Postural balance in rowing athletes*

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ABSTRACT

The influence of fitness on long-term postural balance is not clear yet. This study aims to compare stabilometric parameters in long-term balance tests performed by rowing athletes and by a control group of non-athletes healthy subjects, who stood upright on a force plate for 31 minutes. At every five minutes of test, a modified Borg scale was shown to the subjects to score the discomfort. The parameters studied were: standard deviation, average velocity and average frequency of the lateral and anterior-posterior centre of pressure displacements, and the elliptical area of the displacement on the level of the force plate. The athletes did not show significant differences in parameters during the entire test. The control group presented significant higher values in the elliptical area and in average velocity from the middle to the end of test. The athletes presented significant lower values in Borg's scale, showing a greater resistance to discomfort. It is suggested that stabilometric alterations showed by the non-athletes occurred in response to peripheral physiological processes, and that physical fitness seems to be an important factor for the maintenance of a long-term static balance.

Keywords: Postural control. Stabilometry. Rowing.

INTRODUCTION

The control of standing posture depends on motor-sensory information, based on the body internal representation by the central nervous system, which guarantees the system stability through adequate strategies[1]. The body axis corrections by postural control mechanisms, mentioned as consequence of the live body dynamics itself, gives to the human body small and constant oscillations whenever standing, with an important role in the pressure distribution on the feet soles and in the efficiency of the venous return[2].

The stabilometry is a technique of balance evaluation in the orthostatic posture, which consists of the quantification of the body anterior-posterior and lateral oscillations, while the individual is standing on a force plate[3-4]. Once the center of pressure displacement (PC) is representative of the postural oscillations, the registry is done by the instant calculation of its position (x, y coordinates), which correspond to the placement of the applied forces result on the surface in contact with the feet, which is the touching ground. The signal processing is usually applied in the time and frequency settings and since a protocol for the stabilometric test has not been established, different methodologies are applied, concerning the test time and the touching ground as well. Short time periods are usually adopted, around 30 seconds[5-8], according to Carpenter *et al.*[9] and Mello *et al.*[10], a period of 60 seconds is recommended to guarantee the steadiness of the stabilometric signal. The touching ground is a variable that does not influence the signal parameters when controled[11].

Stabilometric tests for long periods are less frequent. Duarte *et al.*[12], used 30 minute tests in non-restrictive posture, which means that the individuals could freely move on the plate. Their aim was to identify specific displacement patterns of the PC, as a postural control strategy to make this posture maintenance possible for an extended time. On the other hand, Imbiriba *et al.*[13], conducted stabilometric tests of 31 minutes in restrictive posture, where the individuals stayed in the same standing posture on a force plate, and reported the degree of discomfort every 5 minutes through a subjective scale. Significant differences for the lateral displacement of the center of pressure were found from 15 minutes on approximately, when compared to another group which was submitted to short resting times during the exam. The standing posture for an extended time showed a high level of discomfort in the individuals, according to the authors caused by a fatigue process.

Many daily tasks demand the orthostatic posture as ordinary postural orientation, especially in situations of long standings in line and in militarism. Physiological changes caused by tasks of these nature, related to the individual´s need to stand for a long time, are derived from the gravitational forces that deeply affect the cardiac debt[14]. Therefore, one may expect that the individuals with physiological adaptations derived from a developed muscular and cardiovascular conditioning, are more apt to overcome these alterations.

It has not been found in the literature information that gives evidence to the effects of physical conditioning in the displacement of the center of pressure in long term stabilometric tests. Thus, the behavior of the postural oscillations that face the physiological adaptations imposed by physical training during the process, induced by fatigue caused by the long standing posture, is unknown.

This study aims to compare the stabilometric parameters in long term tests between a group of rowing athletes and a group of non-athletes, in the standing still posture.

MATERIALS AND METHODS

The sample consisted of 19 rowing athletes (11 men and 8 women) from the Clube de Regatas Vasco da Gama, with at least four years of competition, registered in the Rowing Federation of Rio de Janeiro State (FRERJ). 19 healthy sedentary students (12 men and 7 women), from the Physical Education and Sports Federal University of Rio de Janeiro, were the non-athlete group. Table 1 presents the ages and the anthropometrical characteristics of the groups. The work was submitted and approved by the Ethics Committee of the Federal University of Rio de Janeiro.

