CLINICAL STABILOMETRY STANDARDIZATION

FEET POSITION IN THE STABILOMETRIC ASSESSMENT AND POSTURAL STABILITY

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Abstract

In this paper we address the subject of feet position during the quiet stance stabilometric test over a force platform. Such position is widely discussed and three among the most widely accepted criteria were submitted to comparison in our test.

30 subjects devoid of any evident motor dysfunction were receiving the test in the three feet position configurations (Joined Parallel **[**JP**],** 30° degrees with 5 cm heels apart [30°], Parallel Apart at about 15 cm distance from each other [PA]). The tests were administered into six combination sequences in order to avoid learning or fatigue bias in the test results.

The results have demonstrated that:

a) The Romberg quotients (the ratio between homologous parameters calculated in the Closed Eyes Test vs. the Open Eyes Test) are just slightly affected by the feet position;
b) The "Resolution" of the test on "normal" subjects is highest in the Joined Parallel Feet [JP] position and lowest in the Parallel Apart Feet position [PA];
c) The 30° test seems to be the most comfortable one and therefore likely to be the most convenient for unstable or dysfunctional subjects;
d) The PA test provides results very similar to the ones given by the 30°;
e) There seem to be no appreciable learning effect due to the sequence of tests.

All the three tests should therefore be considered of clinical value and three different "Normal" ranges should be proposed. Although a first choice option should be for the JP configuration, the others might be better suited selection for impaired patients.

General

Test Standardization requirement

The Romberg Test on Force Platform is aimed primarily to detect proprioceptive deficit through the ratio among the homologous values of the parameters calculated over the Closed Eyes vs. Open Eyes Test measurements.

The computerized analysis is however providing an insight into motor control capabilities and performances that can suggest the likelihood of possible impairment leading to an appropriate diagnostic path. To the purpose parameters must be calculated with the best accuracy and diagnostic clues, based on such data, should be provided to the clinician.

Parameters and normality values for each of them should be given and any diagnosis should rely on the differences between every specific parameter value and the corresponding normal reference. In the aim of homogeneous diagnosis there is therefore a test standardization requirement.

Several efforts have been made and recently ISPGR appointed a specific Committee with the task of providing common guidelines and standards for the test in clinical practice.

In the framework of the process:

(1) Environmental conditions as set forth-in 1983 [1] were discussed and confirmed;
(2) The issue of the force platform design was overruled by a set of performances specifications: the COP (Center of Pressure) path is to be provided within set accuracy limits [2];
(3) The length of the recording and the sampling frequency were also discussed and the recommended choices were set forth in the same paper.

The topic of Parameters Calculation Software validation is being presently addressed and will form the content of a further forthcoming communication.

Feet position during Romberg Test

Scope of the present paper is to provide an indication for the selection of the most appropriate feet position. The topic was discussed by a number of qualified authors [3], [4] but a conclusive recommendation on the subject has not been reached yet [5]. Among the most popular instructions there are:

a) The "standard" indication of the Romberg Test (feet parallel and in contact to each other) cited by many authors [6] and defined above as "JP" [Joined Parallel];
b) Mostly coming from the French Posturographic School there is an indication of test with feet forming an

angle of 30° degrees and heels slightly apart (3 to 5 cm) [7]. Such was above defined as "30°" [heels 5 cm apart and toes spread at 30°];

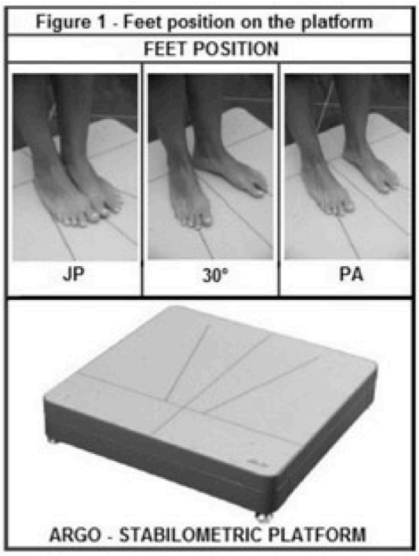

Figure 1 - Feet position on the platform

c) Known as the "Osteopathic Approach" there is an indication of test with feet parallel to each other at some distance (both feet should rest parallel to each other in a plane vertical under the ipsilateral trochanter to form an ideal parallelogram on the Coronal Plane). Such was above defined as "PA" [Feet parallel but apart]
To assess the impact of feet position on the force platform balance test measures we submitted to the test in the three conditions 30 healthy subjects and compared the obtained results.

