Preliminary Results of Static Tests of Balance among Asymptomatic Normal Filipino Adult Volunteers

Generoso T. Abes,[1,2] Patrick John P. Labra,[2] Franco Louie L.B. Abes,[2] Romeo L. Villarta, Jr.[2] and Abner L. Chan[2]

[1]*Philippine National Ear Institute, National Institutes of Health, University of the Philippines Manila*
[2]*Department of Otorhinolaryngology, College of Medicine and Philippine General Hospital, University of the Philippines Manila*

ABSTRACT

Objectives. To determine the effect of age, sex and body mass index on selected static tests of balance and to generate reference normative data among the different population groups.

Methods. In this cross-sectional study, 100 asymptomatic normal adult Filipino volunteers, aged 20 to 69 years were tasked to perform selected static balance tests. These tests included classic Romberg (CR), Romberg with Jendrassik (RJ) maneuver, tandem Romberg (TR), standing on foam with feet apart (SOFFA), standing on foam with feet together (SOFFT) and standing on one leg (SOL). All tests were done with eyes opened (EO) followed by eyes closed (EC) for 30 seconds each. Volunteers were grouped into age groups by decades, normative values were obtained and effects of age, sex and body mass index, if any, on performance of the various tests were determined.

Results. All volunteers were able to do the CR and RJ maneuver for 30 seconds. All were able to perform for 30 seconds the TREO, SOFFA EO and SOFFT EO procedures. Some volunteers were unable to complete the TREC, SOFFA EC, SOFFT EC, SOL EO and SOL EC procedures. The mean performance duration values for TREC, SOFFA EC, SOFFT EC, SOL EO AND SOL EC were significantly negatively correlated with age. Although majority of tests were negatively correlated with body mass index, the correlations were not statistically significant.

Conclusion. Age significantly affects selected static balance performance whereas sex and body mass index do not significantly affect selected static balance performance. The normative values generated in this study are inconclusive because of inadequate sample size, particularly in the older age group. The results, however, showed the potential value of the 5th percentile as a normative norm in systematically assessing the involvement of the vestibular, visual and proprioceptive organs in balance function.

Key Words: dizziness, clinical tests of balance, static balance tests, normative values, Filipino adults

Corresponding author: Abner L. Chan, MD
Department of Otorhinolaryngology
Philippine General Hospital
University of the Philippines Manila
Taft Avenue, Ermita, Manila 1000 Philippines
Telephone: +632 5264360
Email: abnerchan@yahoo.com

Introduction

Dizziness is a common disorder and a considerable cause of lower quality of life for which patients seek consultation with primary care physicians.[1] In a community-based cohort study among 2064 questionnaire responders aged 18-64 years old in Great Britain, 23% reported dizziness. Further, 4% of all patients registered in a general practice suffered persistent dizziness, 3% of which were severely incapacitated.[2] On the other hand, it is speculated that the incidence of bothersome dizziness is underreported since a survey done among random samples of patients in a general practice showed more than 20% of samples aged 18-65 years old experienced dizziness within the past month.[3] Though several pathologic conditions are known causes of dizziness, even intake of medications alone for various illnesses list dizziness as a common side effect.[4] In another foreign study on management practices among general practitioners, one third of dizzy patients underwent diagnostic studies mainly consisting of blood studies and other laboratory studies, except balance tests. Less than 10% were referred to the specialist for diagnosis and further management. These observations imply that most dizzy patients are being given medications without pathologic diagnosis.[5] In the Philippines, anecdotal evidences also indicate that a significant proportion of patients seen in general practice complain of dizziness. Objective measures of balance that are available in few dizziness centers entail expensive, complicated and space occupying instruments needing high level of expertise for interpretation. Further, there are no known protocols involving objective measurements to assess balance disorders, either in general or in specialist practice. To address these issues, it is important to do an investigation on common clinical tests of balance, which do not require costly instrumentation and which may be carried out easily by general practitioners and specialists alike.

