ORIGINAL PAPER

Physiotherapy Quarterly (ISSN 2544-4395)
2024, 32(4), 68–73

Reliability and concurrent validity of the iHandy level mobile application to measure thoracolumbar range of motion in low back pain patients

DOI: https://doi.org/10.5114/pq/174496

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Abstract

Introduction. The use of smartphone technology and software (apps), in addition to an inclinometer and goniometer, has expanded the clinician's assessment possibilities. However, the legitimacy and trustworthiness of these cell phones and applications are still questioned. This study aimed to determine the reliability and concurrent validity of the iHandy level mobile application to measure the thoracolumbar range of motion in people with low back pain.

Methods. This descriptive study included 40 participants, of which 20 were symptomatic, and 20 were asymptomatic for non-specific chronic pain in the lower back. Measurements were taken for extension, flexion, and left and right-side bending range of motion (ROM). Two investigators were involved. One measured ROM values with a Samsung iHandy level and inclinometer, and the second investigator registered the data. Two values were taken and the mean was used for further analysis. Measurements were taken at baseline and one-week follow-up.

Results. In asymptomatic participants, the mobile application had ICC values of 0.81, 0.70, 0.79, and 0.85, while in symptomatic, regarding intra-rater reliability, these were 0.80, 0.78, 0.81Regarding the concurrent validity of mobile apps in asymptomatic patients, ICC values were 0.94, 0.93, 0.84, and 0.89, while in symptomatic patients, the ICC values were found to be 0.92, 0.89, 0.83, and 0.85 for flexion, extension, RLF, and LLF, respectively. These showed an excellent correlation between the inclinometer and mobile app regarding intra-rater reliability and concurrent validity.

Conclusions. iHandy level smartphone applications might be considered reliable and valid for assessing thoracolumbar motion ranges in individuals with chronic pain in the lower back.

Key words: low back pain, range of motion, lumbar spine, inclinometer, mobile application

Introduction

Low back pain (LBP) is widespread. Back discomfort is a symptom, not a sickness or a medical condition. It affects almost all countries, including high-income, middle-income, and low-income, and involves people of all ages, from small children to older adults. It is estimated that from 1990 to 2015, the rate of disability due to (LBP) increased by 54% worldwide; specifically, middle- and lower-class countries showed a more significant upward trend than others. The main reason is the increasing population and age [1]. Age may be a contributing factor due to pain and restrictions in social and physical functions, leading to the deterioration of soft tissues. Now, the leading cause of disability worldwide is LBP. Data provides evidence that the prevalence of many populations with LBP and years lived with a disability has also risen significantly [2].

LBP is characterized by aching and discomfort limited between the costal margins and the inferior gluteal area, including referred or non-referred pain in the leg [3]. Chronic LBP (CLBP) is described as pain in the back that remains for at least three months. In 85% of chronic pain disorders, the LBP is classified as non-specific chronic LBP (NSCLBP) because of unknown causes [2].

The point prevalence of NSCLBP is estimated to be almost 18% and is the reason for a substantial economic strain on the healthcare system and people's lives [4]. NSCLBP persists as a deteriorating condition, making activities of daily living (ADLs) and quality of life of affected individuals difficult regardless of the latest efforts to understand the underlying mechanism. The most suggested risk factor for developing NSCLBP is a sedentary lifestyle, such as extended time sitting as an office worker and free time with less than 600 metabolic equivalent minutes/week. These inactive habits decrease muscular strength and cause muscle atrophy and neuromuscular efficiency reduction. All these things lead to pain and lower postural control [5]. The range of motion (ROM) measurements of joints, either static or dynamic, active or passive, are crucial in musculoskeletal examination [6]. Goniometers have long been used to measure the ROM of peripheral joints, but their reliability is reduced when it comes to the spine because palpation of reference points in the spine is challenging [7].

Many studies have proven the inclinometer's reliability and validity, but the analyses were primarily performed on healthy individuals. Accessibility in clinics and doctor knowledge of the measuring protocols might be limitations of the inclinometer [8, 9].