Materials and methods

Study Design

The subjects were to be submitted to the tests (both in closed and in open eyes conditions) in all the above-indicated three conditions. (See Figure 1). To the purpose the reference feet positions were established on the platform surface. Such surface (600 x 600 mm) is covered by a Cartesian grid (origin on the left posterior corner) with a BASELINE parallel to X axis at Y=150 mm and a CENTERLINE parallel to Y-axis at x=300 mm. Two lines from the BASELINE opening forward at 15°on both sides of the CENTERLINE are also indicated.
The three different positions were indicated as follows:
a) JP: heels were positioned against the BASELINE and in contact with each other along the CENTERLINE
b) 30°: heels were positioned touching the BASELINE with the second toe and the center of the heel of each foot on each of the two 15° reference lines
c) PA: from the BASELINE two perpendicular lines at 15 cm from the CENTERLINE were drawn on purpose and heels were positioned touching the BASELINE with the second toe and the center of the heel of each foot on each of the two lines symmetrical to the CENTERLINE

Learning/Fatigue Bias

To avoid "learning" effects or any potential reciprocal interference between tests in different feet position, the 30 subjects were subdivided into six subgroups that were submitted to the test in the six different combinations of sequences for the three given tests as follows (1st - 2nd - 3rd Test):
1. JP-30°-PA;
2. JP-PA-30°;
3. PA-30°-JP;
4. PA-JP-30°;
5. 30°-JP-PA;
6. 30°-PA-JP

All parameters calculated after the acquisitions were to be compared and the Romberg Quotients for each of the three feet positions were to be calculated and compared.

The Sample

The sample was composed by 30 young subjects devoid of any evident functional impairment taking part to the Osteopathy Master in La Sapienza University (ROME).
The sample was composed by 19 Females and 11 Males.
Mean Age 30.9 yrs.
Mean anthropometric data: Height 169 cm Weight 64.8 Kg Shoes size (I) 39.9
The Subjects, duly informed about the test characteristics and about the purpose of the study, gave the appropriate informed consent in writing.
Exclusion criteria:
a) Any musculoskeletal trauma in the past six months
b) Assumption of drugs either on a regular basis or in the last five days prior to test

The test

The test was performed using the ARGO® Force Platform (RGMD - Italy) enjoying a metrological validation [8] and duly calibrated [9].
Acquisition time was set at 45 seconds and the first 5 seconds were discarded being considered as adaptation time. Such condition meets the requirements set forth in the previous work [10]. Environmental conditions meet the already accepted requirements [1].
The Closed Eyes test was performed before the Open Eyes one to the purpose of limiting the oculomotor control memory on balance keeping in Closed Eyes condition.
The sampling frequency of the device is 100 Hz. A post-processing filter is used for a signal frequency band up to 10Hz.

The device provides:

a) Classical Parameters (Oscillations, Sway Path, Sway Area, Confidence Ellipsis)
b) Sway Density Parameters (Mean Stay Time, Mean Spatial and Time distances) [12]
c) Harmonic Analysis (FFT) on the Coronal (X) and Sagittal (Y) planes each divided into 8 bands.
c) Practice of any Sport discipline at competition level.

The results

Main Parameters

Averaged data are given in Table 1. (Highest value in white text over dark background)

TABLE 1 – TEST RESULTS

TEST PARAMETERS (AVERAGE)						
TEST TYPE / PARAMETERS	JP		30°		PA	
	OPEN	CLOSED	OPEN	CLOSED	OPEN	CLOSED
SD(x) [mm]	4.06	5.41	2.30	2.82	1.18	1.43
SD(y) [mm]	3.58	5.51	3.28	4.04	3.31	4.36
Sway Path [mm/sec]	10.05	19.11	6.68	10.22	6.49	8.53
Sway Area [mm^2/sec]	16.23	44.51	7.55	15.04	5.75	8.60
Ellipse Area [mm^2]	176.87	385.27	94.11	146.71	50.22	75.47
Mean Stay Time [sec]	1.39	0.67	2.63	1.50	3.69	2.18
Mean Spat. Distance [mm]	3.13	6.69	2.15	3.40	1.94	2.54

ROMBERG QUOTIENTS			
SD(x)	1.33	1.23	1.21
SD(y)	1.54	1.23	1.32
Sway Path	1.90	1.53	1.32
Sway Area	2.74	1.99	1.50
Ellipse Area	2.18	1.56	1.50
Mean Stay Time (*)	2.08	1.75	1.69
Mean Spat. Distance	2.14	1.58	1.31

(*) calculated as reciprocal or Open Eyes / Closed Eyes

VARIATION COEFFICIENTS						
TEST TYPE / PARAMETERS	JP		30°		PA	
	OPEN	CLOSED	OPEN	CLOSED	OPEN	CLOSED
SD(x) [mm]	42.70	31.08	43.05	45.36	40.61	37.51
SD(y) [mm]	39.23	38.10	36.51	40.39	47.93	60.01
Sway Path [mm/sec]	23.94	31.42	24.53	37.03	36.33	30.80
Sway Area [mm^2/sec]	53.06	56.55	53.05	80.33	93.69	58.19
Ellipse Area [mm^2]	60.86	70.76	88.03	93.64	90.72	74.99
Mean Stay Time [sec]	48.31	36.55	76.80	64.09	65.98	64.98
Mean Spat. Distance [mm]	35.06	36.77	39.14	57.36	69.91	38.92

For the purpose of this evaluation we assume that a larger value is affording a higher resolution: this assumption, based on numerical considerations should drive to a conclusion towards the JP feet position as the most appropriate one.