Studies on clinical tests of balance showed that timed measurements of static balance may systematically assess the influence of the vestibular, visual and proprioceptive organs to maintain balance.[6] A test quite familiar to clinicians and considered an integral component of the routine neurological examination is the Romberg test. Some foreign studies showed that normal subjects could do Romberg and other static balance tests at least for 30 seconds.[7,8,9] However, it is shown that age and other factors may influence performance level and it is suspected that performance measures may differ among different ages, gender and population groups with varying body mass index (BMI).[8,10,11] Reference normative values derived from these investigations may potentially assist the clinician to do valid screening assessment of balance function. Since there are no known published data in the Philippines, it is believed that an investigation regarding these issues is relevant. This paper aims to determine the effect of age, sex and BMI on selected static tests of balance and to generate reference normative data among the different population groups.

Methods

Included in this cross sectional study were apparently normal asymptomatic adult Filipino volunteers recruited at the Philippine General Hospital, aged 20-79 years, who were willing to undergo the selected balance tests for the study. An apparently normal volunteer was defined as one who had no previous balance problem nor any complaint of dizziness. Procedures for the study were explained after which informed consent was secured. Exclusion criteria included: past history of vertigo, dizziness or otologic problems like ear infection; orthopedic disorder affecting the lower limb or spine; neurologic disorder including myopathy, neuropathy or disorders affecting the somatosensory system; ophthalmologic disorder; medical condition that may affect gross balance like diabetes mellitus, hypertension, hypotension, respiratory or cardiac disease; psychiatric disorder; drug intake that may have central nervous system or depressant effect. The exclusion criteria were mostly identified by history, pre-test ability to stand for about 1-2 minutes and by the ability to walk a line on the floor. The demographic data were gathered through interviews using a guided questionnaire.

Ethical considerations

The study was approved by the University of the Philippines, Manila Ethical Review Board. No monetary compensation was given to any of the participants. The participant was given freedom to drop out of the study at anytime during the conduct of the investigation. Oral and written consents were taken prior to the conduct of the tests. Confidentiality was assured by using codes on the data sheet. Safety was ensured by investigators standing on both sides of the subject during the test to prevent falls. Each participant was provided a copy of the test result either by electronic mail or by an on-the-spot interpretation of the results based on the results of a European study.[7] Participants with grossly abnormal results were referred accordingly to proper specialists.

Data analysis

The data were recorded and analyzed with the use of statistical package for the social sciences (SPSS) 17.0 for Windows and Microsoft Office Professional Plus 2010 for Windows. Descriptive statistic was used to analyze the demographic characteristics. The obtained values were expressed in averages, 5^{th}, 50^{th}, 95^{th} percentile and quartile values. Chi-square test compared the differences between categorical variables, independent samples t-test the differences between two means and the one way analysis of variance (ANOVA) between more than two mean values.

Performance of the Different Static Tests

General descriptions of test procedures and assessment parameters:

The choice of the static test procedures was based on the principle that balance among neurologically normal individuals is maintained by coordinated and congruent inputs from the vestibular, visual and proprioceptive systems and that loss of balance occurs whenever there is dysfunction in any one or combination of these organs.[12,13] Corollary to this principle, there will be greater dependence on the vestibular and proprioceptive organs to maintain an upright stance while standing on a solid floor with eyes closed because of the abolition of visual cues. Furthermore, standing on a compliant surface such as a thick foam, will also diminish or abolish proprioceptive cues and make the individual more dependent on the vestibular system, particularly with eyes closed procedure. In short, while the visual reference information may be varied by covering the eyes and the proprioceptive reference information by changing the consistency of the floor, the vestibular reference, which is gravity, remains unchanging. The function of the vestibular system may, therefore, be reflected on the individual's ability to maintain upright stance by varying the visual and proprioceptive reference informations.[14] On this basis, the following static test procedures were therefore chosen: Classical Romberg test with eyes opened (CREO) and eyes closed (CREC), Romberg with Jendrassik maneuver with eyes opened (RJEO) and eyes closed (RJEC), tandem Romberg with eyes opened (TREO) and eyes closed (TREC), standing on foam feet apart with eyes opened (SOFFA EO) and eyes closed (SOFFA EC), standing on foam feet together with eyes opened (SOFFT EO) and eyes closed (SOFFT EC) , standing on one leg with eyes opened (SOL EO) and eyes closed (SOL EC).

