DOI: 10.1590/0004-282X20130106

ARTICLE

Assessment of gait deviation on the Babinski-Weill test in healthy Brazilians

Avaliação do desvio no teste da marcha de Babinski-Weill em uma amostra representativa de indivíduos brasileiros saudáveis

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ABSTRACT

Objective: The aim of this study was to validate a simple and reproducible method for assessing gait deviation on the Babinski-Weill test in a representative sample of healthy Brazilians. **Methods:** Gait deviations were measured in 75 individuals (median=30 years, 41 women) for forward, backwards, and Babinski-Weill steps. The test entailed blindfolded individuals walking 10 paces at a frequency of 1 Hz with deviations subsequently measured by a protractor. **Results:** Mean gait deviation forward was 0.53º with standard deviation (SD)=4.22 and backwards was 2.14º with SD=4.29. No significant difference in deviation was detected between genders (*t* test p=0.40 forward and p=0.77 backwards) or for age (ANOVA, p=0.33 forward and p=0.63 backwards). On the Babinski-Weill test, mean gait deviation was 5.26º; SD=16.32 in women and -3.11º; SD=12.41 in men, with no significant difference between genders (*t* test, p=0.056). **Discussion:** Defining normative gait patterns helps distinguish pathological states.

Key words: vestibular system, gait, Babinski-Weill test.

RESUMO

Objetivo: O objetivo deste trabalho foi validar para uso no Brasil um método simples e reprodutível para avaliação do desvio no teste da marcha de Babinski-Weill. **Métodos:** As medidas de desvio da marcha foram realizadas em 75 indivíduos (mediana=30 anos, 41 mulheres) na marcha para frente, para trás e no teste da marcha Babinski-Weill. Durante os testes, indivíduos com olhos vendados andavam 10 passos na freqüência de 1 Hz, sendo os desvios mensurados com transferidor. **Resultados:** O desvio para frente teve média de 0,53º com desvio padrão (DP)=4,22 e para trás 2,14º com DP=4,29. Não houve diferença nos desvios entre os gêneros (teste t p=0,40 frente e p=0,77 trás) e entre as idades (ANOVA, p=0,33 frente e p=0,63 trás). No teste da marcha de Babinski-Weill as mulheres desviaram em média 5,26º; DP=16,32 e os homens -3,11º; DP=12,41, sem diferença entre os gêneros (teste *t*, p=0,056). **Discussão:** O estabelecimento de padrões de normalidade possibilita a identificação de estados patológicos.

Palavras-Chave: sistema vestibular, marcha, teste de Babinski-Weill.

The role of the vestibular system is to stabilize the image on the retina, control posture and balance, as well as to provide information on spatial orientation. The system is comprised peripherally by the otolith organs and semicircular canals which measure linear and angular acceleration, respectively. These send signals to the central nervous system, mainly to the vestibular nuclear complex and cerebellum. This information is used in conjunction with inputs from the visual and somatosensory systems to control gait[1-5].

Normal gait requires maintaining an erect posture, bearing weight, forward locomotion at different speeds and determining position in three-dimensional space. The vestibular system is involved in stabilizing the head and maintaining alignment with forces of gravity during walking and dynamic balance by means of vestibulo-spinal reflexes. The primary contribution of the vestibular system in gait involves double support phase, foot placement control and trunk rotation[6-9]. In the absence of visual information for spatial recognition, the vestibular system constantly monitors gait trajectory.

Study carried out at Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (FMUSP), São Paulo SP, Brazil.

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Conflict of interest: There is no conflict of interest to declare.

Received 26 April 2013; Received in final form 16 April 2013; Accepted 23 April 2013.

Patients with acute vestibular loss show lateral deviation and trajectory errors when walking without visual afferences[10-12].

