Portable Posturography (BAP): Validation of Angular Sway Using Head Tilt, Head-Shaking and Lateral Fast Head-Turning Tests

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Abstract

Background: Clinical tests performed in posturography are a useful element in evaluating balance and postural control. It usually demands, however, large and expensive equipment and for this reason this examination is not performed by many neurootologists.

Aims/Objectives: This study was conducted with a recently developed posturography system - Balance Angular Posturography (BAP) - in order to evaluate it to clinical practice.

Materials and Methods: Ten healthy volunteer without vestibular disease or complaint of loss of balance were studied prospectively using BAP to establish the reference values of the variables, standardizing its use. They were tested standing over the floor or over a foam platform and were stimulated with right and left Head Tilt, Head-Shaking and right and left Fast Head-Turning tests. The stimuli were presented both with eyes open and closed.

Results: Ten volunteer were enrolled in this study. The results varied but allowed for the establishment of reference values.

Conclusion: The validated BAP protocol may become useful to study patients with imbalance complaint and document their improvement after vestibular rehabilitation.

Significance: This equipment may contribute to increase the interest in posturography, particularly with patients that need vestibular rehabilitation.

INTRODUCTION

Posture control is defined as the ability to balance the body in space to perform a task. It is influenced by three individual factors: sensory, motor and cognitive elements. The sensory contribution occurs from visual, somatosensory and vestibular stimuli that are capable to modulate the motor response and necessary corrections for maintain posture [1].

Dynamic Posturography is the reference method to evaluate the human balance and thus to study the disorders of posture control. However it usually demands large and expensive equipments [2]. D’Albora developed a portable posturography (BAP – Balance Angular Posturography), in 2017, in order to facilitate balance assessment [3]. Carmona et al, defined the reference values of the variables, standardizing its use [3]. The device assesses five different conditions according to the angular Sway in the X and Y axes and the area based on the measures that indicate the possible variables found in a person with a balance disturbance: vestibular dysfunction, visual preference, visual dependence, somatosensory dependence and aphysiological pattern. In vestibular dysfunction, vestibular information is used in an altered way and this is able to correspond to peripheral or central lesions. Visual preference appears when there is instability in situations of great visual conflict and this does not identify a disease. Visual dependence reveals limited use of vestibular and somatosensory information, through better action with visual information. In somatosensory dependence, an optimal balance is maintained on a firm and regular floor; since there is difficulty in the management of visual and vestibular information. Aphysiological pattern refers to obtain better results...
in simpler tests than in the more complex ones, suggesting self-
simulation or exaggeration about the complaints due to an
anxious personality [3].

Vestibular stimulations, such with Head Tilt test and passive
Head-Shaking maneuver, increase significantly the differences
observed performing posturography [4,5]. Adopting other
vestibular activations in the BAP, as also active lateral Fast
Head-Turning test, a new protocol could be a better indicator of
peripheral vestibular asymmetry and its central compensation
process by vestibular rehabilitation. Including these three new
situations in the exam, this paper analyzes the normative data
of the Sway per minute (X and Y) presented by patients with no
vestibulopathy, in order to establish the limits of normality of
its variables.

MATERIAL AND METHODS

Ten healthy volunteer patients without vestibular disease or
complaint of loss of balance were evaluated prospectively using
BAP (Figure 1).

The portable posturography equipment is usually composed
of an accelerometer and a 3-axes gyroscope connected to an 8-bit
microcontroller that processes the sensors information input. A
combination of acceleration and angular velocity measurement
provides the position of the sensors in angular values, which are
transmitted to a computer through a USB port (or a BlueTooth
connection, although not available yet). These values, that
represent the position of the body in a certain time and condition,
are converted graphically by the software, representing the
maximum and minimum angular movements in the X and Y axes
and an area based on the measures. Therefore, it calculates the
patient Sway per second or per minute (Sway/s or Sway/m,
respectively) [3].

After being asked to remove the shoes, the equipment was
placed immediately above the internal malleolus of the patient’s
right ankle (Figure 2) and he was requested to assume the
orthostatic position, leaving an intermalleolar separation of 8 cm
[3].