All procedures were done for 30 seconds. Timing with a digital stopwatch commenced once the participant signified readiness to start the test. The participant was allowed to hold the examiner's hand upon assuming the position but this was released once the test started. Timing was stopped after completion of the 30 second limit or when the participant disengaged or stepped out of position. When the participant completed the 30 second limit, no further trial was done. On the other hand, when he failed to complete the 30 second limit, he was allowed to do two more trials and the average of three trials was recorded. The two-legged tests were done prior to the one-legged procedures. Participants were allowed to wear flat shoes or sandals. An opaque mask was used over the eyes during the eyes closed tests.

Specific descriptions of the static tests:

A. Classical Romberg test: (CR)

Procedure	Illustrative example
Participants stood with feet touching each other with eyes opened. Head was held in horizontal position, looking straight ahead. The arms were placed on the sides. The test was done on a concrete floor. Timing the test was commenced when the participant signified his readiness and was stopped when the thirty second limit was reached or when the participant disengaged from his previous position. The eyes closed procedure was done after the eyes opened test. A black opaque mask was placed over the eyes for the eyes closed procedure. The timing of the test was commenced and stopped using the parameters used during the eyes opened test.	

B. Romberg with Jendrassik maneuver (RJ)

Procedure	Illustrative sample
Participants stood the same way as in the classical Romberg test, except that the hands were clasped over the chest, pulling each other in opposite direction. The head was held in horizontal position. Timing was commenced and stopped in the manner observed in classical Romberg test. The eyes opened test was done prior to the eyes closed test using a black opaque mask.	

C. Tandem Romberg (TR)

Procedure	Illustrative example
Participants stood one foot directly in front of the other. They were allowed to choose which foot to place in front and to alternate feet between trials. The head was held in horizontal position looking straight ahead. The arms were folded and the hands were rested over the opposite shoulders. Timing was commenced and stopped according to the parameters observed in classical Romberg test. The eyes opened was done prior to the eyes closed test using the same opaque mask.	

D. Standing on foam feet apart (SOFFA)

Procedure	Illustrative sample
Participants stood with feet apart at about 5cm distance on a six inch medium density foam that measured 45cm x 45cm. Arms were clasped on the sides. Head was placed in horizontal position. Timing procedure and eyes closed test were done similar to the classical Romberg test	

E. Standing on foam feet together (SOFFT)

Procedure	Illustrative sample
Participants stood on the same foam as in SOFFA, except that the feet were placed together, heel to toe. The arms were on the sides and the head was held in horizontal position. The timing procedure was similar to that of the Classical Romberg test. The eyes opened procedure was done prior to the eyes closed test.	

F. Standing on one leg (SOL)

Procedure	Illustrative sample
Participants stood on one leg with the lifted foreleg not allowed to touch or rest on the other foreleg. Any of the two legs was lifted according to the participant's preference and could be alternated between trials. The arms may be placed on the sides or may be free to move in accordance to the participants preference. The head was held in horizontal position. The timing procedure was similar to that observed in classical Romberg test. The eyes opened procedure was done prior to the eyes closed test.	

Results

One hundred participants, aged 20-69 years (mean=34.78, SD=12) were recruited and tested (Table 1). There were slightly more female recruits than males but there was no significant difference in mean age between the two groups (p=0.502). There were significant differences in average weight and height (p=0.004 and p=0.0000, respectively) but there was no difference in body mass index (p=0.34). Most were students, household, industrial and office workers (Figure 1).

All participants were able to do the eyes opened and eyes closed classical Romberg and Romberg with Jendrassik maneuver for 30 seconds. All were also able to perform for 30 seconds the eyes opened procedure for the tandem Romberg, standing on foam feet apart and feet together procedures. Some participants were not able to complete the eyes closed procedure while doing the tandem Romberg, standing on foam with feet apart and feet together, and the eyes opened and eyes closed tests while standing on one leg (Table 2).

