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Normative Values for One-Leg Stance Balance Test in Population-Based Sample of Community-Dwelling Older People

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Abstract: This study aimed to generate normative values for one-leg stance test (OLST) with eyes-opened and eyes-closed conditions across Arabian population by age and gender to serve as an acceptable reference standard. 194 volunteers healthy Saudi community-dwelling elders, aged 60-80 years were recruited from Riyadh, Kingdom of Saudi Arabia. Their ability to stand balanced on one leg was measured. Results showed that the duration that individuals are able to maintain standing balance on one leg, is age-specific and related to gender. There was inverse relation between age and balance with longer time maintained in on limb with eyes-opened than with eyes-closed. Men showed better performance than women. In conclusion, this study would aid clinicians in understanding the age specific level of performance that is to be expected in healthy community-dwelling elders during OLST examination and provided normative values to which individuals could be compared.

Key words: Age-related changes · Clinical balance testing · One-leg stance test · Normative values

INTRODUCTION

Balance disturbances have been documented in healthy senior citizens [1]. For the main types of balance (static postural control, dynamic- anticipatory and reactionary- postural control) there are numerous clinical tests to assess performance. The one-leg stance test (also referred to as timed single limb stance, unipedal balance test and one-leg standing balance) is a simple test for measuring static aspects of balance that can be used in a variety of settings and requires minimal equipment or training [2]. The one-leg stance test (OLST) is a valid measure [3] considered to assess postural steadiness in a static position by a temporal measurement [4]. The examination of balance with the OLST is a logical and functional approach, since transient balancing on a single limb is essential for normal gait and is critical for activities of daily living such as turning, stair climbing and dressing [2]. Clinicians caring for elderly people recognize that, as people age, there is a general deterioration in a number of musculoskeletal and sensory systems that affect postural control and balance [5]. It is therefore vital to assess balance ability and impairments accurately. The cost, complexity and size of the instrumentation required for complex balance test, as force platforms, makes them impractical for general application. Clearly, if clinicians are to use balance tests as apart of examination, they need test that are objective and for which age-related data are available. Even though the OLST appears to be used often in clinical settings to test static balance for a variety of reasons, limited normative data for the eyes open and closed conditions have been established. For the best of the author's knowledge, no or unpublished normative data for OLST were available for community-dwelling Arabian population. Limited normal values make it difficult for clinicians to use OLST to detect balance impairments. Further, establishing more extensive normative values by age group and gender would also offer clinicians and patients realistic goals to reach during a rehabilitation program [2] and an understanding of age-related changes in balance system is important when considering the design of training programs for the elderly [6].

The purpose of this study was to generate normative values for the OLST with eyes-opened and eyes-closed conditions across community-dwelling Arabian population by age and gender to serve as an acceptable reference standard.

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MATERIALS AND METHOD

This repeated measure, cross-sectional study was approved by the Rehabilitation Health Sciences Department, King Saud University. Eligible elders signed a consent form to participate and data was collected from September 2008 to April 2010.

Volunteers recruited from Riyadh, Kingdom Saudi Arabia were healthy Saudi community-dwelling elders, aged 60-80 years. Elderly were excluded from participation if they had a known history of balance impairment (for any reason); peripheral neuropathy (Clinically diagnosed or if they had symptoms of numbness/tingling in the lower extremities); orthopedic lower extremity or lumbosacral conditions requiring consultation with a health care professional; pain of any level presenting simultaneously in both lower extremities; or unilateral lower extremity. All subjects were able to follow the test instructions.

Researcher followed Springer 's *et al.* [5] protocol to carry out the test. Eligible subjects were asked to stand barefoot on the limb of their choice, with the other limb raised so that the raised foot was near but not touching the ankle of their stance limb. Subjects were asked to focus on a spot on the wall at eye level in front of them, for the duration of the eyes open test. Prior to raising the limb, subjects were instructed to cross their arms over the chest. The researcher used a digital stopwatch to measure the amount of time in seconds the subject was able to stand on one limb. Time commenced when the subject rose the foot off the floor. Time ended when the subject either: (1) used his arms (i.e. uncrossed arms), (2) used the raised foot (moved it toward or away from the standing limb or touched the floor), (3) moved the weight-bearing foot to maintain his balance (i.e. rotated foot on the ground), (4) a maximum of 45 seconds had elapsed, or (5) opened eyes on eyes closed trials. The procedure was repeated 3 times and each time was recorded on the data collection sheet. The average of the 3 trials was recorded. Subjects performed 3 trials with the eyes open and 3 trials with the eyes closed, alternating between the conditions. For example, 1 trial with eyes open followed by 1 trial with eyes closed equaled 1 trial set. The order of testing was randomized by coin. At least 5 minutes of rest were allowed between each trial set to avoid fatigue.