Not long ago, smartphones were used to monitor joint movement and provide the same or more reliable measurements than goniometers. Explicitly, smartphone software applications (apps) are coded to measure joint movement. Smartphones are cost-effective, straightforward, and extremely handy. Smartphone software apps designed for assessing joint ROM have the potential to offer healthcare professionals an innovative clinical instrument for evaluating

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Received: 10.07.2023
Accepted: 25.10.2023

Citation: Ijaz N, Riaz S, Raza T, Ali S. Reliability and concurrent validity of the iHandy level mobile application to measure thoracolumbar range of motion in low back pain patients. Physiother Quart. 2024;32(4):68–73; doi: https://doi.org/10.5114/pq/174496.

joint functionality and identifying disparities in joint motion [10, 11] Several types of research have already been performed to check the reliability of smartphone apps to measure ROM in joints [7, 11–15]. Moreover, most previous studies have been conducted on asymptomatic subjects [16].

In 2019, Keogh et al. [7] researched using a smartphone app and an inclinometer to assess the concurrent validity of thoracolumbar ROM and intra-rater reliability in adults with back pain and without pain. According to the findings of this study, both instruments displayed robust connections with each other, indicating the effectiveness of the smartphone app. In 2020, Monreal et al. [17] performed an analysis to examine the intra-rater reliability and validity of the Clinometer app in measuring cervical motion ranges and to determine minimal detectable changes and the standard error of measurements. The results demonstrated that measurements between devices had moderate to excellent validity and test-retest reliability [17]. Furness et al. focused on a similar analysis in 2018 to analyse the reliability and validity of Compass (an app for iPhone) in measuring rotational ranges in motion of the thoracic spine in the healthy population. A significant positive correlation was found between the universal goniometer and the Compass app, suggesting the Compass app to be a valid and reliable tool in clinical settings [18].

Although concurrent validity and reliability of an inclinometer and the iHandy level mobile app were found in previous literature, there was a literature gap in intra-rater reliability after one week. Thus, the primary objective of this study was to take measurements after one week to determine the reliability and concurrent validity of the "iHandy Level" android app to investigate the thoracolumbar motion ranges in patients with pain in their lower back.

Subjects and methods

Study design

The study design was descriptive.

Setting

The study was conducted at Central Park College of Allied Health Sciences, Lahore, Pakistan.

Duration of study

The study was completed six months after the approval of the synopsis.

Sample size

A sample size of 40 was calculated. The sample size was based on previous literature; a minimum of 20 participants was necessary to achieve a minimally significant ICC value of 0.61, alpha of 5%, and power of 80% as computed using the website http://www.openepi.com [19]. The study included 20 subjects without symptoms and 20 with non-specific pain in the lower back.

Inclusion criteria

For asymptomatic subjects [11]
– 20 to 50 years of age
– Both males and females
– No back discomfort or history of musculoskeletal damage
– Willing to participate in the study

For symptomatic patients (LBP)
– Age 20 to 50 years
– Both males and females
– Non-specific chronic pain in the lower back present for at least a three-month duration
– Willing to participate in the study [9]

Exclusion criteria [19]
– Patients with any diagnosis of fracture or spinal tumour
– Ankylosing spondylitis
– Disc herniation, lumbar stenosis, neurological involvement, spondylolisthesis
– History of back surgery
– Fibromyalgia
– Pregnancy

Data collection tool

– Bubble inclinometer
– Samsung Galaxy S21 model smartphone with iHandy level application.

Procedures

All the participants were selected using the fixed criteria. Analyst 1 measured spinal ROM, and Analyst 2 documented the measured ROM values. Subjects were first given warm-up exercises for two minutes. The warm-up exercises selected were pelvic rotations with knees bent to 90 degrees and pelvic rotations of 30 to 45 degrees to the right and left for two minutes. After the warm-up, subjects were asked to stand comfortably while their skin was marked with a dry-erase marker at the T12 spinous process level. As explained by Wellmon et al., this was employed as a landmark for positioning the inclinometer [19]. The smartphone's position was with its top edge touching the skin and central area at the level of the T12 spinous process to measure extension and flexion. The inclinometer was placed with its base against the subject's skin, and its centre was aligned with the T12 level. Both instruments were set at the T12 level for LF measurements, with their screens facing analyst one. The subjects were informed on all of the anterior, posterior, right lateral, and left LF movements. After that, they were asked to perform one practice session. The purpose was to familiarize participants with the movements. After that, subjects stood comfortably and were allowed to perform each movement at an acceptable pace. Each performance was done two times and the mean of the repetitions was utilized for assessment. At the start, subjects were instructed to perform flexion and extension until the limit of ROM. However, during hyperextension, they were instructed to place both hands at the L4–L5 level to maintain balance while executing hyperextension. Subjects were instructed to perform LF by sliding their hand down the side of their thigh as far as possible while keeping their torso and head facing forward, first to the right and then to the left. The next week following the initial examination, the individuals were invited to return to the clinic for a second test identical to the first, with the mobile device only.

