Day-time effect on postural stability in young sportsmen

Luca Russo[1]
Umberto D'Eramo[2]
Johnny Padulo[3,4]
Calogero Foti[5]
Riccardo Schiffer[2]
Fabio Scoppa[2]

[1] Department of Applied Clinical Sciences and Biotechnologies, University of L'Aquila, Italy
[2] Faculty of Medicine and Dental Surgery, Sapienza University of Rome, Italy
[3] University eCampus, Novedrate, Italy
[4] Tunisian Research Laboratory "Sports Performance Optimization" National Center of Medicine and Science in Sport, Tunis, Tunisia
[5] Tor Vergata University, Rome, Italy

Corresponding author:
Johnny Padulo
University eCampus
Via Isimbardi, 10
22060 Novedrate, Italy
E-mail: sportcinetic@gmail.com

Summary

Background: **stabilometry is commonly used from clinicians and posturologists for stability and postural assessment of patients. In the daily practice a large number of posturologists are usual to control the effect of their treatments on the same subject through stabilometry but tests are not always performed at the same time, so it is necessary to be sure that data are not influenced by the time-of-day. The aim of this study was to evaluate the time-of-day effect on stabilometric parameters and theirs variation.**
Methods**: for this aim 61 healty sportsmen performed on four repetitions of the stabilometric test during the same day (morning - evening). Data collected from each test were: centre of pressure sway path length, Naiperian logarithm of the ellipse of confidence area, of the *x* mean and of the *y* mean, eccentricity of the ellipse area.**
Results**: no significant difference was found in any parameter at any time of the day. Intra-class Correlation Coefficient value confirmed the reliability of the stabilometric evaluation in healty subjects (sway path length 0.836 and 0.816 for open and closed eyes, respectively).**
Conclusion**: these findings suggest that stabilometry evaluation is not affected by a time-of-day, therefore the test and retest in different time of day is reliable to assess postural sway.**

KEY WORDS: balance, circadian variation, intra/inter variability, reliability, testing, stabilometry, time of day.

Introduction

Stabilometry is widely used to study the orthostatic postural control in sport science[1, 2] and clinical daily practice[3, 4]. Maintaining balance during the natural orthostasis is a complex task for humans because of the intrinsic instability of the position[5]; stabilometry does not measure balance but the stability properties of the human system while keeping a balanced standig position, because balance does not correspond to an absolute reality but it is a position-specific skill. Individuals keep the orthostatic position bringing forward the mechanic perturbations thanks to postural adjustements that minimize instability[6]. Stabilometry studies this aspects both for healthy and unhealthy people or in particular cases of life[7-11].
It is well known and certain that circadian rhythms[12, 13] strongly influenced the everyday life of individuals and during the whole day different hormonal profiles are present, having an effect on the wake-sleep cycle[14]. For this reason it can be supposed that the hormonal profile at the moment of the postural evaluation with stabilometry could significantly affect the results. This hypothesis means that performing two stabilometric test at different time of the day could make it impossible to compare the clinical results and could limit the interpretation of the effects of a postural treatment on the same subject[15-20].
The aim of this study is to test the hypothesis that circadian rhythms[13] can affect the postural stability in a sample of healthy male subjects through four repeated and constant measures during the day. Other researchers have recentely studied this phenomenon[21, 22], two study confirmed the lack of a time-of-day effect on stabilometric data[21, 23] and one study found a difference in stabilometric data during the day[22]. The number of measurements during the same day, the number and gender of subjects and the used protocol, except one study[23], were different compared to this study; for these reason in literature there is a lack

of clarity about the theme and further study are needed. The present study differs from other authors' ones for only-male gender, larger sample size and more measurements.

Materials and methods

Sixty-one young healthy male volunteers (age 22±3.4 yrs, body height 178±8.3 cm, body mass 77±16.4 kg) participated to this study. Subjects were recruited from the Sports Science Faculty of L'Aquila volunteer list. Each subject was fully informed and trained about the test's procedures and everyone gave the written informed approval to partecipate to the study in according with the guideline of the Muscle, Ligament and Tendons Journal[24].

Participants were selected according to the following criteria of inclusion:

1. Age between 18 and 30 years[25, 26]
2. No pain symptoms referred to the postural system or the muscle-skeletal apparatus[27]
3. No chronic pathology[26]
4. No medicine assumption
5. No alcohol or drug assumption[26]
6. No night shift worker
7. No sleep disorder
8. No neurological disorder[23,27]
9. No vestibular disorder or injury or surgey in the last 12 months before the test[21].

Due to the chronobiological nature of the study, authors chose to study only male subjects because of the impossibility to exactly control the female menstrual cycle.

Procedures

Stabilometric tests were performed on a platform (FreeMed, Sensor Medica, Guidonia, Italy)[28]. A stabilometric laboratory corresponding to the indications of the International Society do Posturology was chosen for the tests[29]. Each subject was tested four times during the same day: first test between 9 a.m. and 11 a.m., second test between 11 (10') a.m. and 1 (10') p.m., third test between 3 p.m. and 5 p.m., fourth test between 5 (10') p.m. and 7 (10') p.m. No measurement was performed during the night because the absence of postural reflexes during sleep. A maximum of 13 subjects could be tested at each time range; tests lasted 5 days in order to collect the whole sample of participants.

