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Validity of using smart phone sway balance application in measuring dynamic balance

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ABSTRACT

Background: *Fall risk is one of the major problems in the older adults' life due to the reduction of the balance level. A presence of a valid, cost effective and easy in use objective tool to measure the balance (static and dynamic) is very important.* ***Purpose*** *of this study is to test the validity of the use of Sway balance software in measuring the dynamic balance.* ***Methods:*** *Thirty healthy non-athletic subjects (8 females and 22 males; age= 23.9 ± 3.38 years and BMI= 22.53 ± 1.64 kg/m²) were tested and their dynamic balance was measured by Sway balance software mobile application and the Biodex balance system at the same time through four conditions (foot together, semi tandem, tandem and single leg stance) with eyes opened. Each participant performed four conditions at difficulty level 8 of Biodex balance system with a familiarization trail prior to the experiment one.* ***Results:*** *The correlations between overall postural sway and overall stability index at level 8 were moderate negative significant correlation at foot together and single leg stance while it was strong negative significant at tandem and no correlation at semi tandem.* ***Conclusion:*** *Sway balance software mobile application can be used in clinics and other fields as a valid objective tool to measure dynamic balance.*

Key words: *Accelerometer, Dynamic balance, Fall, Validity.*

INTRODUCTION

Falls are a major health problem for older people, through effects such as fractures and head injuries or even disability and loss of independence [1]. Balance is a key component of motor skills ranging from maintaining posture to executing complex sport skills [2]. Balance impairment is a primary risk factor in the occurrence of falls [3]. A percent 27.7% of injury-related deaths are elated to falling in ages 70–79 years, and this percent increases to become 46.4 and 64.8% in ages 80–89 years and 90-99years respectively [4]. One-third of people over 65 years are expected to experience one or more falls each year [5]. Fall is a main cause of injuries leading to death [6]. Between 1.6 and 3.8 million sports-related concussive injuries occur annually in the USA and account for 5–9% of all sports-related injuries. Balance is one symptom that is impaired after concussion [7]. Falls cause over 90 percent of hip fractures [8]. Balance or posture stability can be defined as the ability to maintain the body center of mass within its base of support [9]. Dynamic balance is the ability to maintain the balance and coordinate muscle activity in reaction to disturbance of stability [4]. The ability to provide quantitative measures of balance

and posture is the benefit of objective tools as force platforms and accelerometers [10]. Accelerometers have been shown to give valid and reliable measure of postural balance [11]. Accelerometers are small, light in weight and able to be attached to the subject. An advanced accelerometer can be found in the iPod and iPhone, they integrate micro electro-mechanical systems nano-accelerometers that measure the instantaneous acceleration of an object [10]. The Sway Balance Software (SBS) is a mobile application is software which uses the built-in tri-axial accelerometers of a mobile electronic device to assess postural movement and it has a clearance from food and drug administration to be a balance testing system [12]. The Biodex Balance System (BBS) is a multi-axial device that objectively measures individual's balance and it uses a circular platform that is free to move in the anterior–posterior and medial–lateral axes simultaneously and allows up to 20° of foot platform tilt [13]. Biodex balance system is valid and reliable to measure balance [9,13,14,15]. The purpose of this study is to investigate the validity of Sway balance software installed on iPhone device in measuring the dynamic balance by comparing it with the Biodex balance system which is a valid device in that issue.

METHODOLOGY

SUBJECTS:

Thirty healthy non-athletic subjects with normal body mass index (8 females and 22 males; age= 23.9 ± 3.38 years and BMI= 22.53 ± 1.64 kg/m²) free from any injury or other medical condition that may affect their ability to control their balance participated in the present study. The participants were selected randomly from 70 volunteers who expressed their desire to join and fulfilled the selection criteria from the undergraduate and post graduate students in the faculty of physical therapy – Cairo University where the study was conducted. Each participant were tested to a primary examination to obtain a complete picture of their health status to identify any health problem may interfere with the study results with inclusion criteria including person with age between 18 to 35 years, body mass index (BMI) 20 to 24.9 kg/m^2 didn't have any medication a night before the procedure. Participant was excluded if he had previous inner ear troubles, musculoskeletal deformities or injuries, history of cerebral concussion and who take any medication that may affect their balance, also who is overweight or very thin.

Procedures

The study protocol, aim and importance were explained to all the participants. A written agreement form was signed by each participant. All the participants caught the iphone device containing the SBS in the upright position with the screen facing their mid of sternum and pressed it against their sternum while performed four tests (foot together, semi tandem, tandem and single leg stance) all done with eyes opened while the participant standing on the platform of the BBS (performing the test on BBS and the SBS at the same time as it is concurrent validity test) fig.1, 2, 3&4. The dominant leg was the leg in front in both tandem and semi tandem positions and the leg of weight bearing in the single leg stance position. Each test was done for 10 seconds and all participants performed experimental trials on level 8 Biodex Balance System difficulty with a familiarization trail prior to it. The overall stability index for each test was collected from experimental trial of each participant on both BBS and the same the overall postural sway was collected from SBS for each test and statistically analyzed.

Statistical analysis:

A statistical power analysis suggested that sample sizes above 15 participants required to achieve more than 80% power. Descriptive statistics were done to calculate the mean ± standard deviation (SD) for all measured variables. Difference between SBS and BBS measurements were analyzed using Pearson Product Moment Correlation Coefficient. The level of significance for all statistical tests was sit at < 0.05. All statistical measures were performed through the statistical package for social studies (SPSS) version 19 for windows.

