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## BODY SWAYS ARE DIFFERENT BETWEEN OLYMPIC ELITE AND MILITARY SHOOTERS

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### SUMMARY

The aim of this study was to analyze the body balance patterns of two pistol shooters groups with different technical levels, considering their best and worst shots. The sample consisted of 24 subjects divided in Group A, 12 elite athletes experts in pistol shot and Group B, 12 military shooters. Volunteers were positioned on a force plate and performed seven series of five shots using a shooting simulator and a semi automatic pistol .32 caliber. The best shots were characterized by the lower standard deviation of the aim point fluctuation (APF) considering the preparatory period of 1.5 s prior to firing, in the lateral and vertical directions. It was observed that the postural sway differed significantly between the elite athletes ( $Area_{Gp\_A} = 0.0683 \text{ cm}^2$ ) and the military shooters ( $Area_{Gp\_B} = 0.1893 \text{ cm}^2$ ).

### INTRODUCTION

Shooting is an Olympic sport with over 15 different categories [1] and is a common and essential practice in the Armed Forces and Military and Federal Police. The main focus of the studies about shooting is to identify parameters determinant of the success. The motor patterns of the shot is a relevant analysis to understand the nature of postural instability and its influence on performance. Body balance and stability of the gun barrel are the main variables that influence shooting performance [2].

In shooting, postural stability is more relevant than in other athletic events [3] and small postural changes can lead to significant changes in the results [4]. In normal quiet standing position [5] and also during the execution of the rifle shot [4,6], the oscillations of the body, identified by the analysis of its center of pressure (COP), are lower in highly trained shooters compared to less expert shooters [4]. Among non expert shooters, postural balance shows oscillations significantly higher for the worst shots, when compared to the best ones [4]. However, no association between the aforementioned parameters were found among the high-level technical shooters [4,7].

The aim of this study was to analyze the body balance patterns of two groups of shooters with different technical levels, considering their best and worst shots.

### METHODS

This study included 24 healthy, active and right-handed subjects, without history of locomotor injury and neurologic and cardiologic diseases. The subjects were divided into two groups: Group A (Gp\_A), 12 elite athletes (ten men and two women) of pistol shooters, with  $39.0 \pm 3.5$  years of age (mean  $\pm$  SD)  $82.9 \pm 14.4$  body mass kg and height  $181.3 \pm 6.5$  cm; Group B (Gp\_B), 12 military shooters (men) with practice in combat pistol shot, with  $37.6 \pm 5.7$  years, body mass  $83.2 \pm 13.9$  kg and height  $175.5 \pm 7.2$  cm. The experimental protocol was approved by the local CEP and all of them signed an informed consent form.

The experiment was accomplished in two days. On the first day, for the stabilometric test, the subjects stood upright on a force plate during 60 s, with arms along the body, gazing at a point 6 m away and 1.50 m in height [8]. The feet were positioned with the heels apart by 7 cm and with  $30^\circ$  lateral rotation. A force platform was developed especially for this study, with dimensions of 1 x 1 m ((Biomec400, EMG System, Brazil). The axes of the platform were oriented such that the anteroposterior direction (Y) would be parallel to the firing line and the mediolateral direction (X) perpendicular to this line. The signal acquisition was performed with a sample frequency of 100 Hz by an analog-to-digital converter of 16 bits. The stabilograms were digitally filtered by a Butterworth low-pass filter fourth order with cutoff frequency of 10 Hz.

On the second day, the shooters executed seven series of five precision shots in their preferred position holding the weapon with one hand, without support, and in the standing position on the force plate, in front of the target positioned at 6 m away (Figure 1). It was used a semi automatic .32 caliber pistol (Walther, Germany) suitable for proofs of Fire Central. The shots were done without real ammunition and using the firearms training simulation systems (Noptel Oy, Finland), each series having a maximum duration of 5 min, mediated by 3 min of rest.



**Figure 1:** The shooters executed the shots holding the weapon with one hand only, standing on the force plate.

To classify the shots, it was selected the 10 best and 10 worst shots of each subjects, among the 35 shots, based on the standard deviations in X and Y directions of APF (Dev\_X and Dev\_Y).