Unilateral peripheral vestibular defects often lead to leaning of the head and trunk toward the damaged side, asymmetric tonus of lower limbs with reduction ipsilateral to the lesion, increase in load transfer on the lesion side and impaired head stability. Patients presenting with this type of lesion also have vertigo, loss of balance and gait deviation toward the side of lowest tonus[5,9,13,14]. This deviation in gait was also found to be inducible in healthy individuals upon walking in the absence of visual afferences during galvanic stimulation. The process produced a disturbance that selectively affected the vestibular system, resulting in increased firing of vestibular neurons on the cathode side yet reduced rate on the anode side, leading to changes in gait trajectory toward the side with less tonus[11,15].

Deviations in gait are speed-dependent in healthy individuals as well as subjects with vestibular disorders. For instance, studies have shown greater deviation in gait at a frequency of 1 Hz than at 3 Hz[7,16,17].

In clinical practice, analyzing gait deviation yields an objective measurement with which to identify dysfunction in the vestibular system and is performed routinely by applying the Babinski-Weill or star walking test. In this test, the patient is asked to step repeatedly forward and then backwards within a space bound by a circle, 5 to 10 times while keeping their eyes closed. A star-like gait is the result of postural asymmetry which causes deviation to the side ipsilateral to the lesion during the steps forward and to the contralateral side during backward steps. These deviations, when joined together in successive tries, trace out a star shape[18,19].

Despite wide use of the Babinski-Weill test in clinical practice, deviation paths and the axis of rotation are analyzed in the absence of any objective measurement (in centimeters or degrees). The only method available in the literature for assessing deviations on this test is cranio-corpography. This method requires a special room in which a camera is trained on a convex ceiling-mounted mirror. Lights are strategically placed on the head and shoulders of the individual under test. The light is then captured by the camera allowing subsequent measurement of deviations[20]. Given the extensive equipment required, the test is unavailable at many centers and cannot be replicated in clinical practice.

The aim of this study was to propose a simple, low-cost, practical and reproducible method for assessing and quantifying gait deviation on the Babinski-Weill test in a representative sample of healthy Brazilians.

METHODS

Participants

This study was carried out with the prior approval of the Ethics Committee for Research Project Analysis of the Hospital das Clínicas of the FMUSP (CAPPesq), and all participants signed a free and informed consent form.

A total of 75 healthy individuals (18 to 69 years old) with a median age of 30 years were assessed. The sample distribution for gender and age was similar to that registered in the last 2000 Brazilian Demographic Census, where subjects were stratified into an 18–29 year age band and other bands with increments of 10 years[21-23]. Exclusion criteria were as follows: (1) neurological and/or orthopedic deficits affecting gait (such as asymmetry of lower limbs and arthrosis), with motor or sensitivity deficits; (2) history of confirmed or suspected vestibular disorder; (3) auditory deficits or unilateral or bilateral tinnitus complaints; (4) abnormal vision; (5) cognitive disturbance; (6) subjects in use of psychotropic drugs; and (7) history of fall and/or loss of balance secondary to vertigo in the past year.

Materials

The tests were performed in a silent and large room preventing subjects from gaining a bearing from environmental information.

Items used included a 40 cm wide 180º protractor, string, circular marker stickers, a cloth blindfold and an Apple® I pod with head phones. Participants listened to a series of beats, repeated once per second (1 Hz frequency), produced by free metronome software downloaded from the Internet.

Measures

The first measurement performed was gait deviation in the forward direction. For this assessment, participants were asked to step 10 paces forward at 1Hz while blindfolded. After the ten steps, circular stickers were used to mark points on the floor mid-way between the subject's heels. Subsequently, the individual (still blindfolded) was returned to the start position and the blindfold removed to allow them to orient themselves spatially in the room. The blindfold was then replaced and the procedure repeated. The forward gait test was repeated a total of five times.

The second measurement performed was gait deviation in the backward direction. For this assessment, participants were asked to take steps as per the previous procedure, only this time in the backwards direction. Again, the gait test was repeated five times. For the third measurement, gait deviation on the Babinski-Weill test was assessed. In this test, blindfolded participants were asked to take 10 steps forward followed by 10 steps backwards, at a speed of 1 Hz, repeating the procedure five times.

