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Original Article

Clinical measurements of spinal mobility, static balance, and functional performance in healthy participants: a simple biokinesiological analysis of performance

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Abstract. [Purpose] To explore the relationship between functional outcome measurements of spinal mobility, static balance and functional performance. [Participants and Methods] Fifty two healthy participants aged between 18–36 years participated. Spinal mobility included forward bending and side bending. Balance was tested via maintaining single-leg stance position with eyes open and with eyes closed. Functional testing included five times squat to stand, walking on heels and walking on tiptoes. [Results] Two-way mixed intraclass correlation coefficients (ICCs) consistency model average measure ($ICC_{3,K}$) for single-leg standing with the eyes are open and closed was excellent (0.85) and very good (0.79) respectively. Mean forward spinal mobility score of the recreationally active group ($M= 3.3 \pm 5.7$) was significantly lower ($M= 9.5 \pm 10.5$) than inactive group. Regarding five times squat to stand, the mean score of the recreationally active group (10.4 ± 4.3) was not significantly different from the mean of the recreationally inactive group (9.5 ± 2.6). [Conclusion] Walking on heels significantly took more time and perceived with more exertion than tiptoes walking. Also, standing on one leg was harder when eyes are closed. Recreationally active had shown significant forward mobility but no difference between sidebending mobility. The relationships between different outcome measures need to be furtherly explored.
Key words: Balance, Functional outcomes, Clinical biokinesiology

INTRODUCTION

Functional activities, balance and mobility are fundamental outcome measurements that have been immensely discussed in literature either to determine the physical-functional capacity among healthy participants or patients with different disorders[1–9]. Lower extremities functional movements and performance tests have been investigated in several studies aiming to explore the relationship between different functional outcomes[6–8, 10]. However, the majority of research studies reported results and outcome measurements obtained from athletes or patients with different medical disorders without having functional outcome measurements from average-adult individuals. There is a gap in the body of knowledge regarding having feasible, ready to be used clinical measurements to address spinal mobility, static balance and functional performance. Also,

there is uncertainty of the differences or the associations between different outcome measurements. We hypothesize that the outcome measurements of spinal mobility, static balance and functional performance are preliminary instruments to predict overall performance among average-adult individuals. The primary objective of the present study was to explore the relationships between the clinical outcome measurements of spinal mobility, static balance and functional performance and its relationship with being recreationally active or inactive.

PARTICIPANTS AND METHODS

Fifty two healthy participants aged between 18–36 years were recruited to participate. The measurement study was approved by research ethics committee at college of medical rehabilitation sciences, Taibah University (Approval No. CMR-PT-2019-09). Participants were recruited from physical therapy department at Taibah University and with a word-of-mouth from participants. Participants were included if they are community ambulant, healthy and willing to participate. Participants were excluded if they were suffering from any significant history of musculoskeletal or neurological disorder or have recent history of significant pain symptoms. Every participant was introduced with data collection form that included demographic data in addition to mobility, balance and another functional testing. Demographic data included age, body mass index, body diagram to mark on any painful body region, recreational status, frequency of exercises, and number of risk factors. According to American academy of sports medicine, participants were labeled as recreationally active if they were engaged in 30 minutes of moderate intensity exercises for five times/week or 45 minutes of vigorous intensity exercises for three times/week[11]. Frequency of exercises was assigned as never, rarely, 1–2 time/week, 3–4 time/week, and more than 4 times/week. Risk factors that were investigated were lack of exercises, smoking and overweight[12]. The examiner had explained the Borg Category Ratio (CR) scale for rating of perceived exertion to indicate right after each exertion[13]. Spinal mobilities of forward bending, right and left side bending were measured. Every participant has to stand up straight and bend forward as far as possible. The examiner measured the distance from fingertip to the floor[14, 15]. Regarding sidebending mobility, the examiner measured the distance from fingertip to the floor while having participants standing straight and after bending to the sides as far as possible[15]. The distance after bending was divided by the distance from erect standing and then subtracted from one to calculate the percentage of displacement. In reference to five times standing to squatting, every participant was instructed to stand up bare feet and have his hands on his chest then transit between standing and squatting as fast and safe as possible for five times[16]. The examiner used verbal encouragement and close supervision. Participants were given one familiarization session to ensure participants' understanding and ability to achieve the full range of mobility. The examiner recorded the time in seconds and asked every participant to indicate the level of exertion using Borg CR10 scale[13].

