BIOMECHANICAL PREDICTORS OF RECURVE ARCHERY PERFORMANCE

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SUMMARY
Biomechanical predictors of recurve archery performance were studied in 15 male archers. In the aiming position, aiming tremor, postural sway, shoulder girdle steadiness and MVC were measured. Shoulder girdle steadiness is a fair single predictor of performance.

INTRODUCTION
Elite recurve archers have to shoot a target (radius: 6.1 cm) placed 70 m away repetitively. Success critically depends on accuracy in the arrow releasing phase, as small errors are amplified during the 70 m flight of the arrow. In the aiming phase, tremor reflects the dynamics of the biomechanical system. The decisive components are the relative activation of the muscles and mechanical amplification through long lever arms e.g. from the shoulder joint to the wrist. The purpose of this study was to identify potential biomechanical predictors of shooting performance.

METHODS
15 male recurve archers spanning from elite to sub-elite level (age 26.6 ± 9.3 years, body mass index 24 ± 2.2 kg·m^{-2}) participated. Each archer performed an indoor shooting session and a laboratory session.

The archers completed 150 arrows on an 18 m FITA approved indoor shooting track. Indoor shooting was selected to eliminate weather confounders. Performance was calculated as average point per arrow.

In the laboratory, the archers were placed on a force platform and instructed to aim at a target placed 2.5 m in front of them (Figure 1). After warm up and familiarization, each archer completed 6 arrows with an extended aiming phase lasting 10 seconds. Data were obtained from the aiming phase of the last four arrows. Sway length data was obtained from the force platform. The tremor transferred to the bow (aiming tremor) was measured with an accelerometer placed on the bow. Aiming tremor amplitude was calculated as the SD of vertical and horizontal acceleration data. Total power in three frequency ranges: (1) 0 – 1 Hz, (2) 3 – 8 Hz and (3) 8 – 12 Hz, were calculated and normalized to total power 0 – 30 Hz.

To isolate shoulder girdle tremor a steadiness task was performed in the aiming position (Figure 2). The archers were instructed to keep a steady force, matching their individual level of bow-force with online visual force feedback. Stediness was calculated as SD/mean force (Fcv). Furthermore in this set up, maximal pull strength (MVC) was measured.

Force data were sampled at 1 kHz and accelerometer data were sampled at 0.25 kHz.

RESULTS AND DISCUSSION
Significant negative correlations were found between performance and the following: steadiness ($r^2 = 0.45$, $p < 0.01$), vertical tremor amplitude ($r^2 = 0.26$, $p < 0.05$) and vertical tremor power in the 3 – 8 Hz frequency range ($r^2 = 0.30$, $p < 0.05$). Linearly combining vertical tremor power in the 3 – 8 Hz and the vertical tremor amplitude an $r^2 = 0.54$, $p < 0.01$ was obtained.
The correlation between performance and both 3 – 8 Hz vertical tremor and steadiness indicates motor adaptations in elite archers. The 3 – 8 Hz vertical tremor in this setup is expected mainly to originate from CNS oscillations [1]. Facilitating motor adaptations at CNS level requires immediate evaluation of motor performance during exercise, hence visually feedback are important. Shoulder girdle steadiness is a fair single predictor of archery performance (Figure 3). Shoulder steadiness decreases with increasing relative loads [2]. Therefore improving MVC in the aiming position is expected to be beneficial for archers.

Furthermore, when bow-force exceeded 40 %MVC, performance tended to decline \((r^2 = 0.43, p = .054)\). Mean MVC and bow-force were 532 ± 117 N and 196 ± 16 N, respectively.

**CONCLUSIONS**

Shoulder girdle steadiness measured in an aiming position is a fair single predictor of archery performance. Frequency and amplitude analysis of aiming tremor suggest CNS motor adaptations in elite archers. Based on the present data, we suggest aiming exercises with visually feedback, in order to facilitate motor adaptations and reduce aiming tremor. Furthermore increasing MVC in the aiming position could improve steadiness and should be considered when deciding the level of bow-force.

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**REFERENCES**