Statistical Analysis: Data collection sheets were summarized into the 13.0 release of Statistical Package of Social Sciences (SPSS) for Windows. Summarization included the elder's age, sex, mean times achieved for each test condition and age category as elders were grouped by 5-years of age into 4 age groups (60-64 years, 65-69 years, 70-74 years and 75-80 years).

Descriptive statistics were calculated for the three trials mean times of OLST for both genders within all 4 age groups for both the eyes-opened and eyes-closed condition. A 2 x 2 x 4 mixed model ANOVA with gender and age group as fixed factors and test condition (Eyes-opened, eyes-closed) as a repeated factor was calculated to identify a 3 factor interaction. 2 x 2 mixed model ANOVA was calculated for gender versus test condition, 2 x 4 mixed model ANOVA was calculated for test condition versus age group and 2 x 4 fixed factor ANOVAs were calculated for gender versus age group. One way ANOVAs for each testing condition along with Gabriel post hoc test were used to determine specific differences between age groups. Both Pearson (r) and Spearman (r_s) correlation coefficients were conducted between the time of each test condition and age both for the entire data set and for each age group to determine the relationship between test performance and age. Alpha was set at 0.05 and 95% as confidence intervals.

RESULTS

Out of 194 eligible elders, 97 (50%) were males. Table 1 provides the mean OLST times for males and females with eyes-opened and eyes-closed for the four age groups as well as values for males and females independent of age. Figure 1 demonstrates the decrease in elders' abilities to stand balanced on one leg with advancing of age.

The 2 x 2 x 4 mixed model ANOVA showed a 3 way interaction of the factors (P= 0.015). The main effects demonstrated a significant main effect for test condition (P= 0.0001), gender (P= 0.0001) and age group (P= 0.0001).

The 2X2 mixed model ANOVA (Test condition versus gender) demonstrated significant interaction (P = 0.0001), a significant main effect for test condition (P = 0.0001) and a significant difference for gender (P = 0.0001).

The 2X4 mixed model ANOVA (Test condition versus age group) demonstrated significant interaction (P = 0.0001), a significant main effect for test condition (P = 0.0001) and a significant difference for age group (P = 0.0001).

The 2 X 4 fixed factor ANOVAs (Gender versus age group) demonstrated significant interaction for open eyes (P= 0.013) but not for closed eyes (P= 0.618). Figure 2 demonstrates that males had better balance performance than females in all age groups and for eyes-opened and eyes-closed test conditions.

Table 1: One-leg stance test time (second) by age group and gender for eyes open and eyes closed.

Age and gender group	Eyes open mean of 3 trials (sec) Mean (SD)	Eyes closed mean of 3 trials (sec) Mean (SD)
60-64		
Male (n=46)	26.4 (14.2)	9.1 (8.2)
Female (n=47)	14.6 (11.8)	5.3 (4.4)
Total (n=93)	20.4 (14.2)	7.2 (7.0)
64-69		
Male (n=26)	26.5 (16.0)	6.5 (3.3)
Female (n=26)	8.6 (5.4)	3.2 (2.7)
Total (n=52)	17.6 (14.9)	4.8 (3.4)
70-74		
Male (n=17)	9.4 (6.6)	4.5 (2.7)
Female (n=16)	7.2 (2.0)	2.8 (1.4)
Total (n=33)	8.3 (5.0)	3.7 (2.3)
75-80		
Male (n=8)	7.4 (3.9)	1.6 (1.4)
Female (n=8)	2.1 (1.5)	0.5 (0.9)
Total (n=16)	4.8 (3.9)	1.1 (1.2)
Total (all ages)		
Male (n=97)	21.9 (15.2)	7.0 (6.7)
Female (n=97)	10.7 (9.6)	3.9 (3.7)
Total (n=194)	16.3 (13.8)	5.5 (5.6)

Table 2: Differences in One-leg stance test mean times (second) for different age groups for eyes open and eyes closed conditions.

