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Validity and reliability of balance Y-MED application in chronic mechanical low back pain patients

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Abstract

Background: Low back pain patients suffer from balance disturbance. Balance allows a person to interact with the surrounding environment and to do his daily activities. As recent technology has facilitated patient monitoring and enhanced our ability to monitor patients remotely, smartphone apps have been developed to achieve this goal. There are various balance assessment instruments used nowadays. It may be subjective or objective assessments. This study was applied to verify if the measurements of balance Y-MED smartphone applications are valid and reliable compared to the HUMAC balance board in order to offer easy, fast, cost-effective, and time-effective valid and reliable balance assessment that can be used in a clinical setting.

Methods: Fifty-four patients (12 males and 42 females) with chronic mechanical low back pain for more than 3 months was volunteered to participate in the current study with an age range of 25–60 years and BMI range of 18–34 kg/m^2. Compared with the HUMAC balance board, the validity of the balance Y-MED smartphone application is evaluated, and the test-retest reliability of the balance Y-MED smartphone application is obtained by the same examiner 3 times.

Results: For concurrent validity, the correlations between balance measurements by Y-MED smartphone application and HUMAC balance board were not significant in both eyes open ($r = -0.12$, $p = 0.38$) and eyes closed ($r = 0.26$, $p = 0.054$). The smartphone application showed poor test-retest reliability measurement of balance with eyes open; (ICC was 0.279, with 95% CI − 0.117–0.554) and with eyes closed (ICC was − 0.159, with 95% CI − 0.814–0.287).

Conclusions: According to the evaluation scheme selected in this study, the researchers were unable to confirm the validity of the balance Y-MED smartphone application in the balance assessment of patients with mechanical chronic low back pain. More than that, the balance Y-MED smartphone application has been shown poor score reliability. This makes it inaccurate for use in assessment balance.

Keywords: Center of pressure, Balance, Mobile application, Validity, Reliability, Low back pain, Y-MED

Background

Low back pain (LBP) is one of the conditions that affect many people around the world, and it is considered one of the problems that affect health and economic life through absenteeism from work and disability [1, 2]. LBP is classified as specific or non-specific back pain and most people suffer from it; if the specific source of the pain cannot be identified, so it is classified as non-specific LBP [3]. When the back pain arises from the spine, intervertebral disks, or surrounding soft tissues, it is called mechanical low back pain (MLBP) [4]. The diagnosis of CMLBP is solely clinical; however, imaging studies may show degenerative spondylosis,

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asymptomatic lumbar disc herniation, and spinal stenosis. Some imaging abnormalities are consistent with the dynamic flexion/extension movements, but there are no clinical symptoms associated with these abnormalities [5]. Balance is essential for proper daily activities [6]. Balance disturbance and impairment of postural control may affect persons' participation in many sports and physical activities. In addition, it can hinder the development of motor skills, reduce motor skills performance and increase the risk of falls [7]. Moreover, back pain with its various causes is always associated with poor balance and a high risk of falls [8, 9]. As many as 9% of patients experience balance changes due to back pain, and age is the main determinant [10].

Balance control is achieved through the interaction between the vestibular, visual, and somatosensory systems, as they provide information about the position of the body in space, the forces acting on it, acceleration, and any other factors in the surrounding environment [11]. Impairment of one of them stimulates the nervous system to rely more on other equilibrium systems to maintain balance, according to the sensory reweighting theory [12]. Therefore, impaired proprioception can lead to increased demand for visual and vestibular input. However, this response may not fully explain deficiencies in proprioception [12].

Deficits in lumbar proprioception, decreased range of motion and altered muscle density are always associated with chronic low back pain (CLBP), because impaired proprioception will cause defective muscular responses, which can lead to a deficit in posture control and trunk balance [13–15]. Impaired lumbar proprioception is thought to reduce the ability to obtain and maintain a neutral spine posture and properly coordinate muscle activation. This impairs spinal control and increases trunk muscle activity as well as spinal pressure and strain, which may prolong LBP and cause further deterioration of proprioception [16].

The employment of emerging technologies like smartphones and tablets offers researchers and coach's opportunities to assess physical performance in the field, instead of science lab sports. Current smartphone technologies include advanced computing capabilities, inertial sensors, global positioning systems, and high-speed video capture [17]. The benefits of these devices are being financially suitable, portable, and need only a software application to access the data outputs of the installed sensors [18]. Smart mobile phones and tablets are used in the assessment of balance due to their containing of triaxial accelerometer [17, 19]. Measurements are taken by a simplified approach from the location of the center of mass (COM) which is typically described by a random single point where the sensor is placed [20, 21].