TABLE 1
There is no significant difference between the groups

	Age (years)	Weight (kg)	Height (m)
Athletes	20.3 ± 2.7	78.8 ± 13.4	1.77 ± 0.75
Non-athletes	21.7 ± 2.0	78.4 ± 18.7	1.73 ± 0.82

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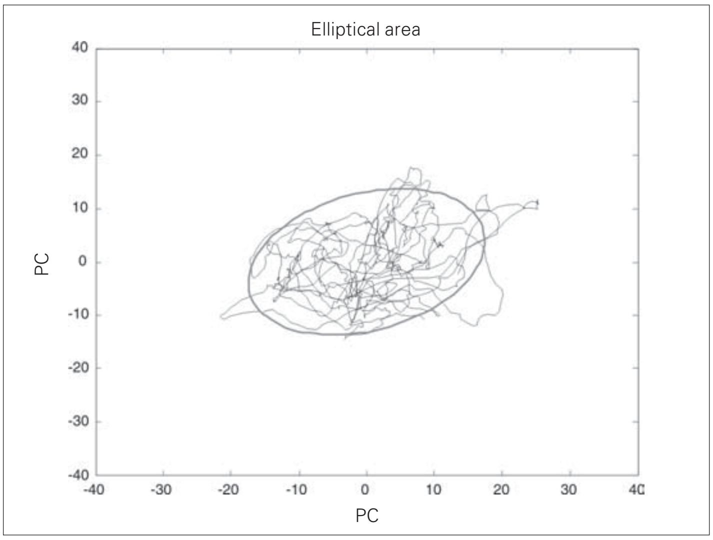

Figure 1 – *Example of an ellipsis adjusted to the center of pressure way (CP) in the anterior-posterior and medium-lateral axes*

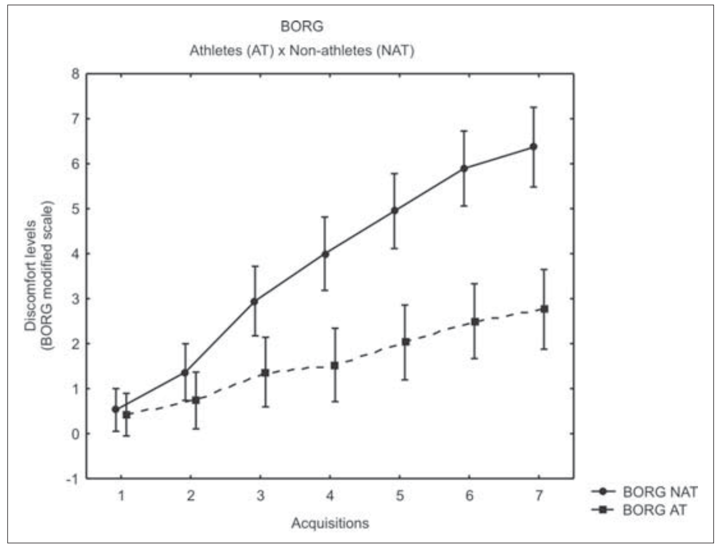

Figure 2 – *Level of discomfort during the test for the athletes (BORG AT) and non-athletes (BORG NAT)*

The acquisition system was a *AccuSway Plus* force plate, with the *Balance Clinic software*, using a sample frequency of 50 Hz (AMTI, 2001).

The athletes and students, after written agreement, stood on the plate for 31 minutes with feet united, arms on the side of the body and facing a wall 2,0 m distant. The signal was registered during the first minute of the test and, from that time on, at every five minutes, making a total of seven scores of one minute. At every register, a modified scale of Borg was shown, where their degree of discomfort at that moment was scored, being zero for "none" and ten for "impossible to continue".

The stabilometric parameters analyzed were: average velocity, standard deviation of the breadth and average frequency of the PC displacement of the lateral and anterior-posterior directions, besides the elliptical area of PC displacement in the level of the plate.

