

Test-retest reliability of an Android application (Protractor) for range of motion evaluation

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ABSTRACT

Several tools are used by physical therapists to assess the range of motion (ROM) for joints of the upper and lower limbs. However, most of them are costly, time-consuming, and difficult to use. The current study aimed to determine the within-visit test-retest reliability of an android application (App) (Protractor) for elbow, wrist and ankle joints range of motion evaluation in outpatients with post fracture fixation. We evaluated the Android App (Protractor) in twenty-six patients with a mean age of 30 years, who had undergone operative treatment for fractures around the elbow, wrist, and ankle. These patients were recruited from the physiotherapy outpatient clinic at the Faculty of Medicine, Tanta University. Repeated measures were performed within the same session, focusing on motions in the sagittal plane for the elbow, wrist, and ankle joints. All measurements were conducted by the same investigator. Pearson correlation coefficient (r) and intra-class correlation coefficient (ICC) were calculated. Within-visit test retest intra-rater reliability for elbow, ankle, and wrist joints, ROM was excellent (r and $ICC \geq 0.99$) except for wrist joint flexion ROM, it was weak

and insignificant. The mean group difference of measures obtained in the first and second measurements was close to zero, with the exception of wrist joint flexion, which was -5 degrees, and ankle joint plantar flexion, which was +2 degrees. The Smartphone android App (Protractor) displayed reasonable within-visit reliability.

KEYWORDS

Range of Motion; Reliability; Smartphone; Mobile Application; Protractor

1. INTRODUCTION

Measurement of joint ROM is an essential component of assessment of all orthopedic cases especially those who were post fracture, due to limitation in range of motion which is a common complaint. In addition to that, range of motion measurement is beneficial for proprioception evaluation which is an important element in the evaluation and rehabilitation of all orthopedic conditions. Range of motion evaluation is a vital component in rehabilitation; its measurement guides the selection of treatment, its progress, and its ending points (Norokin et al., 2009).

Smartphones equipped with mobile applications specifically designed to measure ROM offer clinicians a quick and easy method to examine flexibility (Wellmon et al., 2016). With smartphone ownership increasing among clinicians, there is an increased opportunity to use these devices to support clinical decision-making (Divall et al., 2013). However, with evolving technology, the need to assess the utility of devices for guiding clinical decisions became a necessity and the reliability of smartphone-based goniometer apps as a measure for ROM among clinicians must be determined (Wellmon et al., 2016).

Smartphone apps are now widely available, allowing them to be used as an inclinometer or goniometer (Keogh et al., 2019). Reliability and validity studies of new technologies are scarce (Vohralik et al., 2015). Smartphone applications showed sufficient intra-rater reliability to measure neck ROM in people with and without neck pain (ElguetaCancino et al., 2022), hip, knee ROM (Takeda & Furukawa., 2022), and shoulder as well (Shin et al., 2012, Mitchell et al., 2014). Furthermore, some studies addressed the reliability of ROM measurements using smartphone apps in the ankle joint (Alawna et al., 2019; Mohammad et al., 2021; Miyachi et al., 2022) and elbow joint (Hussein & Refaat., 2020). However, more studies are needed to be of a high quality and include more participants, cover more pathological conditions, use many other apps, assess other joints, and utilize other statistical methods (Keogh et al., 2019; Hahn et al., 2021).

It is important to address the reliability issues of these new applications. The purpose of this article is to report test-retest reliability for an android App (Protractor) for the range of motion evaluation in outpatient cases with post fracture.

2. METHODS

2.1. Participants

Twenty-six post-fracture (post-surgical) outpatients (23 males, 3 females), mean age 30 years. Informed consent was obtained from study participants by the investigator during work in the outpatient clinic. This study was approved by the research ethics committee Faculty of Physical Therapy, Cairo University 'No:P.T REC/012/004182'. This study followed the ethics of research, based on the World Medical Association Declaration of Helsinki: Statement of Ethical Principles for Medical Research. Figure 1 shows the flow chart of the study participants. Descriptive statistics of patients are presented in table 1.