Many smartphone motion accelerometer programs can be found in Android Play stores such as Balance Y-medical, Balance Test, Gwangju, Korea. These programs use the instantaneous acceleration of the smartphone and use the built-in accelerometer based on the x, y, and z axes for evaluation. It scores one point every 60 ms and 1000 points per minute. The data process is done by dividing the horizontal plane into eight levels and the data is processed at each level. The data process includes the sum of the data points distributed from each level, the distance between the origin point and the farthest data point, and the percentage of points in a given plane [22].

One developed application for assessing balance is the balance Y-MED smartphone application. Balance Y-MED is a smartphone application that uses a motion accelerometer sensor that has its base in a smartphone which has been tested for its reliability and suitability for use as a convenient tool for assessing the postural balance in everyday life [22]. Due to the large number of LBP patients, we need a practical and simple way to easily and quickly measure the balance in the clinic to determine the effectiveness of the treatment methods used to treat the patients. Therefore, we chose to measure the validity and reliability of an easy and fast application on the phone that enables us to take the required data, and therefore, we compared the efficiency of the results extracted from it compared to the HUMAC balance board. Compared with the HUMAC balance board, is the balance Y-MED smartphone app reliable and effective in measuring the static balance of patients with mechanical chronic low back pain? The aims of the current study were (1) to determine the concurrent validity of the balance Y-MED smartphone application in comparison to the HUMAC balance board in chronic mechanical low back pain CMLBP patients and (2) to assess the test-retest reliability of the balance Y-MED smartphone application for measurement of balance in CMLBP patients.

Methods

Design of the study

This study is designed as a cross-sectional study to evaluate the test-retest reliability and concurrent validity of the balance Y-MED smartphone application in CMLBP patients. All measured values are recorded in a laboratory setting where HUMAC Balance Board is available.

Participants

Fifty-four patients (12 males and 42 females) with CMLBP for more than 3 months, with an age range of 25–60 years and BMI range of 18–34 kg/m^2 participated in this research. All the patients were diagnosed clinically and radiologically as MLBP and were referred to a doctor. The patients suffer from a neurologic deficit such as sciatica; distal weakness secondary to disc lesions was included in our study. The sample size was calculated with G*Power 3.1.9.2 and alpha level 0.05, an effect size of 0.5, and power 0.95; the total number of patients was equal to 54 patients. Any subject with epidural abscess, spinal malignancy, cauda equina syndrome, urinary incontinence, infection, visual or auditory complications, vestibular dysfunction, and structural deformities of the foot was excluded from the study. The study measurement and procedures were explained clearly for each patient. Non-eligible patients were excluded from the beginning of the study.

Procedures of the study

The copyright and consent for using this app for validation is the amount of money that was paid for using this application and the registration on the Play Store, and the right to use is assigned based on our paid subscription. The HUMAC balance board is a static force plate used to measure the center of pressure (COP) and force. The HUMAC balance and tilt system adds a tilt sensor to the HUMAC balance board allowing static force and dynamic tilt measurements [23].

Demographic data (subject's weight and height) were recorded at the start of the study and foot placement on the platform was conducted following the manufacturer's recommendations before the test is being measured. For evaluation purposes, the accuracy of the balance Y-MED smartphone application was compared to the HUMAC balance board, and it was validated against the conventional force plate [23]. The subject performed the modified clinical test of sensory integration of balance (mCTSIB) specialized to HUMAC balance board (300772B HUMAC balance). This test was used to assess the balance of the patients in two conditions; eyes opened and eyes closed. The patient was instructed to stand on the platform placed about 3 feet from the wall, then the patient was instructed to look at a target on the wall placed at the level of his eyes and maintain this position for 30 s. Then he was instructed to close his eyes for 30 s, and repeat the same test for three times, and the mean value was calculated from the results in Figs. 1, 2, and 3. The balance is measured using a Huawei Y7 prime mobile phone with the balance Y-MED app (version 1.9.9). The vestibule balance test was examined in our study. The therapist asked the patient to stand with

Fig. 2 HUMAC balance board

Fig. 1 the modified clinical test of sensory integration of balance "mCTSIB." **A** With open eyes. **B** With closed eyes