The elliptical area (EA), that corresponds to the ellipsis area that best adjusts to the PC way (figure 1), was calculated through the statistics technique of Analysis of Main Components[3,15]:

$$\sigma_{cp}^2 = \left(\sigma_{xx}^2 + \sigma_{yy}^2 \pm \sqrt{\left(\sigma_{xx}^2 - \sigma_{yy}^2\right)^2 + 4\left(\sigma_{xy}^2\right)^2} \right) / 2 \quad (1)$$

were σ_{xy}, σ_{xx}, σ_{yy} are respectively: co-variance, variance in the x and y axes.

The Discreet Transformed of Fourier[16] was applied for spectral estimates. The average frequency was calculated in the average of 0 to 2 Hz for each lateral and anterior-posterior displacement axis (FMX and FMY, respectively).

The average velocity was calculated for the lateral and anterior-posterior displacement VELMX, VELMY), through the ratio of the displacement in the axes related to test time. The breadth standard deviation of the displacements was also calculated for each axis (DPX, DPY). The obtained values through the discomfort scale constituted a variable as well (BORG), with discreet values from 0 to 10.

The statistics analysis used the STATISTICA® 6.0 aplicative (StatSoft, EUA). The ANOVA test with repeated measures was applied to compare the results among the seven registration periods of the groups and the post-hoc HSD by Tukey, with significance level of $p < 0.05$.

RESULTS

Figure 2 shows the obtained results through the *Borg* scale for the two groups, exposing progressive discomfort during the test, expressed by the average values of 1,6 ± 1,6 and 3,7 ± 2,7 for the athletes and non-athletes respectively.

Table 2 presents the average values of the DPX, DPY and FMX, FMY parameters in the first and in the last minute of the test. These parameters did not show any significant differences in any time of the test, neither between the groups nor in each group separately. The average values for the first, third, fifth and seventh minute of the AE, VMX and VMY variables acquisition in the group of non-athletes, are presented in table 3. A significant increase of these parameters ($p < 0,02$ e $p < 0,001$) from the middle of the test on, was seen comparing these values, twentieth and thirtieth minute respectively, in relation to the first register.

No statistic difference was found within the athletes group for any variable analyzed during the test. Figure 3 compares the average values of the elliptical area of displacement between the two groups, with higher results for the non-athletes group, not statistically significant, though. The average, lateral and anterior-posterior velocity was higher for the non-athletes, however, it was not statistically different between the groups.

DISCUSSION

Although no statistic difference was identified, the displacements in the lateral and anterior-posterior directions of the non-athlete group presented an increase of approximately 51,38% and

TABLE 2
Average values for the variables: standard deviation and medium, lateral and anterior-posterior frequency (DPX, DPY, FMX and FMY respectively), for the two groups, in the first and the last minute of the test

	DPX (mm)		DPY (mm)		FMX (Hz)		FMY (Hz)	
	1 min	**30 min**	**1 min**	**30 min**	**1 min**	**30 min**	**1 min**	**30 min**
Athletes	3.92 ± 0.96	4.76 ± 1.40	4.20 ± 1.63	4.27 ± 1.60	0.28 ± 0.09	0.23 ± 0.10	0.17 ± 0.06	0.19 ± 0.08
Non-athletes	4.02 ± 0.92	5.13 ± 1.82	4.34 ± 0.98	6.57 ± 4.38	0.22 ± 0.06	0.26 ± 0.08	0.18 ± 0.05	0.18 ± 0.06

TABLE 3
Average values and standard deviation for the variables area and average velocity in the two axes (VELMX and VELMY) for the non-athletes group, in the 1, 10, 20 and 30 minutes of the test

	Area (mm²)				VELMX (mm/s)				VELMY (mm/s)			
	1	10	20*	30*	1	10	20*	30*	1	10	20*	30*
Average	210.94	347.42	442.57	471.30	8.48	9.30	10.73	10.96	7.54	8.82	10.06	10.79
SD	77.74	131.61	297.46	447.52	1.08	2.70	2.74	3.87	1.47	1.83	3.02	5.49

* significant difference.