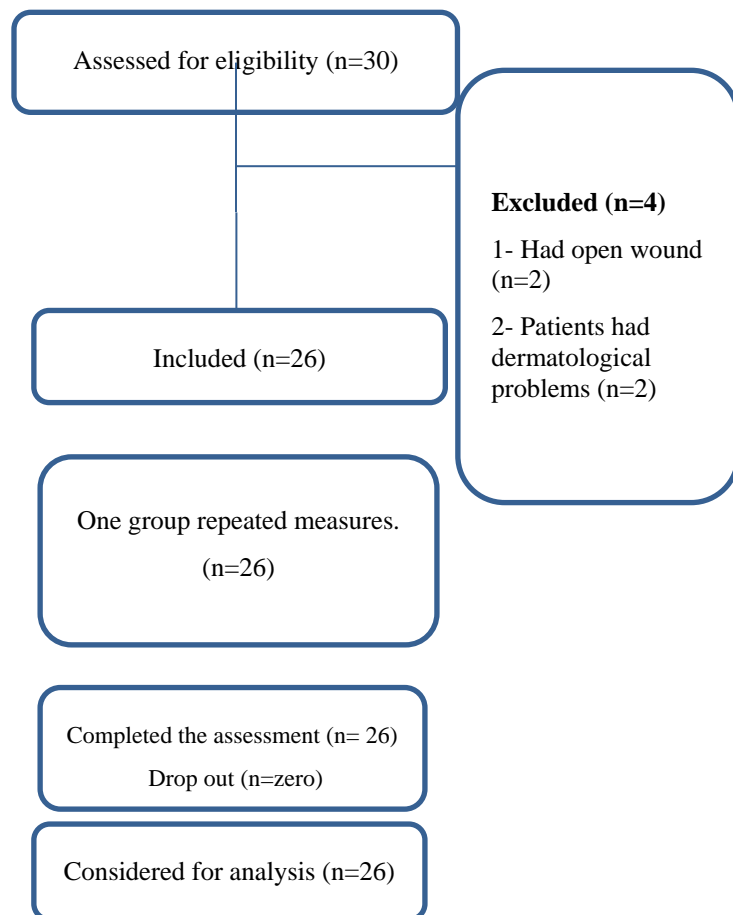


Figure 1. Flow chart of study participants

Table 1. Descriptive statistics of study participants

Characteristics	Mean (SD)
Age	30 (15) years
Weight	70 (10) kg
Height	166 (16) cm
Duration of illness	3.5(2.5) months
Gender (M/F)	23/3
Type and site of fracture	
Distal humerus (count)	10
Shaft humerus (count)	3
Distal radius (count)	6
Ulna (count)	2
Pott's (count)	5

Sample size calculation

Sample size calculation using G* power software (version 3.1) with an average correlation of 0.74 from previous studies (Vohralik et al., 2015; Wellmon et al., 2016) revealed a sample size of about 10 patients on average.

2.2. Instrument

Android mobile phone (Redmi 8) was used, with Android app, Protractor, (Keuwlsoft Co.) installed on it. This App is free to be downloaded from the play store.

2.3. Procedures

For elbow range of motion measurement, each participant was requested to put on a half – sleeve wide shirt and positioned comfortably in the supine position, and the mobile was held by the examiner, it was placed horizontally (on its side) on the palmar (for extension) and dorsal (for flexion) surfaces of the distal forearm (with elbow supinated). The arm of the patient was by the side and placed horizontally (zero degree flexion) on the bed. The shoulder joint was stabilized. The patient was asked to flex and extend the elbow to the available range. Two measurements were taken in the same session. For ankle range of motion measurement, the same position was used with the mobile placed on the dorsal (for planter flexion) and plantar (for dorsiflexion) surfaces of the foot. For wrist range of motion measurement, the patient was placed in a sitting position with the hand not supported, and the mobile was placed on dorsal (for flexion) and palmar (for extension) surfaces of the hand, with the forearm horizontally placed (zero degree). All measures were obtained by the same investigator (SE).

2.4. Data Analysis

We analyzed the test-retest data using spearman correlation coefficient and intra-class correlation coefficient. Descriptive statistics were presented. Reliability was considered poor for ICC values less than 0.40, fair for values of 0.40 to 0.59, good for values of 0.60 to 0.74, and excellent for values of 0.75 to 1.0 (Cicchetti et al., 2006). The ICC for reliability should be greater than 0.90 to ensure reasonable validity (Portney et al., 2009).

3. RESULTS

Within-visit reliability of range of motion of elbow, wrist and ankle joints were excellent except for wrist flexion (insignificant). The mean group difference of measures obtained on the 1st and 2nd measurements was close to zero, except for wrist flexion (-5 degrees) and ankle planter flexion (+2 degrees) (Table 2).