Statistical analysis

Data was analysed using SPSS 25. Descriptive analyses were used to review the participants' demographic data. Cronbach's alpha and intraclass correlation coefficients (ICCs) were utilized to measure intra-rater reliability, and the Pearson correlation test was applied to determine the concurrent validity of the mobile app.

Results

Forty participants were included in the study; 20 were symptomatic, and 20 were asymptomatic. All the participants completed the study without any dropouts. Characteristics of all the participants are provided in Table 1.

The mean and *SD* values for ROM measurements at zero hours for the inclinometer and mobile app and after one week, only for the mobile app are shown in Table 2.

ICC values in both symptomatic and asymptomatic participants, regarding intra-rater reliability of the mobile app, showed good reliability for flexion and left and right LF but showed moderate reliability for extension. The values of Cronbach's alpha showed good reliability for all measurements (Table 3).

Concurrent validity of the mobile app for both symptomatic and asymptomatic participants showed that for flexion ROM, the ICC value with *p*-value < 0.001 showed a good to an excellent correlation between the inclinometer and mobile app. For extension ROM, Lateral right flexion, and left flexion ROM, the ICC value with *p*-value < 0.001 showed a moderate to good correlation betwixt the inclinometer and mobile app (Table 4).

Discussion

The current study aimed to assess the intra-rater reliability and concurrent validity of the Android iHandy level mobile app and the bubble inclinometer for determining thoracolumbar ROM in 20 healthy people and 20 people with NSCLBP. Because these movements are fundamental when analysing the

Table 1. Characteristics of the participants

Groups	Age (mean ± *SD*)	Height (mean ± *SD*)	Weight (mean ± *SD*)	BMI (mean ± *SD*)	Gender %age
Symptomatic	36.90 ± 8.84	1.655 ± 0.10	71.15 ± 11.10	25.933 ± 2.93	male: 60% female: 40%
Asymptomatic	39.85 ± 9.77	1.62 ± 0.11	76.6 ± 11.54	29.41 ± 5.07	male: 45% female: 55%

BMI – body mass index

Table 2. Mean and standard deviation of ROM

Device	Day	Flexion (mean ± *SD*)	Extension (mean ± *SD*)	Right LF (mean ± *SD*)	Left LF (mean ± *SD*)
Symptomatic participants					
inclinometer	zero hour	78.95 ± 6.52	28.25 ± 1.68	30.20 ± 4.09	28.70 ± 3.96
mobile app	zero hour	85.75 ± 6.83	27.90 ± 2.07	27.70 ± 1.83	31.40 ± 2.98
mobile app	1 week	83.60 ± 5.69	28.20 ± 1.88	29.65 ± 3.31	31.65 ± 2.53
Asymptomatic subjects					
inclinometer	zero hour	82.74 ± 6.79	26.89 ± 2.92	29.01 ± 3.37	28.89 ± 3.24
mobile app	zero hour	84.34 ± 6.91	28.69 ± 2.82	30.71 ± 3.27	30.52 ± 3.44
mobile app	1 week	83.82 ± 6.74	28.23 ± 3.42	30.51 ± 3.44	30.21 ± 3.21

LF – lateral flexion

Table 3. Intra-rater reliability for the iHandy application

Measurements	Flexion Mean (*SD*)	Extension Mean (*SD*)	Right LF Mean (*SD*)	Left LF Mean (*SD*)
Symptomatic participants				
ICC	0.80	0.78	0.81	0.79
95% CI	0.38–0.87	0.54–0.92	0.56–0.91	0.58–0.92
significance	< 0.001	< 0.001	< 0.001	< 0.001
CA	0.89	0.86	0.89	0.88
Asymptomatic participants				
ICC	0.81	0.70	0.79	0.85
95% CI	0.59–0.92	0.38–0.87	0.56–0.91	0.50–0.94
significance	< 0.001	< 0.001	< 0.001	< 0.001
CA	0.89	0.87	0.88	0.89

ICC – interclass correlation coefficient, CI – confidence interval, CA – Cronbach's alpha, LF – lateral flexion