In fact by considering the normalized ratio between the Standard Deviation and the Average of every measured parameter (Variation Coefficient) the JP test seems to be the most sensitive one as it affords the lowest Variation Coefficient on most of the parameters (See Table 2). A comparison of the three configurations on a row of differently dysfunctional subjects is required to confirm experimentally the highest sensitivity likelihood.

Romberg Quotients

Romberg quotients in the three feet positions (30 tests for each condition) do show remarkable differences.

Although the general meaning of the Romberg Test is retained by the three modes (the quotients are all over the threshold value of 1, meaning that parameters calculated for the Closed Eyes test are higher than the corresponding ones calculated for the Open Eyes one), differences between the two tests are amplified by the "difficulty" level of the motor task thus suggesting a choice in favor of the JP configuration.

The feet positions ensuring the highest balance effectiveness are the 30° (this is well known to seamen that do keep that feet position while standing to attention on a pitching and rolling deck!) and the PA.

Although probably less sensitive, the tests in these two modes might be applied to impaired patients (where there might be reasonable concern for the patient safety in the closed-eyes recording) without losing the original meaning of proprioceptive deficit detection test.

Balance Parameters

Once more it is clear that the JP configuration is the one affording highest sensitivity. It is to remark that the three test show very similar parameters in terms of Antero-Posterior Oscillations and both in the Open-Eyes and in the Closed-Eyes test suggesting that the Antero-Posterior control is not significantly modified by selecting whichever of the three feet position configurations. The fact that the 30° is showing the best performances in reducing the oscillations on both planes might entail the adoption of a balance control strategy mixing up the sagittal and coronal planes motor control circuits. It could be extremely interesting to understand if and how this control strategy is adding effectiveness/efficiency through redundancy of control or by multiplying applied forces.

Learning Effects

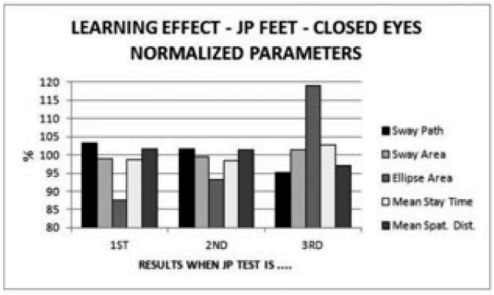

Figure 2 - Learning effect

To check whether the sequence of tests was affecting the result of each test, the mean parameters measured for each of the three tests in each of the six groups were grouped into nine subgroups into which the same type of test was performed as 1st, 2nd or 3rd of the sequence.

Values were then averaged and all values were then normalized to such average. The plot of the normalized main parameters show no learning or fatigue effect and the parameters seem to be just slightly floating around the mean value (see Figure 2).

There is in fact no coherent change in parameters that might be related to the sequence of tests most probably because, even if there were some learning or fatigue bias, their effect would be well within intrinsic variability of the COP sway.

The findings in respect to the different feet configurations are therefore not affected by any specific bias due to the test sequence and the overall results of a comparison of three test configurations with a solid 30

subjects sample are strongly reliable.

Discussion

As far as the proprioceptive deficit is concerned, the three different configurations seem to be apt to the purpose with the following remarks:

(1) First choice should be the JP (Joint ad Parallel feet) test configuration

(2) The 30° or the PA configurations might be suggested as a clinical option when submitting to test impaired subjects.

It might be argued that when the balance test is performed to evaluate functional overall performances (such as for example a "Risk-Of-Fall" estimate), the 30° and/or the PA feet positions, most likely resembling the normal subject standing are more realistic.

The most reasonable suggestions are therefore:

a) To standardize the adoption of the JP position to provide Full Diagnostic Report Data

b)To adopt the other configurations mostly in auto-differential application (tomorrow vs. yesterday measurement)

c) To suggest the exploration of the correlation among Risk-Of-Fall indexes and force platform measurements in the three different configurations in order to select the best suiting one for this specific clinical requirement.

A further series of the three tests on rows of differently dysfunctional subjects is required to quantify the sensitivity differences and to confirm the first choice option in favor of the JP feet configuration.

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