RESULTS

The purpose of this study was to investigate the validity of using smart phone sway balance application in measuring dynamic balance. Thirty healthy subjects participated in this study. Data obtained from the study group regarding overall posture sway of smart phone sway balance application were correlated with overall stability index of biodex balance system at stability level 8 under four conditions; foot together, semi tandem, tandem and single leg stance. Thirty health subjects (8 females and 22 males) were included in this study with descriptive statistic as shown in table (1). The mean ± SD overall posture sway at stability level 8 with foot together was 98.79 ± 1.18, with maximum value of 99.9 and minimum value of 94.1. The mean ± SD overall posture sway with foot semi tandem was 99.08 ± 0.95,

with maximum value of 100 and minimum value of 96. The mean ± SD overall posture sway with foot tandem was 96.49 ± 3.87, with maximum value of 99.9 and minimum value of 83.5.The mean ± SD overall posture sway with single limb stance was 96.18 ± 4.8, with maximum value of 99.8 and minimum value of 77.7. The mean ± SD overall stability index at stability level 8 with foot together was 1.72 ± 0.48, with maximum value of 3.3 and minimum value of 0.9. The mean ± SD overall stability index with foot semi tandem was 1.82 ± 0.59, with maximum value of 3.6 and minimum value of 0.7. The mean ± SD overall stability index with foot tandem was 2.23 ± 1.1, with maximum value of 4.8 and minimum value of 0.7.The mean ± SD overall stability index with single limb stance was 2.21 ± 1.02, with maximum value of 5.8 and minimum value of 0.9. The correlations between overall posture sway and overall stability index at level 8 were moderate negative significant correlation at foot together ($r = -0.42$, $p = 0.02$), moderate negative no significant correlation at foot semi tandem ($r = -0.35$, $p = 0.053$), strong negative significant correlation at foot tandem ($r = -0.8$, $p = 0.0001$), and moderate negative significant correlations at single leg stance ($r = -0.61$, $p = 0.0001$). (table, 2).

Figure (1&2). The participant is performing the foot together stance and the semi tandem stance while using the SBS and standing on BBS at the same time.

Figure (3&4). The participant is performing the tandem stance and the single leg stance while using the SBS and standing on BBS at the same time.

Table (1): Descriptive statistics for the mean age and BMI of the study group

	$\overline{X}$ ±SD	Minimum	Maximum	Range
Age (years)	23.9 ± 3.38	18	33	15
BMI (kg/m²)	22.53 ± 1.64	20.1	24.9	4.8

$\overline{X}$ = Mean SD = Standard Deviation

Table (2): Correlation between overall posture sway and overall stability index at stability level 8

Overall posture sway	Overall stability index	r value	p value	Sig
Foot together	Foot together	-0.42	0.02	S
Foot semi tandem	Foot semi tandem	-0.35	0.053	NS
Foot tandem	Foot tandem	-0.8	0.0001	S
Single leg stance	Single leg stance	-0.61	0.0001	S

r value: Correlation coefficient value p value: Probability value S: Significant NS: Non significant

DISCUSSION

The results of the present study show that there is no significant difference between SBS over all postural sway and BBS over all stability index in measuring person dynamic balance while feet together, foot tandem and single leg stances with eyes opened at level 8 Biodex difficulty but there is a significant difference while the foot semi tandem and eyes opened at level 8 Biodex difficulty. These results mean that the SBS is valid to measure the dynamic balance as it has the ability to access the built in tri-axial accelerometer in the iPhone and as both tri-axial accelerometer and BBS are valid to measure dynamic balance so SBS is valid to measure the dynamic balance. This study was limited by the IPhone SBS can only measure the overall postural sway but cannot measure the anterior/posterior postural sway or the medial/lateral postural sway also the participant hands which catching the IPhone device may be deviated or even the IPhone position is slightly shifted while trying control his position on the BBS. Sway balance software has been developed recently, so, there is few number of studies done to test its validity and two of the following studies agree with the results of the present study while only one study disagreed but these studies were done to test the validity of SBS to measure the static balance. The result of the present study comes in agreement with the study done by (**Patterson, et al., April 2014**) where the anterior/posterior stability index and the anterior/posterior postural sway were collected by BBS and SBS respectively for participants in the single leg stance position as the version of SBS at this time was measuring the anterior/posterior postural sway only and they found no significant difference between anterior/posterior stability index that was measured by BBS and anterior/posterior postural sway was measured by Sway balance software [10]. The result of the present study also came in agreement with the study done by (**Patterson, et al., May 2014**) which aimed to compare the SBS in measuring balance with balance error scoring system. Balance error scoring system consist of three different standing conditions which are feet together , non dominant single leg stance and tandem standing with non dominant foot behind the dominant one done firstly on firm surface and then on foam one with two experienced administrators for assessment.

Comparing the results collected by Sway balance software and those of the balance error scoring system showing strong inverse correlation [11]. While **(Seymor et al, 2015)** shows results that did not agree with the current study. Their study aimed to explore the reliability and validity of SBS and pressure sensing platform (Mobile Mat, Tekscan). They compared them with force plate device (BioSway, Biodex) and balance error scoring system. They found them reliable but not valid [18]. But in the previous study they found that SBS is not valid as they made three stations of testing one for SBS and one for the Mobile mat and the last for the BioSway force platform and each station with different sub tests from the other stations. Then the average of each station is calculated statistically compared with the others and that what we obviate in our research as both SBS and BBS were tested at the same time for the same stances.

Conclusion

Using of smart phone Sway Balance application in measuring the dynamic balance is valid as well as the static balance as it was compared with the laboratory gold standard Biodex Balance System which is proved to be valid in measuring dynamic balance. This is a very important result as it providing an easy using, portable, cost effective and objective method to evaluate the dynamic balance in any field. So, it is recommended to the physical therapists to use the SBS in testing and reevaluation of the dynamic balance and at any field.

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Conflict of Interest: The authors declare that there is no conflict of interest. The manuscript has been read and approved by all authors.

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