3-D BIOMECHANICAL ANALYSIS OF THE MOTOR PATTERNS OBSERVED DURING THE 10 M RIFLE-SHOOTING MODALITY.

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INTRODUCTION

Postural stability is an important characteristic of sport activities like shooting and archery. The ability of the athletes to control quasi-static motor patterns has been considered as the most important factor to obtain high scores. The behavior of the shooter-rifle system emerges from the dynamic interactions of its parts. Thus the problem of postural control consists in the maintenance of a stable posture developing a series of neuromuscular actions to eliminate degrees of freedom in the joints. The main purpose of this study is to describe, on the basis of mechanical parameters, the small amplitude oscillations of the body segments that take place during aiming and evaluate their influence on the performance.

METHODS

During the experimental procedure (Table 1) a shooter (Fig. 1) used a special designed suit to perform 60 shots (score 7.81±1.38) with an air-rifle from the distance of 10 m. The kinematic and stabilometric data were registered using a measurement chain (Gianikellis et al., 1994) integrated by a SAC Sonic Digitizer (GP8-3D), a strain-gauge force platform (DINASCAN-IBV) and a microphone fixed on the rifle to detect the instant of the shot. The sonic digitizer system has been evaluated according to a standard protocol (Stüssi and Müller, 1990) and its technical characteristics and performance are :

- number of markers : 16 sequentially activated (time multiplexing) ultrasound emitters that are automatically identified
- active volume (V) : 1800mm x1300mm x1400mm
- range of measurement (D): 2625 mm
- nominal systems resolution (r): 0.1 mm
- definition of the system (d): 16 bits
- accuracy (A): 0.054 with $A_x = 0.022$, $A_y = 0.038$ y $A_z = 0.032$
- precision (P_i) of the measurement of the distance to the microphones : P_A=1:23893, P_B=1:26300, P_C=1:28564, P_D=1:27967
- precision (p) of the reconstructed 3-D coordinates of the emitters: 0.115 mm with p_x=1:28125, p_y=1:26000, p_z=1:17073
- sampling rate of the whole system (f): 66.6 Hz
- sampling frequency per emitter (f_e): 22.2 Hz.
- spatio -temporal resolution of the system (Q): 70.7 $\sqrt{Hz}$ mm^{-1}.
- Maximum time of data acquisition: 30 sec
- calibration time: 5 minutes

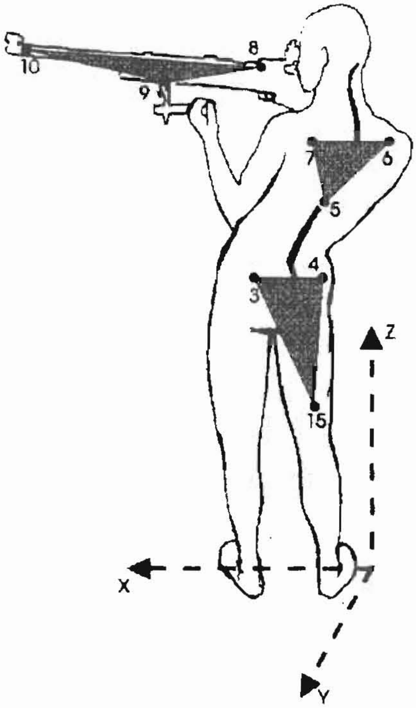

Figure 1. The numbers represent ultrasound emitters that define three body segments A - the rifle, B - the upper trunk and C - the lower trunk.

	Sonic Digitizer	Force platform
mode of initiation	keyboard	external signal
number of samples	1000	1500
sampling rate	66.6 Hz	100 Hz
time of sampling	15 milliseconds	10 milliseconds

Table 1. Working mode of the measurement chain during the experiment.

The treatment of the data was carried out using the package "Generalised Cross-Validatory Spline" (Woltring, 1986) according to the true predicted mean-squared error. After data treatment the interval of the last 5 sec of the aiming time has been divided in ten intervals (500 ms) and the following stability parameters have been calculated for the coordinates of every landmark and every segment (Fig.1) defined by three markers (Zatsiorsky and Aktov, 1990) :

- the range of the movement
- the standard deviation of the position of the landmarks

- the total displacement of every landmark respect to its averaged position
- the length of the trajectory of every landmark
- the absolute velocity of every landmark

RESULTS

The results of the statistical analysis of the data confirmed significant ($p < .0004$ - $p < .005$) linear correlations ($r = -.45$ - $r = -.35$) between the scores obtained on the target and the stability parameters especially during the seventh interval that is 2 - 1.5 s before the shot. During this interval the shooter was gradually started to press the trigger. Besides, it seems to be very important and at the same time very difficult to control the oscillations of the lower trunk during the aiming ($r = -.42$, $p < .0009$). One of the most important findings was the insignificant influence of the kinematic parameters of the rifle, given that most studies have been directed to this aspect of sport technique. Finally discriminant analysis of the obtained data on the basis of principal components (canonical correlation coefficient = .0564, $p < .00072$) suggested that 84.21% of the good shots (>7) and 72.73% of the poor shots (<7) were classified correctly according to five stability parameters.

CONCLUSION

For the described experimental conditions and aiming procedures the results of the present study confirm that the shooting quality (performance) depends strongly on the obtained stability parameters. Besides, it seems to be valid the hypothesis that according to an important principle of the general systems theory the behavior of the shooter - rifle system emerges from the dynamic interactions of its parts. The parts in interaction are ultimately responsible for the resultant behavior of the system. Finally the proposed methodology could be useful in the study of similar motor patterns in the field of Biomechanics.

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