. As for temporal strategies, the aiming phase in LS lasted 3.0s ± 1.4s and the aiming phase in HS lasted 2.3s ± 1.1s.

Table 1. Postural control variables for the participant in the aiming phase.

Variable	LS	HS
	(mean ± SD)	(mean ± SD)
S (mm ²)	32.5 ± 13.4	23.2 ± 14.2
RX (mm)	8.1 ± 2.9	6.1 ± 1.9
RY (mm)	4.6 ± 1.2	5.3 ± 2.1
VX (mm/s)	16.6 ± 1.2	17.1 ± 0.9
VY (mm/s)	9.9 ± 0.6	9.8 ± 1.1
V (mm/s)	11.1 ± 1.3	11.9 ± 0.6
Vmax (mm/s)	54.4 ± 11.5	80.9 ± 32.4

Several points require deeper examination. The chosen camera's accuracy may not be sufficient for defining phases precisely. UT activation is lower than reported in literature. Analyzing this muscle is relevant for performance but needs confirmation with a larger sample size.

This protocol will be implemented with a group of 8 archers, aiming to generalize these results. Consequently, comprehensive statistics calculated from the data measured on 8 subjects will enable the results to be generalized further.

4. Conclusions

This case study allows us to validate our protocol, especially given the relevance of the measured variables. The next step involves presenting the results for a group of 8 archers. To our knowledge, this study

is the first to consider all performance determinants in archery within a single experimental protocol. The findings may assist coaches in discerning whether a performance factor stems from an individual strategy or indicates a different skill level, and thus, whether it is trainable.

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Conflict of Interest Statement

The authors have no conflicts of interest relevant to this study.

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