Table 2. Reliability (Spearman and intraclass correlation coefficients) for the range of motion of elbow, wrist, and ankle joints

	r (P value)	ICC (95%CI)	Mean (SD)	
			Test	Retest
Elbow				
Flexion	0.989 (0.000)	0.998(0.994-0.999)	128.4 (29.2)	128.6 (29.1)
Extension	0.998 (0.000)	0.998(0.994-0.999)	-13.86(20)	-14.2(19.76)
Wrist				
Flexion	0.377 (0.357)	0.348(-0.415-0.823)	38(13)	33(9)
Extension	0.99 (0.000)	0.984(0.894-0.998)	35.7(13.5)	36.2(15)
Ankle				
Dorsiflexion	0.998 (0.002)	0.989(0.837-0.999)	-2.3(20)	-2.8(23)
Planter flexion	0.998 (0.002)	0.997(0.954-1)	32(21.3)	34(20.5)

Note: r: spearman correlation coefficients; ICC: intraclass correlation coefficient; CI: confidence interval; SD: standard deviation.

4. DISCUSSION

This study was conducted to investigate the intra-rater test retest reliability of Android App (Protractor) in assessing the ROM of elbow, wrist, and ankle joints. It was found that protractor has excellent reliability in all joints and movements studied except for wrist flexion. This may be due to a less stable base for the mobile on the dorsum of the hand. ROM assessment is an essential component in musculoskeletal system evaluation, as well as it is necessary for evaluating the prognosis of

pathologic diseases, determining treatment plans and testing fitness levels. There are several modalities to measure ROM, each with positive and negative aspects (Alawna et al., 2019). The literature does not provide sufficient information about the reliability of smartphone ROM measurement applications so, there is a great need to establish enough information about its reliability and validity as well as the factors causing errors in the different techniques, which may be helpful for physical therapists when assessing ROM.

On the other hand, the current study provides physical therapists with information about the reliability of (Protractor) smartphone app which requires less surface anatomy landmarks knowledge, less training, and less palpation experience, the smartphone application provides advantages for inexperienced practitioners and physical therapy students as well as the potential to be used by patients to measure and track their own improvement. Home-based physical therapy, which is one of the key components of the rehabilitation process, gives patients the benefit of being able to monitor their ROM without having to purchase pricey devices. This motivates patients to be engaged in enthusiastic self-rehabilitation while receiving home-based physical therapy for conservative or postoperative management because it allows for immediate self-feedback.

Furthermore, at critical times as in COVID-19 pandemic, digital applications were able to provide the physicians and physical therapists with valuable information about the progress course of their patients.

The findings of the current study are supported by Vohralik et al. (2015) who studied the reliability of other apps in 20 subjects for assessing ROM of ankle joints and found a reliability or ICC of 0.97. In addition, Ferriero et al. (2011) used another app to examine elbow and knee ROM and reported a reliability or ICC > 0.95.

Several studies used smartphone-based goniometers to assess active ROM of the ankle joint and found a reliability or ICC between 0.53- 0.82 (Alawna et al., 2019; Hahn et al., 2021; Mohammad et al., 2021). In the present study, we found a higher reliability may be due to differences in the conditions of participants and techniques of measurement.

The current study comes in agreement with Hussein & Refaat (2020) who found that the correlation between 1st and 2nd measurements of elbow ROM measured by smartphone application was $r=0.81-0.91$, respectively. In the present study, a higher reliability was detected. Our study supports the findings of Wellmon et al., 2016 who concluded that smartphone apps had excellent reliability and can be used instead of universal goniometer or inclinometer to measure the ROM of various joints.

This study partially supports the report that no great differences between smartphone-based goniometric applications in ROM assessment (Sakata et al., 2020). To the best of our knowledge, no study has demonstrated the reliability of multiple-joint ROM and the previous studies used single-joint ROM reports. To fill this gap in the literature, this study examined the test retest reliability of the measurement of ROM of the joints using a smartphone application. Miyachi et al. (2022) found that smartphone apps had substantial to almost perfect intra-rater reliability (ICC 0.668–0.939) in measuring ROM of lower limb joints, except ankle dorsiflexion was lower. In contrast, the current study found excellent reliability in ankle dorsiflexion. The present study disagrees with Behnoush et al. (2016) who found little reliability for elbow flexion (ICC = 0.26) and extension (ICC = 0.06). Differences may be due to time variables and more than one rater. In summary, Protractor mobile App provides a reliable, accurate, and objective assessment of the ROM of several joints.

5. CONCLUSIONS

The within-session reliability of the Protractor mobile android App for measuring the range of motion of several joints (elbow, wrist, and ankle) was excellent except for wrist flexion. Physical therapists and clinicians can use this App for measuring the range of motion of their patients.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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