In addition to the five conditions standardized by Carmona:
Limit of Stability (LOS), Firm Platform Open Eyes (FPOE), Firm
Platform Closed Eyes (FPCO), Foam Pillow Open Eyes (OEPF) and
Foam Pillow Closed Eyes (FPCE) [3], three new situations that
stimulate the vestibular system were added. The patients were
evaluated during a Head Tilt test, after a passive Head-Shaking
maneuver and while performing an active Fast Head-Turning test
in lateral (Yaw) plane. All of the conditions were tested on a firm
surface and then on the foam pillow, following the test blocks
(Figure 3).

In the Head Tilt situation, the patient was tested performing a
cervical lateral flexion of about 15-20° while keeping the look at
a fix target [6], first to one and then to the other side of the head
(Figure 4).

The Head-Shaking maneuver was done flexing the patient’s
head 30° (to horizontalize the lateral semicircular canals) and
shaking it about 2 Hz for approximately twenty seconds in the
horizontal plane [6]. As soon as the maneuver ended, the patient
was tested looking at a fix target with the head straight (Figure 5).

The lateral Fast Head-Turning was tested by asking the patient
to rotate the head suddenly to the right side, until reached the
look over the right shoulder, to better assesses the right lateral
semicircular canal. The same was done to the left side, in order to
separately rate the two lateral semicircular canals, one at a time (Figure 6). As exposed in the respective test block, this was the only test performed only with eyes open, so the patient would not fall from the foam pillow.

Each test block was composed by four positions (A, B, C, D) (Figure 7), configured in the graphic interface with a double letter (AA, BB, CC, DD). But before the patient accomplished a test block, the Limit of Stability (LOS) was customized with a double “L” (LL) and the same command was repeated in the beginning of each test block. LOS is defined by the extreme positions that the patient can oscillate all your body in block without losing balance or taking a step [3].

Each position lasted thirty seconds and, in every position change, the intermalleolar distance of 8 cm needed to be verified. The data computed were the values of Sway/m obtained in the X and Y axes registered on the firm platform with open eyes, foam pillow with open eyes, firm platform with closed eyes and foam pillow with closed eyes. According to the BAP protocol, these values were used to determinate the individual patient variables in each test done: vestibular dysfunction, visual preference, visual dependence, somatosensory dependence and aphysiological pattern. For all variables there is a mean value, standard deviation, minimum and maximum values established that could be calculated [3].

Statistical analysis was performed with the IBM SPSS software, using the GLM test (General Linear Model Repeated Measures, Post Hoc LSD).

RESULTS

Of the 10 patients enrolled in this study, 1 was male and 9 were female, age range 19-31 (22.8 average). The results of Sway/m in the X and Y axes are in the Table 1.

DISCUSSION

Clinical tests performed in posturography are able to quantify functional capacity related to balance and postural control [7]. This paper aims to define reference values for the new tests added to BAP and to standardize its use for future studies.

During the Head Tilt test, statistically significant differences were obtained with closed eyes, on the firm platform as well as on the foam pillow condition. It shows the utility of stimulating the macular labyrinthine receptor of the utricle to detect subtle changes in the postural pattern that would not be detected. This instability observed when tilting the head may be increased in patients with vestibular disease, since they might have a greater visual dependence due to impaired vestibular inputs [4].

The passive Head-Shaking maneuver did not show statistically significant differences in the conditions tested, because the patients submitted to BAP did not present vestibulopathy. However, Head-Shaking increases the neural activity in the velocity storage integrator, disrupting individual posture by providing additional sensory cues that need to be integrated into the task of standing. It can serve to better assess balance disturbances in peripheral asymmetry and changes over time in the central compensation process [8].

The small sample of patients limits the repercussion of the statistically significant results that appeared in only one condition of the active lateral Fast Head-Turning test: performed to the left with open eyes on the firm platform. Exam sensitivity, however, can be discussed. In this study, lateral Fast Head-Turning was tested in the orthostatic position, in order to provide information’s about the vestibular-spinal function or dysfunction and the compensation process at this level for any damage to the vestibular system. It is not possible to access this information by doing this test with the patient in the sitting position.

The present study establishes the normative data of Sway per minute (X and Y) presented by healthy patients evaluated with a portable and compact examination equipment (BAP), under new situations capable of stimulating the vestibular system and then sensitizing the exam.

CONCLUSION

Once validated, this BAP protocol may become useful to study patients with imbalance complaint and their improvement after vestibular rehabilitation, since the vestibular-spinal pathway is evaluated.

REFERENCES