Table 1. Means and standard deviations for age, weight, height, and BMI of males and females and their p values based on independent samples t-test

	Male (N=53)	Female (N=63)	*p value
Age	33.96 (11.24)	35.48 (12.70)	0.502
Weight (kg)	63.30 (11.29)	57.14 (11.07)	0.004[a]
Height (cm)	163.51 (8.53)	152.92 (6.51)	0.000[a]
BMI	23.68 (3.86)	24.44 (4.48)	0.340

** t- test for independent means*

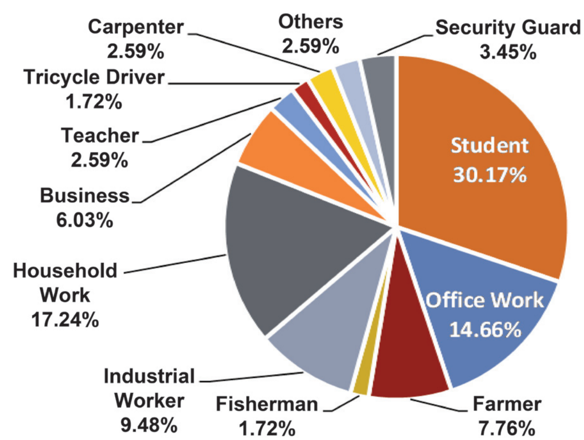

Figure 1. Occupational profile of participants in the study.

The performance of participants at the 5^{th}, 50^{th} and 95^{th} percentile were plotted for the tests which were not completed in thirty seconds – the TREC, SOFFA EC, SOFFT

Table 2. Mean performance durations for the different tests expressed in seconds

Decade	n	CR		RJ		TR		SOFFA		SOFFT		SOL	
		EO	EC	EO	EC	EO	EC	EO	EC	EO	EC	EO	EC
3^{rd}	46	30	30	30	30	30	30	30	30	30	29.7	30	26.9
4^{th}	35	30	30	30	30	30	29.9	30	29.7	30	30	30	27.1
5^{th}	17	30	30	30	30	30	29.5	30	30	30	30	29.4	25.8
6^{th}	14	30	30	30	30	30	29.1	30	30	30	30	30	23.1
7^{th}	4	30	30	30	30	30	25	30	29.2	30	22.5	29.2	10.2
5^{th}-7th	35	30	30	30	30	30	28.8	30	29.3	30	29.1	29.7	22.9

EC, SOL EO and SOL EC (Figures 2-4). The 5th percentile values of the third to sixth decade participants for the TREC test are represented by the dashed gray lines of Figure 2. Performance progressively decreased with age. The poorest performance was that of the participants belonging to the seventh decade at 21 seconds. This indicates that 5% of the subjects in this decade performed the TREC in 21 seconds or shorter. Conversely, this also indicates that 95% of all participants, completed the TREC 22 seconds or longer. Since there were only four participants who belonged to the seventh decade, the plot for this decade is considered unreliable. To make better generalizations, the obtained values obtained form the fifth, sixth and seventh decade participants were taken together and represented by the bold black line. According to this plot, the cumulated 5th percentile value among the fifth to seventh decade subjects was about 23 seconds, longer than the seventh decade subjects but closer to the values obtained among the fifth and sixth decade subjects. The duration of performance similarly diminished in relation to age for the eyes closed SOFFA and SOFFT procedures (Figure 3). The cumulative values obtained among the fifth to seventh decade subjects at the 5th percentile were 25 seconds for the SOFFA eyes closed and 22 seconds for the SOFFT eyes closed tests. There were large discrepancies between the values among the seventh decade and the cumulative values among the fifth to seventh decade subjects. The performance durations of participants in the standing on one leg tests were shorter with eyes closed than with eyes opened (Figure 4). As in the other two-legged tests, performance durations were inversely related to age. The cumulative values of the fifth to seventh decade subjects at the 5th percentile were 26 seconds and 9 seconds, respectively, for the eyes opened and closed tests. There were no significant differences in mean performance values between males and females for TREC, SOFFA EC, SOFFT EC, SOL EO and SOL EC (Table 3). Table 4 shows that the mean performance duration values for the different tests were significantly negatively correlated with age. By contrast, though the majority of tests were negatively correlated with BMI as indicated by the negative coefficient values, the correlations were not statistically significant.