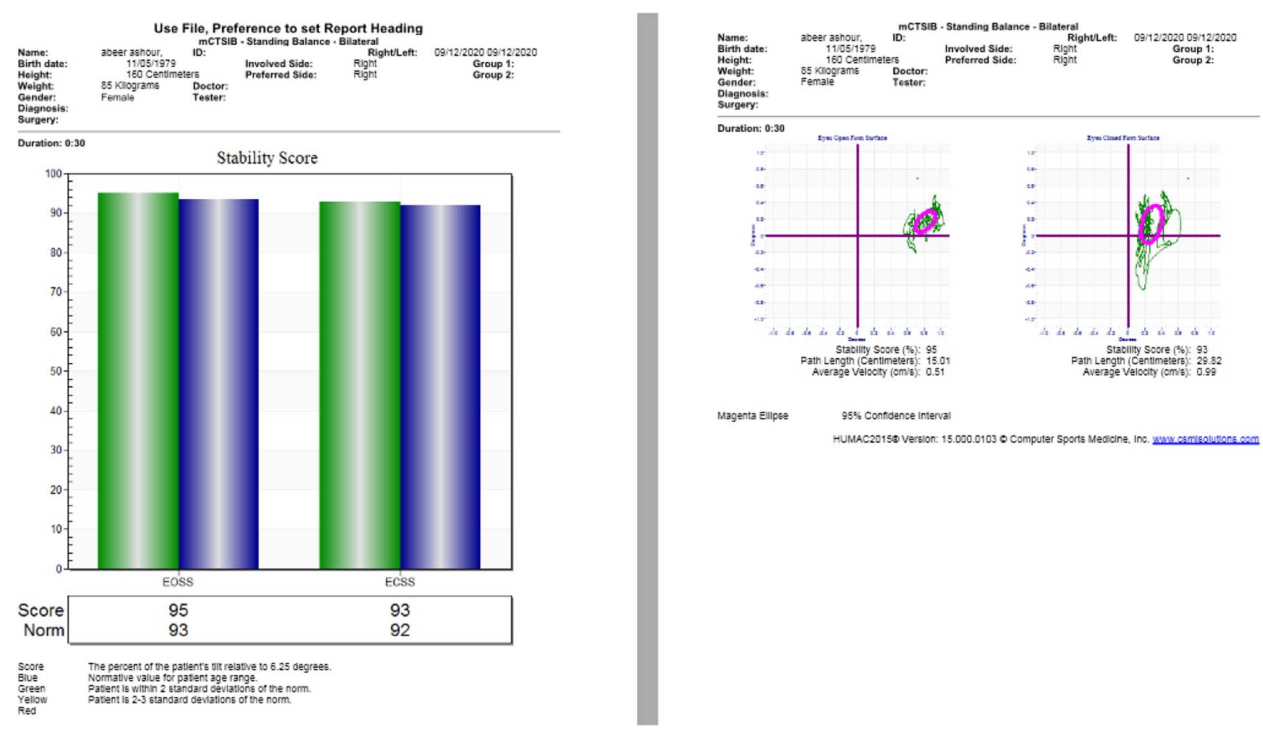

Fig. 3 The mCTSIB report

open eyes and then fixed the smartphone with a belt to the sacrum of the patient and clicked to start button. After the count-down, it was taken to measure in 10 s, and then the patient was asked to close his eyes and measure once again. Then repeat the test 3 times (Figs. 4 and 5). The operational procedure is provided as an Additional file 1.

Statistical analysis

Validity was investigated by determining the correlation between the smartphone application and Y-MED application and HUMAC balance board by Pearson correlation coefficient. Test-retest reliability is expressed in intra-class correlation coefficients (ICCs) with 95% CIs. Measurement error was expressed in the standard error of measurement (SEM) and the smallest detectable change (SDC). SEM = pooled SD $\sqrt{(1\text{-ICC})}$. The SDC was calculated as 1.96 $\times \sqrt{2} \times$ SEM. The level of significance for all statistical tests was set at $p < 0.05$. Statistical analysis was conducted through the Statistical Package for Social Studies (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics

Fifty-four patients with chronic mechanical LBP were included in our study. Table 1 showed the mean ± SD of the subject's characteristics of the study group.

Concurrent validity

Data of balance measured by HUMAC balance and smartphone application are presented in Table 2. The correlations between balance measurement by the Y-MED smartphone application and HUMAC balance board was found non-significant with both eyes open ($r = -0.12$, $p = 0.38$) and eyes closed ($r = 0.26$, $p = 0.054$) (Table 3).