In the first two tries, deviations were measured by aligning the 0º mark of the protractor with the vertical line. A line was then traced using string from the start to end points for each gait direction, yielding deviation angles. The string was placed with one end at the 0º mark of the protractor and the other end at the circular floor sticker. Values recorded included mean deviations forward and backwards, with clockwise deviations considered positive and anti-clockwise negative. For this third condition — assessing gait deviation on the Babinski-Weill test — midpoints between heels for the last try forward (LF) and backwards (LB) were summed and deviations calculated by the same method used previously. Deviations were classified as rotational (for deviations in gait trajectory diagonally from initial vertical line) or parallel (deviation parallel with the initial vertical line) (Figs 1 and 2).

On statistical analyses, the sample had a normal distribution in terms of deviations. The unpaired *t* test was employed to compare deviations by gender, whereas the ANOVA one-way test was used for comparing deviations by age.

RESULTS

Results on the descriptive analysis showed forward deviation in gait ranging between 8.70º and 11.60º (mean 0.53º), with standard deviation (SD)=0.22. Separate analysis of forward deviations by gender revealed a mean of 0.16º with SD of 4.15 for females versus 0.98º with SD of 4.33 for males (Table 1).

Results observed for deviation backwards ranged between -6.5º and 13.4º (mean 2.14º) with SD=4.29. Separate analysis of backward deviations in gait by gender revealed a mean of 2.01º with SD of 3.89 for females versus 2.30º with SD of 4.79 for males (Table 2).

No significant difference in deviation was detected between males and females (*t* test p=0.40 forward and p=0.77 backwards) or for age (ANOVA, p=0.33 forward and p=0.63 backwards).

With regard to gait on the Babinski-Weill test, 61% of women and 65% of men showed rotational deviation, while the remaining subjects presented deviation parallel to the vertical line. Subjects exhibiting rotational deviation on the Babinski-Weill test produced a different angle with the vertical line, representing the Babinski-Weill gait's angle (Fig 1). Women showed deviations ranging from -26 to 33.50 with mean of 5.26 and SD=16.32 whereas men had deviations ranging from -28 to 18.50 with mean of -3.11 and SD=12.41.

Although a tendency toward greater gait deviation on the Babinski-Weill test was observed among women compared to men, this difference did not reach statistical significance (*t* test, p=0.056).

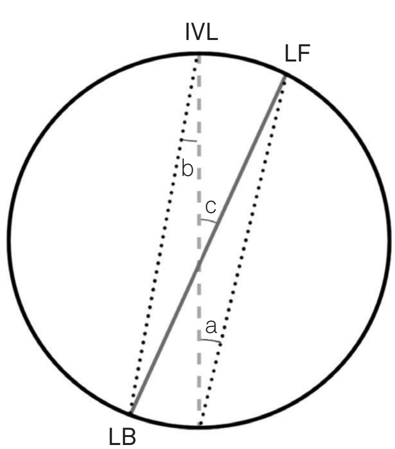
DISCUSSION

The aim of this study was to validate a fast, easy-to-apply, low-cost method for measuring deviation in degrees on the Babinski-Weill test. Although a routinely used test in clinical practice, few reports describing its application or providing normative gait deviation values or variations on the test are available in the literature. Based on the novel method proposed, normative values of mean deviations in degrees in gait for healthy individuals have been established for different age bands.

The results showed that deviations in gait for forward, backward and Babinski-Weill steps are not influenced by gender or age.

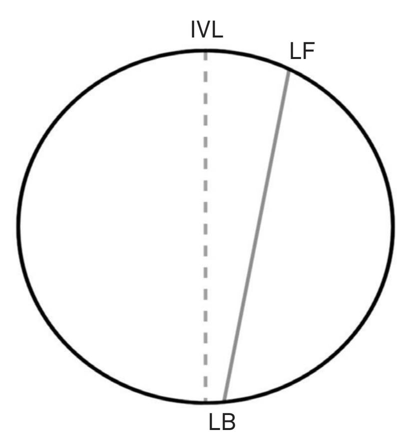
Gait involves the integration of information from visual, vestibular and somatosensory systems. Studies have demonstrated that, when available, visual afferences are the predominant input for gait, where this contribution is most evident for direction and speed. In the absence of visual inference however, vestibular information is integrated with that of somatosensory inputs, where vestibular information makes a significant contribution during target-directed locomotion[6,8,10-12,14,15].