Age groups (A)	Eyes condition	Different age groups (B)	Mean (SE) difference in seconds (A-B)	P- Value
60-64	Open	65-69	2.8 (2.2)	0.732
		70-74	12.1* (2.5)	0.0001
		75-80	15.7* (3.5)	0.0001
	Closed	65-69	2.3 (0.9)	0.066
		70-74	3.5* (1.0)	0.006
		75-80	6.1* (1.4)	0.0001
65-69	Open	70-74	9.3* (2.9)	0.008
		75-80	12.8* (3.7)	0.002
	Closed	70-74	1.2 (1.2)	0.898
		75-80	3.8 (1.5)	0.062
70-74	Open	75-80	3.6 (3.9)	0.927
	Closed	75-80	2.6 (1.6)	0.483

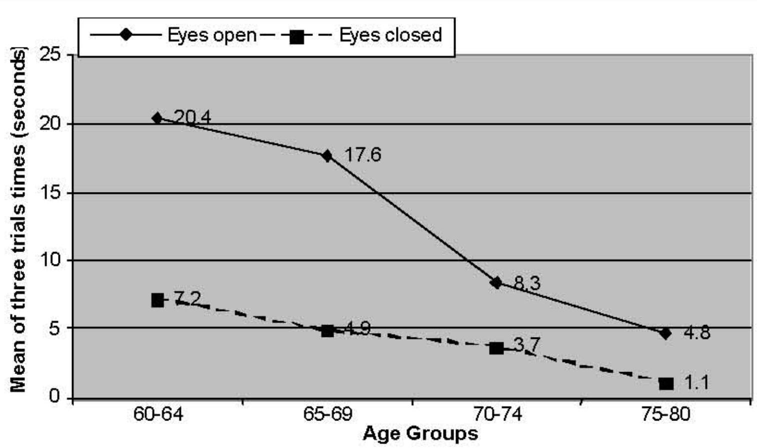

Fig. 1: Mean of three trials times of eyes open and eyes closed one-leg stance test in different elders' age groups

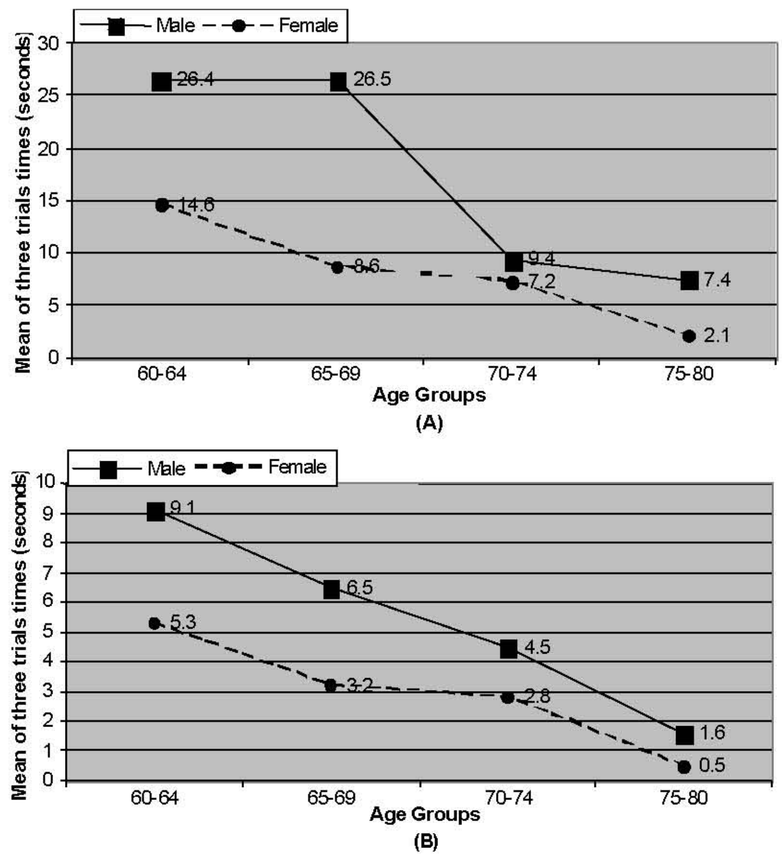

Fig. 2: Mean of three trials times of eyes open (A) and eyes closed (B) one-leg stance test for male and female elders

Table 3: Correlations between one-leg stance test performance and age.