Test-retest reliability

The smartphone application showed poor test-retest reliability measurement of balance with eyes open; ICC was 0.279, with 95% CI − 0.117–0.554; also, the smartphone application showed poor test-retest reliability in the measurement of balance with eyes closed; and ICC was − 0.159, with 95% CI − 0.814–0.287 (Table 4).

Discussion

The purpose of this study was to evaluate the validity and reliability of the balance Y-MED smartphone application in the assessment of balance in CMLBP patients compared to HUMAC balance board that is proven for assessment of balance.

Recent developments in mobile electronics technology have modified the method business is conducted in many alternative industries, including healthcare.

Fig. 4 The vestibule test of balance Y-MED application

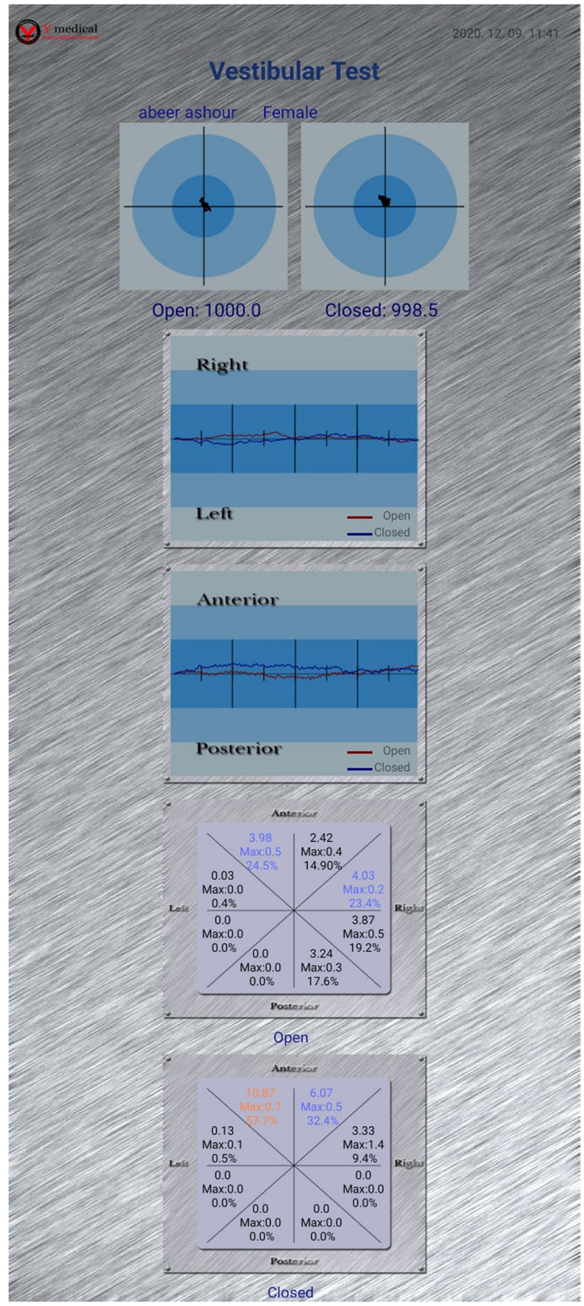

Fig. 5 Report of balance Y-MED application

this can be because of the capabilities of devices like smartphones and tablet computers which have numerous sensors including accelerometers, microphones, gyroscopes, global positioning systems (GPS), cameras, magnetometers and with increasingly efficient operating systems, microprocessors, and batteries [24, 25]. But all this does not make it characterized by the same accuracy and validity of the laboratory equipment used in measuring specific tasks and which is also used in scientific research.

The accuracy of smartphone devices is also affected by the type of system installed on them and the quality of their manufacture. A Chinese smartphone (Huawei) with an Android operating system was used in this study. Using the balance Y-MED application on an iPhone with iOS operating system may change the accuracy and quality of results from it.

While conducting the practical part of this study, we noticed that the method of fixing the smartphone on the lower back area using a belt (according to the application instructions) can lead to inaccurate results due to the possibility of the phone moving during the test, which affects the credibility of the application.

In the end, we must admit that no matter how accurate smartphones are, we will not be able to rely on them completely in scientific research, but they can give us a good indication during the evaluation process for the patient.

Although the recently developed technology facilitated our life and monitored our activities, it is very important to be validated to be used in various healthcare systems.