Subjects had to follow some indications for the tests procedures:

1. Punctuality
2. Silence and concentration during the test
3. Prohibition to get drugs, to smoke and to drink alcohol, coffee or exciting drinks during the whole day of the test
4. Prohibition to eat chewing gum before the test
5. To sleep at least 7 hours the night before the test and to wake up at least 2 hours before the first morning test
6. To keep the same clothes for the testing sessions.

Before each test everyone had to leave every kind of metal wearing, to avoid possible micro galvanism[30], after this operation the tested subject waited 3-min sitting down and then performed the stabilometric test both keeping his eyes open and closed. Stabilometric tests respected the international standardization criteria[29]: visual target within 5 meters, head in neutral position, silence, first acquisition with open and then with closed eyes, each test was 51.2-sec, feet were positioned with heel separated of 2-cm and the feet tips 30° wide apart, arms were close fitted to thighs. Authors chose to use the same protocol of Gagey[23] to be able to compare the results of the study, despite new indications for the standardization of the clinical stabilometric test have been recently provided[31]. Instructions before each test were always the same to avoid possible changes on stabilometry[32].

Data collection

Length of centre of pressure (Cop) sway path (CSPL)[31], Naiperian logarithm of the ellipse of confidence area (LNEA), of the *x* mean (LNX) and of the *y* mean (LNY)[23], eccentricity of the ellipse area (EEA). The transformation of some data in Naiperian logarithm aimed at normalizing this non-linear data[23]. Open eyes and closed eyes conditions were took in consideration for data analysis.

Statistical analysis

Statistical analyses were performed with SPSS 16.0 (SPSS Inc. Chicago, IL). The normally distribution of the population was tested with Shapiro-Wilk test and the homogeneity of variances was verified with the Bartlett's test. Post-hoc power analysis was conducted with the program G*Power[33]. ANOVA design with a Sidak correction and an Intra-class Correlation Coefficient (ICC) were used to evaluate differences between repetead measures during the day and to evaluate the reliability of the measures[34]. The level of significance was set to $p < 0.05$.

Results

Stabilometric data from an amount of 488 tests are showed in Table 1 and 2. ANOVA does not show significant differences between the four series of test for any of the measured parameters both for the open eyes and the closed eyes conditions. Only CSPL and EEA show "p" values on the edge of significance, but the post-hoc comparisons underline the lack of significant variations. The CSPL shows an increasing, but not significant, trend during the day suggesting an increase in the energetic consumption to maintain the orthostatic position. The LNEA remains constant during the four trials; the real values of the ellipse of confidence are contained within the normal range suggested from literature[31]. The center of Cop trajectory, described by the *x* and *y* mean values, show very little variations during the day both in the frontal and sagittal plane. The EEA, clinically referred to as the preferential direction of oscillation, shows a not significant decrease after the morning and then a plateau in the evening.

Finally the radial movement frequencies of the Cop indicate the postural strategy adopted by participants: low frequencies indicate slow postural movements probably managed by feed forward regulatory mechanisms, while high frequencies indicate fast postural adjustments probably managed by feedback regulatory mechanisms. The trend of these values show a moderate and not significant increase during the day. Reliability procedures have been made on the data for average and for single measures (Tab. 3). Both average and single measures seem to be significantly reliable, but single measures show smaller ICC values than the average ones and single measures of EEA are not significantly reliable.

Table 1. Variations of Open Eyes on stabilometric device in different time of day.

Variable	Morning (A)	Morning (B)	Evening (A)	Evening (B)	p value
CSPL (mm)	312.52 (102.80)	329.41 (101.15)	346.95 (97.88)	345.48 (94.00)	0.189
LNEA	4.47 (1.08)	4.54 (0.97)	4.67 (0.95)	4.46 (1.08)	0.630
LNX	-1.65 (0.56)	-1.55 (0.51)	-1.53 (0.58)	-1.60 (0.59)	0.637
LNY	-1.39 (0.69)	-1.40 (0.61)	-1.36 (0.55)	-1.47 (0.62)	0.773
EEA	0.82 (0.16)	0.80 (0.16)	0.80 (0.16)	0.74 (0.22)	0.077

The value are expressed as mean and standard deviation for centre of pressure of sway path length (CSPL), Naiperian logarithm of the ellipse of confidence area (LNEA), of the X mean (LNX) and of the Y mean (LNY), eccentricity of the ellipse area (EEA). ANOVA with “p” value expressed within time-of-day effects: 9/11 a.m. (Morning A), 11 a.m./1 p.m. (Morning B), 3/5 p.m. (Evening A), 5/7 p.m. (Evening B).

Table 2. Variations of Closed Eyes on stabilometric device in different time of day.