Table 4. Concurrent reliability of the inclinometer and mobile app

Measurements	ICC	95% CI	Correlation coefficient (*r*)
Symptomatic subjects			
flexion	0.92	0.86–0.97	0.80
extension	0.89	0.85–0.98	0.70
right LF	0.83	0.67–0.85	0.61
left LF	0.85	0.71–0.93	0.71
Asymptomatic subjects			
flexion	0.94	0.86–0.97	0.82
extension	0.93	0.85–0.98	0.75
right LF	0.85	0.67–0.85	0.62
left LF	0.89	0.71–0.93	0.73

ICC – interclass correlation coefficient, CI – confidence interval, LF – lateral flexion

lumbar spine in any scenario, the intra-rater reliability and concurrent validity were tested for four lumbar spine motions (flexion, extension, and left and right LF). The results revealed a strong connection between the two instruments, demonstrating the app's validity. Furthermore, the measurements obtained demonstrated excellent intra-rater reliability in asymptomatic participants and moderate to good intra-rater reliability in persons with LBP.

Regarding intra-rater reliability, the Samsung app had ICC values in asymptomatic participants of 0.81, 0.70, 0.79, and 0.85 for thoracolumbar flexion, extension, right LF and left LF, respectively. All these values showed good reliability for flexion, moderate reliability for extension, and good reliability for right LF and left LF.

In previous studies involving symptomatic LBP patients, it was observed that the smartphone device's dependability for core movements was evaluated as very significant, whereas the consistency for other movements was scored as excellent. Most research on the reliability of devices for determining spine ROM has been done on healthy individuals. Only four of the 86 papers primarily acknowledged for analysis in Littlewood, and May's examination met the enclosure standards by encompassing individuals with chronic back pain. Additionally, only one of the studies mentioned sought to analyze the use of a smartphone app on patients [19].

There are variations in backbone flexibility between healthy participants and those with chronic LBP, as has been widely reported. Patient ROM volatility is frequently larger than that of non-pain respondents, as Elgueta-Cancino et al. reported in 2015 [20]. This is supported by current study data, which showed a reduced value in ICC. Several factors can be responsible for these variations, including fear of aggravating the pain, which causes fear-avoidance behaviour, as explained by Sánchez-Zuriaga et al. in 2014 [21].

In conjunction with its validity, the instrument's reliability was assessed in the current study on LBP individuals as well as healthy patients in all four lumbar movements, which is an important statistical feature for quantifiable and technical practice. According to this study's results, the intra-rater reliability of the smartphone app is relatively high. Based on the current study's results, the mobile app has a very good intra-rater reliability for scrutiny in healthy subjects. This is per the results of the study done by Macedo et al. [11].

When comparing healthy individuals to patients with chronic LBP of a non-specific nature, a study by Zawadka et al. in 2018 [22] showed non-statistically significant results, implying that the assessment equipment was not sufficiently reliable and that the sample was heterogeneous. However, in the current study, the ICC values for thoracolumbar flexion, extension, right LF, and left LF were 0.80, 0.78, 0.81, and 0.79, respectively. These results exhibited good flexion reliability, moderate extension reliability, and good left and right LF reliability**.** Therefore, this study contends that the mobile app can serve as a ROM assessment tool that aligns with inclinometry, presenting a more readily available, cost-effective, and user-friendly alternative.

The use of this app has introduced a valuable resource for converting measurements into meaningful assessments, particularly in the context of joint ROM. One notable advantage of these apps is their potential to address the challenges associated with landmark identification and alignment, which are common issues when using traditional tools like the universal goniometer [23, 24]. However, the extent to which smartphone apps can completely mitigate the drawbacks of the universal goniometer may hinge on the technology they employ and the clinician's familiarity with this alternative method [7]. Consequently, the introduction of smartphone apps into clinical practice offers healthcare professionals a new array of tools to integrate into their work, particularly for assessing complex joint ROMs that can be challenging to quantify.

According to the current study's findings, the iHandy level mobile app is a viable and reliable instrument for assessing thoracolumbar ROM in people with and without chronic LBP.

Limitations

It was challenging to convince the participants to visit the clinic the following week to take second measurements using the Mobile app.

Conclusions

It was concluded that the iHandy level smartphone app might be considered a reliable and valid instrument to assess thoracolumbar ROM for individuals with chronic pain in the lower back.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies,

has followed the tenets of the Declaration of Helsinki, and has been approved by the Riphah College of Rehabilitation and Allied Health Sciences, Riphah International University Research and Ethics Committee (approval No.: REC/RCR & AHS/21/0124).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

Funding

This research received no external funding.

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