Table 1 Basic characteristics of all participants

	Mean ±SD	Minimum	Maximum
Age (years)	41.12 ± 10.53	25	59
Weight (kg)	77.94 ± 11.61	45	106
Height (cm)	164.77 ± 8.55	151	190
BMI (kg/m^2)	28.66 ± 3.47	18	33.9
Females/males	42 (78%)/12 (22%)		

SD standard deviation

Table 2 Descriptive statistics of balance measures of a smartphone application and HUMAC balance board

	Balance measurement of Y-MED Mean ±SD	Balance measurement of HUMAC balance board Mean ±SD
Open eye	98.8 ± 1.72	91.23 ± 2.6
Closed eye	98.47 ± 2.03	89.68 ± 3.78
Center of pressure		92.66 ± 2.32

SD standard deviation

Table 3 Correlation between balance measurement by Y-MED smartphone application and HUMAC balance board with eyes open and eyes closed

	r value	*p* value
Open eye	− 0.12	0.38
Closed eye	0.26	0.054

r value Pearson correlation coefficient, *p value* probability value

Table 4 Test-retest reliability of the smartphone application in the measurement of balance

	ICC	(95% CI)		SEM	SDC
		Lower bound	Upper bound		
Open eye	0.279	− 0.117	0.554	2.39	6.63
Closed eye	− 0.159	− 0.814	0.287	3.96	10.98

ICC inter-class correlation coefficient value, *CI* confidence interval, *SEM* standard error of measurement, *SDC* the smallest detectable

The current research results show that the correlations between the balance measurement of the Y-MED smartphone application and HUMAC balance board are non-significant correlations with eyes open and eyes closed on a firm surface.

In contrast to this study, Park et al. (2013) conducted a study to validate the smartphone movement accelerometer program (SMAP) against the Biodex balance system (BBS) on a healthy subject. They found that the program is going to be sensible considering that SMAP created results comparable to that of BSS through balance assessment in eye open stability medial-lateral (EOSML), eye open dynamic all (EODA), eye open dynamic medial-lateral (EODML), eye closed dynamic anterior-posterior(ECDAP), and eye closed dynamic medial-lateral (ECDML). They found also that SMAP can be considered as a reliable application because of its high reliability in both static and kinetic balance [22].

Moral-Munoz, Jose A., et al. (2018) made a comparison between the different applications for evaluating human balance, and this comparison included five applications, two for the Android system (balance test by Slani and balance test YMED) and three for the iOS system (Gyrobalance, iBalance fitness, and Sway). Balance test by Slani, the balance test YMED, and Sway are the only validated applications in some way by a scientific group [24, 26].

A good point for the balance Y-MED application is that it has the most detailed information obtained according to the body balance test, although the perception of design needs some improvement [24, 26]. There is not much research about the balance Y-MED application, so we need more study to confirm or deny the validity and reliability of this application.

Limitations and strength of the study

There are some limitations. First, we only recruited participants diagnosed with CMLBP patients aged between 25 and 60 years old, so the results of the study may not apply to older patients or different pathology patients. Second, subjects of varying body sizes and body types may exhibit different testing effects. Finally, the study was conducted on diseased nonathletic patients. Many studies have not been conducted on this application to ensure its validity and reliability, and this was the strength of the study.

Conclusions

The balance Y-MED smartphone app is not a valid alternative to the HUMAC balance board system in measuring the balance of CMLBP patients, but it is less reliable. Therefore, further studies should be done in the future to prove its validity in other pathologies.

To the authors' knowledge, this is study is the first to investigate the concurrent validity and reliability of "Balance Y-MED smartphone application" in assessing balance in patients with CMLBP patients.

Abbreviations

BBS: Biodex Balance System; BMI: Body mass index; COM: Center of mass; CLBP: Chronic low back pain; CI: Confidence Interval; CMLBP: Chronic mechanical low back pain; ECDAP: Eye closed dynamic anterior-posterior; ECDML: Eye closed dynamic medial-lateral; EODA: Eye open dynamic all; EODML: Eye open dynamic medial-lateral; EOSML: Eye open stability medial-lateral; GPS:

Global positioning systems; ICCs: Intra-class correlation coefficients; LBP: Low back pain; MCTSIB: Modified clinical test of sensory integration of balance; MLBP: Mechanical low back pain; *p* value: Probability value; *r* value: Pearson correlation coefficient; SD: Standard deviation; SDC: Smallest detectable change; SEM: Standard error of measurement; SMAP: Smartphone movement accelerometer program; SPSS: Statistical Package for Social Studies.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s43161-021-00064-6.

Additional file 1. HUMAC guideline.

Authors' contributions

The authors read and approved the final manuscript.

Declarations

Competing interests

The authors declare that they have no competing interests.

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