Regarding single-leg stance test, every participant was instructed to stand up erect with raising one leg as long as possible without touching other leg, hands on chest, shoes off and head facing straight ahead. Measurements were taking with eyes open first then with the eyes closed[6, 7, 15]. Timer is stopped if participant touches the floor, makes contact with other leg, creates a step or moves arms off position. The examiner had to counterbalance the sides of measurements. Ceiling time was set as 60 sec.

Participants were instructed to walk on heels or tiptoes for three meters with either regular foot wear or bare feet as preferred[10, 17]. One familiarization session was given before the actual measurement trial. Time was recorded in seconds. The examiner collected the Borg CR10 scale of exertion right after every trial. The order of measurements was counterbalanced. Participants were blinded for the outcome measurements.

Intraclass correlation coefficient (ICC) was run to confirm degree of repeatability of the tests. The ICC is a robust and comprehensive estimate of reliability since it is based on analysis of variance. Paired sample t-test was run for every pair of mean values of the two levels of every single variable[18]. Statistical significance was set at alpha ≤0.05. SPSS 22 (IBM Corp. Armonk, NY, USA) was the software used for all data analyses.

RESULTS

Participants' descriptive statistics and demographics can be seen in Table 1. Participants' demographics in terms of frequency of occurrence can be seen in Table 2. Paired samples t-test of seven different pairs with its significance are presented in Table 3. The pairs included the eye open versus eye close, right side versus left side single-leg standing, right versus left side bending, and three meters walking on heels versus walking on tiptoes, and Borg CR10 when walking on heels or tiptoes.

To determine reliability of measures a correlation analyses using two-way mixed ICCs consistency model average measure ($ICC_{3,K}$) for single-leg standing with eyes open on right and left leg was 0.85 [95% confidence interval (CI) 0.73–0.91]. It is interpreted as excellent. Regarding single-leg standing on right and left leg with eyes closed, the value was 0.79 [95% CI 0.63–0.88]. It is also interpreted as very good.

Regarding to forward bending test for forward sagittal spinal mobility, an independent sample t-test comparing the mean scores of the recreationally active versus inactive participants found a significant difference between the means of the two groups [$t(50) = 2.6$, $p<0.05$]. The mean score of the recreationally active group was significantly lower (M=3.3, SD=5.7) than the mean score of the recreationally inactive group (M=9.5, SD=10.5).

In reference to five times squat to stand, an independent sample t-test comparing the mean scores of the recreationally

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Table 1. Participants descriptive statistics (*n*=52)

Variables	Mean	± SD	Range
Age (years)	22.4	3.7	(18–36)
Height (m)	1.7	0.07	(1.5–1.8)
Weight (kg)	62.4	14.1	(42–100)
Body Mass Index (kg/m^2)	21.9	4.2	(15.2–33.8)
Forward bending (cm)	6.5	9.0	(0–28)
Right side bending (cm)	0.27	0.06	(0.13–0.27)
Left side bending (cm)	0.28	0.07	(0.14–0.52)
Five times squat to stand (sec)	9.9	3.5	(4–18)
SLS-Rt-eyes-open (sec)	37.6	20.8	(4.5–60)
SLS-Rt-eyes-closed (sec)	13.1	15.4	(1–60)
SLS-Lt-eyes-open (sec)	38.3	20.7	(1.8–60)
SLS-Lt-eyes-closed (sec)	12.4	15.9	(1.4–60)
Walking on heels (sec)	4.7	2.3	(2–17)
Walking on tiptoes (sec)	3.3	1.4	(2–9)
BorgCR10-walking on heels	1.8	1.4	(1–7)
BorgCR10-walking on tiptoes	1.3	1.1	(1–7)

Data are the mean ± SD (range).
SD: Standard Deviation; SLS-Rt-Eyes-Open: single leg standing on right leg with eyes are open; SLS-Rt-Eyes-Closed: single leg standing on right leg with eyes are closed; Borg CR-10: Borg category ratio-10.

Table 2. Participants demographics (*n*=52)

Characteristics	Frequency of occurrence
Gender (Male/Female)	40/12
Body Mass Index	
Normal/ Obese	28/4
Overweight/ Underweight	5/15
Risk factors (No/One/Two)	20/22/10
Recreationally active (Yes/No)	25/27
Frequency of exercises	
Never/Rarely	15/14
(1–2/ 3–4/ >4)	6/5/12
Borg CR-10 for 5 times squat to stand	
Light/moderate	31/14
Strong/maximal	6/1

active versus inactive participants found no significant difference between the means of the two groups [t (50) = −0.82, p>0.05]. The mean score of the recreationally active group (*M*= 10.4, SD= 4.3) was not significantly different from the mean of the recreationally inactive group (*M*= 9.5, SD= 2.6).