Variable	Morning (A)	Morning (B)	Evening (A)	Evening (B)	p value
CSPL (mm)	340.61 (105.63)	380.07 (117.02)	382.44 (118.74)	393.43 (106.91)	0.054
LNEA	3.89 (1.11)	4.13 (1.08)	3.90 (1.10)	4.12 (1.04)	0.455
LNX	-1.95 (0.57)	-1.76 (0.61)	-1.86 (0.56)	-1.76 (0.62)	0.244
LNY	-1.70 (0.64)	-1.63 (0.63)	-1.75 (0.57)	-1.68 (0.58)	0.733
EEA	0.75 (0.20)	0.79 (0.15)	0.70 (0.22)	0.72 (0.18)	0.055

The value are expressed as mean and standard deviation for centre of pressure of sway path length (CSPL), Naiperian logarithm of the ellipse of confidence area (LNEA), of the X mean (LNX) and of the Y mean (LNY), eccentricity of the ellipse area (EEA). ANOVA with “p” value expressed within time-of-day effects: 9/11 a.m. (Morning A), 11 a.m./1 p.m. (Morning B), 3/5 p.m. (Evening A), 5/7 p.m. (Evening B).

Table 3. Single and average ICC values of Open and Closed Eyes.

Variable	ICC Single measures		“p” value		ICC Average measures		“p” value	
	OE	CE	OE	CE	OE	CE	OE	CE
CSPL (mm)	0.561	0.526	0.000	0.000	0.836	0.816	0.000	0.000
LNEA	0.620	0.499	0.000	0.000	0.867	0.800	0.000	0.000
LNX	0.447	0.470	0.000	0.000	0.764	0.780	0.000	0.000
LNY	0.503	0.359	0.000	0.000	0.802	0.692	0.000	0.000
EEA	0.061	0.12	0.120	0.396	0.206	0.046	0.120	0.396

Intra-Class Correlation Coefficient (single and mean ICC) between open (OE) and closed eyes (CE) of the centre of pressure of sway path length (CSPL), Naiperian logarithm of the ellipse of confidence area (LNEA), of the X mean (LNX) and of the Y mean (LNY), eccentricity of the ellipse area (EEA) within time of day. Significant differences was showed with “p” value between open and closed eyes.

Discussion

Carrying on a study on a complex and not linear system, as the postural one[35, 36], forces us to make methodological choices in order to avoid bias. The main limit of the study has been the impossibility to fully control the subjects' adherence to the given indications because subjects were volunteers. Stabilometric test was considered an objective and reliable test[23, 37] and precedent studies investigated the time-of-day effect on postural stability, resuming that: static postural balance in single-foot stance is not affect by a time-of-day effect[21], postural stability is influenced by time-of-day[21], random but not significant variations are present during the day[23]. Literature about this issue is not homogeneous, moreover the stabilometric protocols used to test the time-of-day effects are not the same so it is impossible to compare the results and to get a correct information. The present study, compared to the previous ones, has got a larger number of subjects homogeneous in gender, a larger number of test sessions during the day and considered just the closed eyes trials to avoid postural troubles from vision.

It must be highlighted that each data shows high values of standard deviation, especially for CSPL, LNEA and EEA. It can be read as an index of large variability within the subjects. Results from this study can be compared only with the research of Gagey and Weber[23] because the stabilometric protocol (i.e., duration or feet position) was the same, while the two other studies took into account[21, 22] used different stabilometric protocols (i.e., duration or single leg test) and the results can not be compared. The study confirm the previous results[23] and no time-of-day effects are present on postural stability with closed/open eyes, so the null hypothesis must be rejected.

It must be highlighted the high standard deviation for some parameters that are usually used in clinical practice for the test interpretation, such as the CSPL. The increasing trend for such parameters in the evening hours may be due to weariness of the postural and nervous system or to the tipical hormonal profile of the evening hours. The center of the Cop trajectory, expressed by the x and y mean coordinates, do not change during the day. This aspect suggests that no time-of-day effect seems to influence the postural strategy used to maintain the equilibrium point of the Cop. The not significant increase during the day of postural oscillations frequencies, confirms the trend of CSPL and LNEA and the possibility that in the evening hours the proprioceptive system does not work at best. Indeed the ICC procedures confirm the reliability and the objectivity of stabilometry[23, 37], but at the same time the small ICC single measurement values must be stressed suggesting a high subject-effect on this postural evaluation.

The ICC showed that in the closed/open eyes condition there is a high probability that the ellipse of confidence area is smaller and the postural oscillations are faster, suggesting and augmented energetic expenditure due to the additional work of the proprioceptive system. Data from this study coincides with previous studies both for reliability of stabilometry and for lack of time-of-day effect[23, 37]. The absence of significant variations suggest that there is not a better time range compared to another one to perform a stabilometric evaluation of posture with closed/open eyes, proprioceptive system is not affected by the time-of-day. At the same time individual variations during the day are not statistically significant, but still, they are present: it can be considered, for clinical use, to test the same patient always in the same time range to be sure to correctly read the test results always in the same modalities. The limits of this study, testing only male subject[38-41], good healthy and age-class, should be overcome with future studies, by testing the open and closed eyes conditions with the same modalities of the present study with new inclusion of criteria (i.e., injury and elderly subjects)[42].

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Competing interests

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Authors contribution

All authors contributed equally to this manuscript.

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