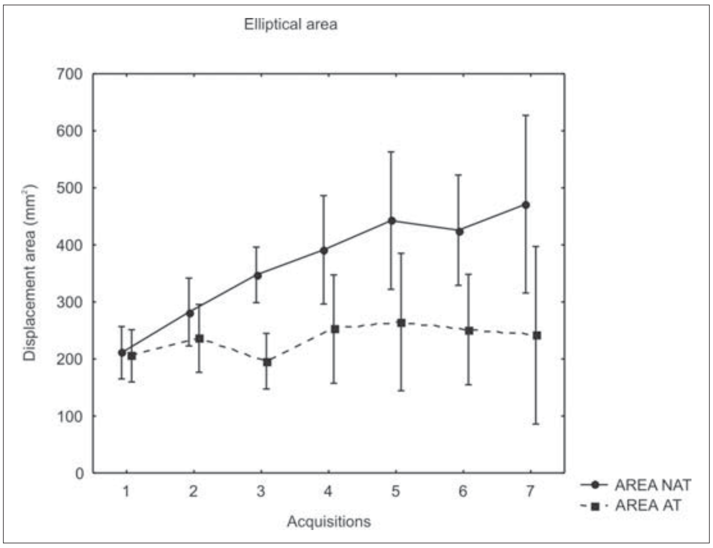

Figure 3 – *Displacement area related to the time for the two groups, athletes (AREA AT) and non-athletes (AREA NAT). Significant difference from the fifth register on.*

27,61%, respectively, until the end of the test (table 2). Such evidence can explain the significant increase of the displacement elliptical area occurred for this group. The greatest discomfort reported by the non-athletes, caused by the task persistence, may have directly affected the analyzed variables, and the cognitive factors associated to the postural control[1], such as the attention, what can also reflect on the oscillations magnitude, increasing the AE variations.

The found changes for the non-athletes group (table 3) demonstrate that the AE, VMX and VMY analyzed parameters, are sensitive to the discomfort induced by the experiment, providing the athletes with higher resistance to fatigue, since they present physiological adaptations due to their intense training. Therefore, no significant differences were observed during the test time to the athletes group, for all analyzed variables. Papers that face the physical conditioning with stabilometric parameters are scarce in the literature, especially in long term tests. Simmons[17] verified that dancers present lower response latency to balance disturbs, showing a more refined control of the postural oscillations through physical training, which may explain the reduced values for the AE of the athletes. The found results for area and average velocity in the conditioned group are similar to other studies that applied stabilometric tests, but of short time, in athletes of different sports, such as soccer, judo and gymnastics[18-20].

The research seems to agree with the time of approximately 15 to 20 minutes in relation to the discomfort signs and the PC displacement changes for healthy individuals but non-athletes, which corroborate with our findings. Gandra *et al.*[21] found a similar behavior of the stabilometric signal in a group of young individuals, whose tendency corresponded to the increase of the elliptical area and the displacement average velocity along the time. The evidence showed that the visual information deprivation emphasized such difference, started at the tenth minute of the test. Imbiriba *et al.*[13] observed a relation between the lateral displacement and the discomfort sensation, when compared results of individuals who continuously stood on the plate, with the others who rested during the test, from the fifteenth minute. Such time may be related to the physiological changes involved in the orthostatic posture maintenance, due to the influence of the gravitational influences in the cardiac debt[22-23]. According to Guyton[2], about 15 to 20% of the blood volume may be lost by the circulatory system during the 15 minutes of static, upright position, as happens when a soldier is in standing position.

The athletes presented a different behavior pattern, insensitive to discomfort, which demands a longer test time to show similar fatigue effects in the static postural control. Being rowing a sport simultaneously dynamic and a great strength application, the condition of being a competitor for at least four years, gives to the rowing athletes a developed muscular and cardiovascular system, as described in the literature[24-25], what may explain the steady characteristic of the postural oscillations with the time, and the low discomfort values.

Aspects related to the extended time of the test, such as the nature of the fatigue process derived from the experiment, and the physiological variables directly involved in the peculiar behavior of the stabilometric parameters of the athletes, could not be identified, representing limitations to the study.

CONCLUSION

As a conclusion**,** one may say that long term stabilometric tests are sensitive to training, allowing to identify individuals with high level of physical conditioning. The athletes did not present changes in the static postural control due to the extended time of the test, since they were kept in the initial pattern of the center of pressure displacement, expressed by the steady behavior of the analyzed stabilometric parameters. However, in the control group, such parameters were passive to changes, occurred simultaneously with the increase of the discomfort level. The intense physical training was the crucial factor for the differentiated characteristic between groups; to the PC oscillation parameters – identified through stabilometry - and to the discomfort sensation induced by the task as well.

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