		Correlations			
		Pearson		Spearman	
Age	Test performance	r	P	r_s	P
60-80	Eyes open	-0.350	0.0001	-.389	0.0001
	Eyes closed	-0.331	0.0001	-0.363	0.0001

Table 4: Different populations One-leg stance test time (seconds).

Study	Participants	Times of eyes open Mean (SD)
MacRae *et al* [9]	94 American men and women (60-89 years)	17.2 (11.9)
Lin *et al* [10]	765 Chinese men and women (≥ 65 years)	9.7 (12.7)
Jedryhowski *et al* [11]	559 Polish men (65-89 years)	
	65-69	57.7 (58.0)
	70-74	31.6 (36.9)
	75-79	22.3 (24.8)
	80-89	17.3 (17.9)
Kinugasa *et al* [12]	495 Japanese men and women (65-89 years)	38. 6 (22.5)
Kim *et al* [13]	253 Korean women (65-84 years)	
	65-69	13. 7 (14.8)
	70-74	9.4 (10.2)
	75-79	6.9 (9.7)
	80-84	4.2 (4.5)

Table 4:Continued

Study	Participants	Times of eyes open Mean (SD)
Netz and Argov [14]	252 Israeli men and women (60-89 years)	
	60-69 right limb	26.4 (22.2)
	60-69 left limb	22.5 (20.6)
	70-79 right limb	18.4 (19.5)
	70-79 left limb	16.0 (17.6)
	80-89 right limb	7.7 (13.2)
	80-89 left limb	7.1 (13.3)
Kronhed *et al* [15]	30 Swedish men and women (70-75 years)	
	men right limb	12.0 (11.0)
	men left limb	16.0 (12.0)
	women left limb	20.0 (10.0)
	women right limb	21.0 (10.0)
Hill *et al* [16]	96 Australian women (> 70 years)	
	70- 74 right limb	21.9 (8.3)
	left limb	19.8 (8.7)
	75-79right limb	18.7 (10.0)
	left limb	18.2 (10.2)
	80 + right limb	9.2 (5.6)
	left limb	11.4 (8.4)

One way ANOVAs for age group differences demonstrated statistical significance for both eyes-opened (P= 0.0001) and eyes-closed (P= 0.0001) and Gabriel post-hoc comparisons revealed multiple age group differences (Table 2).

Table 3 reported the Pearson and Spearman correlation coefficients and significance for the relationship between the age and the time balanced on one leg with eyes-open or eyes-closed. There was significant negative relationship (P= 0.0001) between elders 60-80 years of age and time balanced on one leg with open eyes or closed. This significant negative correlation existed not only for the entire age but also for the age groups.

DISCUSSION

The geriatric approach is to identify and treat significant problems appropriately and at the same time, to examine and optimize the functional state of the patient and provide a constant support [7]. Tests and measures of balance are fundamental component of clinician's examination and although there are numerous options for quantifying standing balance, the time an individual can stand on one leg had been used widely either alone or as part of a larger test battery [3]. Current study provided data for use in clinical examination of one-leg standing balance of elders from 60-80 years and it showed age-related decrease in the time an individual can stand balanced on one leg. Values of parametric correlation coefficient of the entire age data set and the nonparametric correlation coefficient of age groups supported the presence of an inverse relation between age and balance. This is because aging process affects all components of postural control- sensory, effector and central processing [8]. Dividing the elders finely into 5-years age groups clarified the relation between age and balance and gave strength to the current study. In the meta-analysis study carried out by Bohannon [3] confirmed the well established relationship between age and balance. That is, balance diminishes as age increases. In his study, he examined 22 studies to determine normative reference values for single limb stance with eyes open. He documented that there is considerable variability in the time described. His study included electronic searches of MEDLINE (1966-2005), CINAHL (1982-2005) and EMBASE (1995-2005). Of these 22 studies, 13 involved American participants, 2 involved Swedish participants and 1 each involved Chinese, Polish, Japanese, Australian, Korean and Greek participants. Table 4 demonstrated the times recorded in some of these studies as examples of the different continents [9-16]. No Arabian populations were included. This may be due to shortage in this kind of studies or limitations in the international publication. Although this meta analysis study was limited to eyes open test condition, it is still very valuable as it documented the variations between the populations and indicated that providing the normative values of OLST, along with other tests and measures used in clinical practice, for each population is essential for