Discussion

The age-group mean values obtained in our study are similar to those gathered by other investigators,[7,10,11] but also differ with those reported in other studies.[11] Other studies also reported that there are significant differences in obtained mean values in relation to gender[11] and BMI.[7] Such diverse results emphasize the inconsistency in mean values between studies that may be explained by differences in procedures, study subjects and sample sizes. Wearing sandals during the test procedures may be raised as an issue since this may alter the proprioceptive inputs that are important for standing balance.[15] Studies show that there is

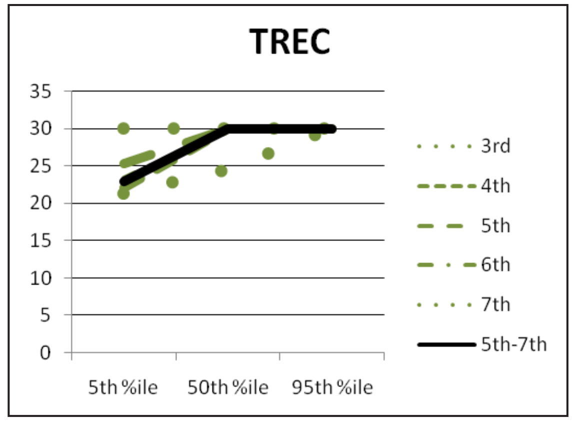

Figure 2. Mean performance durations (in seconds) at the 5th, 50th and 95th percentile for the tandem Romberg eyes closed test.

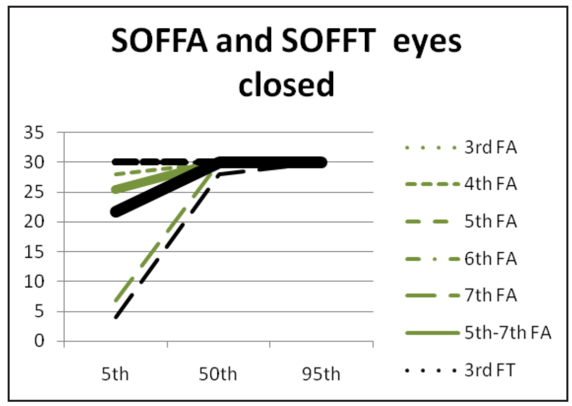

Figure 3. Mean performance durations (in seconds) at the 5th, 50th and 95th percentile for standing on foam feet apart and feet together, eyes closed.

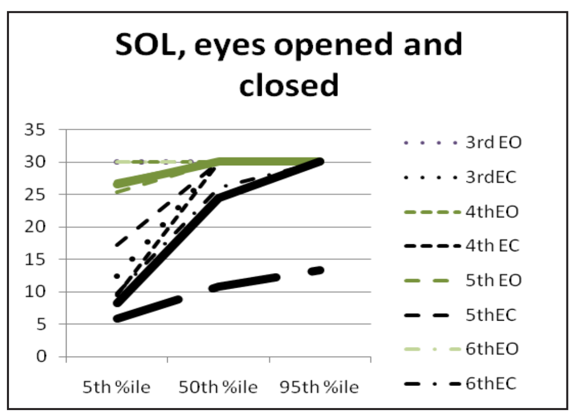

Figure 4. Mean performance durations (in seconds) at the 5th, 50th and 95th percentile for standing on one leg, eyes opened (gray dashed lines) and eyes closed (black dashed lines). The bold gray line and bold black line correspondingly represent the cumulative mean values of the 5th-7th decade subjects for the eyes opened and eyes closed procedures.

Table 3. Mean performance duration (in seconds) values among males and females for the different tests

Tests	Males N=53	Females N= 63	t-test p value
TREC	29.54 (1.73)	29.45 (2.05)	0.814
SOFFA EC	29.80 (1.43)	29.63 (2.91)	0.699
SOFFT EC	30.00 (0.00)	29.30 (3.73)	0.702
SOL EO	39.98 (0.16)	29.83 (0,.78)	0.148
SOL EC	27.12 (5.93)	24.54 (7.83)	0.056

Table 4. Correlation of mean performance values between age, gender and BMI and the different tests