DISCUSSION

The primary finding of the present study was that keeping eyes open or close resulted in significant difference in the ability to maintain balance while standing on the right or the left leg. The results are in agreement with the study conducted by El-gohary et al. who tested healthy college students for single-leg standing with eyes are open and with eyes are closed. There was significant difference (p<0.05) favoring standing on one leg with the eyes open (71.2 ± 45.2) over with the eyes closed (29.3 ± 28.8). Closing eyes deprive participants from receiving visual feedback that is essential to integrate with the vestibular and proprioceptive sensations for maintaining balance longer[6, 19]. The difference in the mean timing of balance on one leg between the two studies is due to using 60 seconds as ceiling time in the present study whereas in El-gohary et al.

Table 3. Paired samples t-test of seven different pairs (*n*=52)

Pair	Variables	Mean	± SD	t	df	*Sig.* (2-tailed)
1st	Rt. Side bending Lt. Side bending	−0.004	0.1	−0.59	51	>0.5
2nd	SLS_Rt-eye open SLS_Rt_eye closed	24.5*	19.1	9.2	51	<0.05
3rd	SLS_Lt-eye open SLS_Lt_eye closed	25.9*	21.1	8.9	51	<0.05
4th	SLS_Rt-eye open SLS_Lt_eye open	−0.68	15.1	−0.33	51	>0.05
5th	SLS_Rt-eye closed SLS_Lt_eye closed	0.69	13.1	0.38	51	>0.05
6th	Walking_on_heels Walking_on_tiptoes	1.42*	2.0	5.1	51	<0.05
7th	Borg CR10_W_on_heels Borg CR10_W_on_tiptoes	0.46*	1.6	2.12	51	<0.05

SD: standard deviation; SLS-Rt-eyes-open: single leg standing on right leg with eyes are open; SLS-Rt-eyes-closed: single leg standing on right leg with eyes are closed; Borg CR-10_W: Borg category ratio-10-Walking.
*indicates significant differences (p<0.05) as determined by 2-tailed test.

previous study the ceiling time was as long as tolerated[6].

In reference to comparing the right and left side, there was no significance difference in the ability to maintain balance while standing on the right versus left leg for both eyes open and eyes closed conditions. Moreover, there was excellent (*r*=0.85) and very good (*r*=0.79) association for eyes open and closed single-leg standing respectively. The results are in harmony with the tentative assumptions since the sample are group of healthy average-adult individuals who are free from any significant pain[6, 7, 15].

There was no significant difference in the right versus left side bending mobility. This is expected since the participants are group of healthy participants free from any significant pain or stiffness[15]. Regarding forward spinal mobility, there was significant difference (p<0.05) with more mobility for recreationally active participants compared with recreationally inactive. The mean values are distance measured from middle fingertip to the floor was less than the distance reported in earlier study but it concords with the mobility expected from testing healthy adult individuals compared with mobility obtained from patients diagnosed as chronic low back pain with disc disorders who had mean age of 41 years[7, 14, 15].

There was significant difference with walking on tiptoes (3.3 sec) in less time than walking on heels (4.7 sec). Also, the Borg CR10 was significant with walking on heels experienced as harder with more exertion compared with walking on tiptoes[13]. The findings correspond with the results reported by Tanabe et al.[17] who said that there is unchanged postural sway during tiptoe standing. The study was conducted on healthy participants and muscle actions seem to compensate for any dynamic disturbances. In contrast, walking on heels seem to be more difficult which was reflected in terms of taking more time to walk a given distance with experiencing more exertion as reported by Borg scale[13].

Regarding five times squat to stand, no significant difference (p>0.05) was detected between recreationally active and inactive participants. This accentuates the need for high intensity exercises more than just regular activities for testing healthy average-adult individuals[1, 7]. In conclusion, the relationships between functional movement tests; addressing different functional outcomes and performances, should be furtherly explored to determine the existing differences and associations that would significantly serve the clinical practice. There are some limitations within the study like the wide range of body mass index and the need for more challenging physical-functional testing on a larger sample. Also, it is recommended to conduct the study on patients with radiculopathy since most of functional testing used in the study are fundamentals with those patients.

Conflict of interest
No conflict of interest to report.

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