Deviation from a straight-ahead path induced by stimulating the vestibular and visual systems is a recurrent theme in the literature, where stimulations are typically galvanic or prism-based, respectively. These studies tend to employ a three-dimensional system of analysis using infrared cameras and infrared diodes placed at different points on the body



LF: last forward; LB: last backward; IVL: initial vertical line; a: angle between IVL and LF; b: angle betwen IVL and LB; c: Babinski-Weill gait's angle.

Fig 1. Rotational deviation.



LF: last forward, LB: last backward, IVL: initial vertical line.

Fig 2. Parallel deviation.

such as legs, feet, head, trunk and spine. These points of reference are then used to measure center of mass and its associated deviations, thereby allowing deviations in gait trajectory to be determined, generally expressed in centimeters[8,15,24-27]. Bent, Inglis and McFadyen[6] used the same method for determining the contributions of the visual-vestibular system during different phases of gait. Deshpande and Patla[8] investigated the effect of age on the interaction between neck vestibular and proprioceptive inputs and found a reduction in deep sensitivity information of the neck with advancing age. In the cited study, the authors attached infrared diodes to the ears, occipital region, the acromion, spinous process of the 7th cervical, 12th thoracic and 2nd sacral vertebrae, in addition to left and right heels. The high number of points allowed more accurate assessment of the rotation of different body segments in response to inputs[28]. Another study used the same method to analyse differences in gait trajectory of healthy young adults during locomotion during neck extension and flexion. Results showed a mean deviation of 2.26±7.23º for cervical extension and 18.84±9.56º for flexion, confirming a significant difference between the two states[29].

Borel et al.[30] used the same method of marking points with infrared diodes to measure walking performance in patients with Ménière's disease pre and post-operatively. The authors found gait deviation toward the operated side in blindfolded tests one week after unilateral vestibular neurotomy with patients showing deviations of 3.7±2.5º when walking at normal speed[30].

Jahn et al.[16] assessed the differential effects on gait deviation in ten healthy young adults of galvanic stimulation walking at frequencies of 1 and 3 Hz. The authors used floor markers placed one-meter apart to assess deviations in gait. The coordinates of the subject's position on the floor were taken using a metric measuring tape after 10-seconds of locomotion and upon crossing a line marking a distance of five meters. Angular deviations from the planned trajectory were calculated using the coordinates measured. In the absence of galvanic stimulation, the blindfolded subjects evidenced slight deviations in gait trajectory, with average deviations of -0.02±1.2º after 10 seconds at 1 Hz and of 0.08± at 3 Hz (with positive values indicating deviations to the right). Upon application of galvanic stimulation, subjects had a mean deviation of 6±2.4º during walking and 2.8±1.8º during running[16].

Dickstein et al.[7] (adopted a different methodology for assessing speed-dependent deviations from a straight-ahead trajectory during locomotion. The study included twelve healthy subjects with a mean age of 32.8 years. Deviation data was collected using ink pads loaded with two different colors (one for each foot) affixed to the heels of the footwear used by the participants. Subjects' position during walking was determined by measuring the midpoint (cm) between the medial edges of participants' heels, with positive values used to indicate deviations to the right. Deviations from a straight-ahead path were measured every 2.5 meters by calculating the distance between the mid-point between heels and the line carried from the start point of locomotion. Based on this analysis, angles of deviation were determined at 10 meters, defined as the final angle. Average final angles were 4.6±2.4º for slow walking; 3.1±2.9º for fast walking and 1.8±1.2º for running (with speeds determined by the individual)[7].