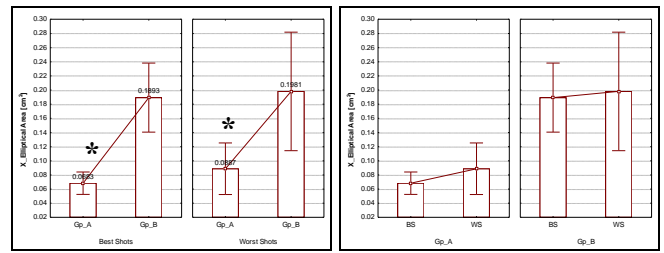
Four variables were calculated to describe the postural sway in the window of 1.5 s prior to firing: elliptical area calculated by principal component analysis [9], the total displacement of postural sway of the COP in the support base (DT); amplitude of displacement of COP in directions perpendicular to the firing line (ACOPx) and parallel to the firing line (ACOPy); average velocity (cm/s) calculated by dividing the total displacement in each direction for the entire period selected (1.5 s) (VCOPx and VCOPy).

The Gaussian distribution of the data was confirmed by the Kolmogorov-Smirnov test. The variance analysis (ANOVA) two-factor (group: A vs. B; quality: Best Shots vs. Worst Shots) with repeated measures was applied for each stabilometric variable. The level of significance was considered  $\alpha=0.01$  and the software Statistica 7.0 (Statsoft, USA) was used for statistical analysis.

## RESULTS AND DISCUSSION

The stabilometric variables didn't show significant differences between groups. Only one study [10] compared the postural sway of the pistol shooters with fencing athletes. In this study, the best shooters showed lower amplitudes and areas in the quiet standing with open eyes and without proper shooting clothes compared to the control group. However, Herpin et al. [10] found no significant difference in the stabilometric parameters at the anteroposterior direction between shooting and fencing athletes and the control group, as evidenced in our study. International level rifle shooters presented lower values for velocity and amplitude in quiet standing than the national level shooters, which in turn showed lower values than the beginners in shooting [4].

During the shooting execution, the Gp\_A had all stabilometric parameters significantly lower than Gp\_B ( $p < 0.01$ ), demonstrating that the postural sway during the aim period was more stable among athletes shooting (Gp\_A) (Figure 2).



**Figure 2:** Elliptical Area during the best shots (BS) and worst shots (WS) on the X axis for both group of shooters (A and B). \*  $p < 0.01$  compared to the quality of shots performed by groups A and B.  $\bar{x}$  Mean  $\pm$  Mean  $\pm 0.99$  Conf. Interval.

However, comparing the best with the worst shots, there were no significant differences in any stabilometric parameter for Groups A and B ( $p > 0.01$ ) (Area\_Gp\_A = 0.0683 cm<sup>2</sup>; Area\_Gp\_B = 0.1893 cm<sup>2</sup>). These data suggest that postural balance during the preparatory period for the shot can distinguish the level of shooters, but not differentiate the quality of the shots.

The stabilograms achieved from preparatory period for the shot suggest that the time of practicing and the experience achieved by elite shooters may have favored the development of special skills. The ability to release small movements and increase joint couplings allow better explore the technical skill of motor control of the whole shooting position and minimize the effects of shooting postural instability on the performance of shots fired.

## CONCLUSIONS

It was observed that the postural sway during the preparatory period for the shot differs significantly between elite shooting athletes and military shooters.

## ACKNOWLEDGEMENTS

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## REFERENCES

1. Ball KA, et al., *J Sports Sci.* **21**:559-566, 2003.
2. Mononen K, et al., *Scand J Med Sci Sports.* **1**:180-185, 2007.
3. Su F, et al., *J Med Biol Eng.* **20**:187-192, 2000.
4. Era P, et al., *J Biomech.* **29**:301-306, 1996.
5. Aalto H, et al., *ORL J Otorhinolaryngol Relat Spec.* **52**:232-238, 1990.
6. Kontinen N, et al., *J Mot Behav.* **31**:11-20, 1999.
7. Ball, K.A., et al. *J Sports Sci.* **21**:559-566, 2003.
8. Mello RGT, et al., *Proceedings of XVIII Congresso Brasileiro de Engenharia Biomédica*, São José dos Campos, Brazil, 2002.
9. Oliveira LF, et al., *Physiol Meas.* **17**:305-312, 1996.
10. Herpin G, et al., *J Electromyogr Kinesiol.* **20**:162-169, 2010.