Tests	Age		BMI	
	r	P value	r	P value
TREC	-0.368	0.000	-0.148	0.113
SOFFA EC	-0.209	0.025	0.053	0.573
SOFFT EC	-0.257	0.005	-0.020	0.829
SOL EO	-0.233	0.012	-0.073	0.434
SOL EC	-0.339	0.000	-0.146	0.118

r= Pearson moment correlation coefficient value

no difference in performance between those with and without shoes.[8,9] Nonetheless, there seems to be uniformity in reporting the effect of age in relation to diminution of mean performance values. These observations indicate that normative reference values must be age-group specific, obtained from studies enrolling adequate sample size, and probably using age-group percentile distribution, rather than mean values. We believe that age-group specific percentile distribution is more useful than mean values because the proportion reported at a particular percentile has a value equal to or lower than the reported value. For example, the 5th percentile value of 21 seconds for the tandem Romberg with eyes closed, indicates that 5% of the subjects in our study had value equal to or lower than 21 seconds (Figure 2). Alternatively, it also indicates that 95% of the subjects performed tandem Romberg with eyes closed at 22 seconds or longer. The notable discrepancies in the percentile distribution of the seventh decade subjects (light dotted line) and that of the summative value of the fifth to seventh decade subjects (bold dark line) is explained by the inadequate sample size of the seventh decade participants (n=4). The summative distribution of the fifth to seventh decades more closely approximates the percentile distribution of the fifth and sixth decade subjects since the later had more sample sizes than the seventh decade subjects. Similar findings were also observed in the standing on foam and the standing on one leg procedures (Figures 3 and 4). It is notable that results were not significantly different between gender and those with different BMI (Tables 3 and 4). However, these assumptions are considered valid only if the reference data are obtained among age groups with adequate sample sizes, which has not been satisfied in this preliminary report. Moreover, valid generalizations for clinical purposes must be withheld until adequate samples were recruited for final data analysis.

Standing balance is primarily dependent on the proprioceptive system, secondarily, on the visual system, and least, on the vestibular system.[15,16] The eyes opened procedure for the classical Romberg, Romberg with Jendrassik procedure and the tandem Romberg test, which were all done on firm surface, were meant to test the efficiency of the three peripheral organs in maintaining standing balance. The eyes closed procedure had little effect on the results of the classical Romberg and Romberg with Jendrassik maneuver among normal subjects but showed more marked effect on the tandem Romberg – a more difficult procedure than the previous two (Table 2). These results imply that the ability to perform tandem Romberg with eyes opened for thirty seconds indicates equal capability to perform Romberg test, with or without Jendrassik maneuver, with eyes opened and closed. Additionally, the ability to perform with eyes opened the standing on foam feet apart and feet together connotes adequate compensation by well-functioning visual and vestibular organ for the loss of the primary somatosensory information for standing balance. However, the additional loss of the visual cues markedly diminished the mean performance values for all age group (Table 2 and Figure 3), suggesting that standing on compliant surface needs visual cues in addition to normal vestibular function in order to maintain standing balance. On the other hand, the values obtained for standing on two legs with eyes opened and eyes closed (Romberg) on a firm surface were notably higher than those obtained from one-legged procedures (Table 2 and Figure 4), suggesting that supposedly normal adults are expected to maintain better balance with two-leg compared to one-leg stance. Muscle mass and strength are important in maintaining upward stance; thus, compromise of such factors with advancing age are expected to be correlated with marked decrease in timed measures and may explain the higher incidence of falls in the elderly - a dangerous sequela of imbalance.[17] This aspect further emphasizes the need to obtain more sample size for the older age groups.

This study was designed to generate normative reference data among asymptomatic, presumably normal adults; hence, there was sole dependence on history taking about the absence of neurologic and other organ function disorders. Generating normal values, as conducted in this study, must be construed to provide a tool for screening patients who may be suffering from balance disorders and not to make definitive, causative diagnosis. At best, the results may equip the practitioner with a means to make proper management decisions and timely referral for their dizzy patients, particularly those who may need further diagnosis and management.

Conclusions

Age significantly affects selected static balance performance whereas sex and body mass index do not significantly affect selected static balance performance. The normative values generated in this study are inconclusive because of inadequate sample size, particularly in the older age group. The results, however, showed the potential value of the 5th percentile as a normative norm in systematically assessing the involvement of the vestibular, visual and proprioceptive organs in balance function.

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