evidence-based practice. The current study mean times of OLST for Saudi population differed from that recorded for other populations demonstrated in table 4. However, population differences should not be dealt as the solo responsible for normative reference values of OLST. The test protocol may also have a rule to play. Examples of test protocol variations include; shoe on/ off, arms crossed/ at body side, recording the best performance or mean performance time, etc.

Other studies showed that differences in test performance with eyes-closed condition were also existed. Example of these studies was that done by Springer *et al.* [2] in which the times, in seconds, of eyes closed mean and SD of 255 Americans were 2.8 (2.2) for age group 60-69 years, 2.0 (1.6) for 70-79 years and 1.3 (0.6), for 80-99 years. The inclusion criteria of these 255 American participants and the used test protocol were similar to that of the current study, but the results still different. This may enhance the concept of variations among populations. However, the concept of population should be treated beyond the limited image of nationality or ethnic issues to include other factors that would help to specify the studied population as level of physical activity and how ether the elders are community-dwelling, hospitalized, or residential care elders.

In the present study; figure 1 showed that the mean duration that one-leg stance balance could be maintained was longer with the eyes open than with the eyes closed and with younger age group than with older. This is because control of posture and balance is governed by inputs from three systems: visual, vestibular and proprioceptive. Proprioception is in normal healthy populations considered the dominant sensory guide to balance, followed by vision and finally vestibular inputs. With aging, however, declines in proprioception are common and it is typical for the elderly subject to become reliant on vision. Unfortunately, vision is also demonstrating significant deterioration with age [8]. Lord and Ward [17] supported this explanation. In their study they found that up until age 65 there was an increased reliance on vision for balance control. Beyond this age, the contribution made by vision declined, so that in the oldest age-groups reduced vision was less able to supplement peripheral input.

The current study found that there was a relation between OLST performance and gender. Males had longer times than females in both test conditions and for all age groups. Author suggested that the underlying causes for this better male performance may be related to differences between both genders regarding the physical activity, life style, psychological or social factors. This is especially because the medical condition was similar for both genders as included in participates selection criteria. The subjective collected data were limited to age and sex and nothing was available regarding the non-medical factors that would interfere with balance and could help to interpret these results. That is why a more comprehensive data collection would be more valuable along with including other younger age group to thoroughly investigate the relation between the test performance and gender. Guccione [8] agreed that other factors rather than disease could modify the disability in the elderly and that in elders it is difficult to distinguish pure age effects from effects of subclinical diseases and life style changes that accompany the aging process. He mentioned life style, smoking, social isolation, weight and education among these factors. He also highlighted an important statistical problem in geriatric research that in any population-based sample of elders, it is likely to contain more women, who, by virtue of living longer, are also more likely to be disabled . This explanation could be applicable as the number of males was more than that of females in the study done by Springer *et al.* [2] and they revealed that performance is age-specific and not related to gender. The equal number of males and females in the current study overcame this problem and showed that gender had main effect on test performance.

In conclusion, these results provided valuable normative balance performance data for community-dwelling elder Arabian men and women. Performance, the duration that individuals were able to maintain standing balance on one leg, was age-specific and related to gender. These performance values would aid clinicians in understanding the age specific level of performance that is to be expected in healthy elders during OLST examination. Clinicians now have more normative values to which individuals can be compared if the same test protocol was followed.

Clinical Implications: This study presented objective information regarding standing balance. Such objective documentation would allow the clinician to make better judgments. It indicated that the ability to balance on one leg diminishes with age. The practical implication of this information in elder's examination was that balance performance in OLST was age specific and gender related that the clinician's expectations for patient would be based on the elder's age and gender.

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