In the present study, deviation in gait was measured at a standard slow walking speed of 1 Hz. Overall, the values found in our study (mean 0.53±4.22º) were lower than those reported in the literature. However, in an effort to better characterize the Brazilian population our study included a larger sample with greater variation in age.

A review of the literature found no studies assessing backward gait deviations.

The Babinski-Weill gait test is not well documented in the literature and scant information is available on methodologies for measuring deviations in this gait pattern[31-33]. In 1988, Oliva discussed the importance of the test for providing an objective assessment of one of the symptoms (lateral deviation in gait) which is a factor increasing risk of falls. The cited study included a description of Babinski-Weill gait based on cranio-corpography, which involves training a camera on ceiling-mounted convex mirror in the test area. The test is performed in the dark allowing the movement of lights strategically placed on the patient's head to be tracked. Within a circle four meters across, the intersection of the points marking the previous and posterior gait trajectories with the circle of reference are mapped. The star-like walk (Babinski-Weill) is recognized on the cranio-corpography as that in which the previous and posterior end points deviate simultaneously in opposite directions. The pattern of the deviation paths and the axis of rotation are analyzed in the absence of any objec-

Table 1. Forward gait deviation in a representative sample of healthy Brazilians.

Age groups (years)	n	Mean	Median	SD	95%CI
18–30	36	-0.54	-0.20	3.35	-1.67–0.60
30–39	16	1.54	0.60	4.38	-0.79–3.87
40–49	9	1.09	0.20	4.19	-2.13–4.31
50–59	8	1.63	2.15	6.03	-3.41–6.66
60–69	6	1.93	2.35	5.69	-4.04–7.91
Total	75	0.53	0.30	4.22	-0.44–1.50

SD: standard deviation; CI: confidence interval.

Table 2. Backward gait deviation in a representative sample of healthy Brazilians.

Age groups (years)	n	Mean	Median	SD	95%CI
18–30	36	2.43	1.85	3.46	1.26–3.60
30–39	16	1.93	0.75	4.93	-0.70–4.55
40–49	9	3.42	0.90	5.56	-0.85–7.69
50–59	8	0.28	-0.40	5.30	-4.16–4.71
60–69	6	1.60	1.75	4.18	-2.79–5.99
Total	75	2.14	1.60	4.29	1.16–3.13

SD: standard deviation; CI: confidence interval.

tive measurement (in centimeters or degrees). The results of cranio-corpography suggest that vestibular-defective patients and healthy individuals differ in terms of the rotational axis of gait, where this phenomenon occurs from the outset of gait in patients, leading to greater deviation[20]. In the present study, 62.6% of participants exhibited this gait pattern in which previous and posterior deviations are simultaneously opposed, crossing the start line, evidencing a deviation in rotational axis. The deviation angle of the Babinski-Weill gait was measured in this group of participants, constituting an objective measure (in degrees) for comparing normal individuals against patients with vestibular syndromes. The findings of the present study revealed a tendency toward greater deviation in Babinski-Weill gait among women compared to men, although this difference did not reach statistical significance. The women studied had clockwise and the men anti-clockwise deviations, explaining the differences observed.

To conclude, this study evaluated a novel method for measuring gait deviation angles in forward, backward and Babinski Weill steps. Since the method proposed requires only basic, low-cost materials, it is easily replicated and offers moderate accuracy measuring angles to the nearest degree, and thus can be applied in both clinical and research settings. This method should be extrapolated for use in different populations through future studies, with a special focus on neurological patients manifesting with sensitivity, coordination or spatial deficits. Such further studies can help determine whether the method is sensitive for differentiating between physiological and pathological states.

The results of the present study revealed no difference in deviation by age or gender. A potential limitation of this study was the high number of younger adults included, although the rationale for this broader sample was to better reflect the demographic age profile of the Brazilian population[21-23]. Defining normative values of deviation allows more accurate assessment of pathological states and the identification of other factors influencing gait deviation besides deficits in the vestibular system.

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