



Research articles

Smartphone application for computing joint range of motion: a reliability test for its efficacy

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ABSTRACT

"Goniometry" is derived from two Greek words: Gonia, which means "angle," and Metron, which means "measure." The focus of the research is to see if a smartphone-based goniometer application for knee flexion range of motion was reliable. The technology of smartphones is one of the most often used alternatives. A literature evaluation of 12 studies showed that smartphone applications are sufficiently trustworthy to be employed in research and clinical practice. As ROM angulation is widely employed in treatment policy decisions, new measures have to be thoroughly tested before use in clinical practice. The study design used was an observational study. The participants were recruited using a simple random sampling method. The total number of participants was 100 in the age group between 20-60. With Universal Goniometer and Goniometer records, three certified physiotherapists measured maximum active knee flexion in a supine position. Data was collected and analysed using SPSS (version: 20) and the Bland Altman Test was used. Results revealed that a significant correlation was found between the application Goniometer Records ($r=0.9409$) and Universal Goniometer ($r=0.8149$) methods for the mean of 3 trials. The application Goniometer records mean and the universal goniometer means were found to differ significantly by the two-tailed paired t-test. The ICC and 95% confidence interval (CI) for Smartphone Goniometer was 0.9409 (95% CI, 0.9133-0.9599) and that for Universal Goniometer was 0.8149 (95% CI, 0.7363-0.871). It could be concluded that the Goniometer Records demonstrated acceptable test-retest reliability. The Goniometer Records exhibited high reliability.

Keywords: Universal Goniometer, Goniometer Records, Smartphone Goniometer, Knee Flexion, Range Of Motion.

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INTRODUCTION

The goniometer is one of the oldest instruments used to measure the angle or the angular position of the joint. The term "goniometry" is derived from two Greek words: Gonia, which means "angle," and Metron, which means "measure." Goniometer has been extensively used to measure the range of motion of joints of the body for the last many decades. Goniometry is thus related to angle measurement, especially angles created by the bones of the body at the human joints [1]. More people use their smartphones to record measurements with technological progress because it is easy to transmit. Several angles measuring smartphone applications have been developed during the past few years. [2]. These include accelerometers, gyroscopes, magnetometers, and photographs, measuring joint angles, and testing for validity and reliability. The smartphone application in Japanese in 2017". These measures are obtained by placing the components of the measuring tool, known as the goniometer. A goniometer is a key element in an extensive joint and surrounding soft tissue examination. The studies with goniometric smartphones show a high degree of knee dependability,

compared to experienced and untrained examiners, for patients who have joint recuperation surgery.

There was also good to exceptional reliability in the assessment of the spectrum of motion of the other articulations with the use of smartphone applications, while studies have proved that smartphone applications are reliable and may be tested for application in research and clinical practice. [3]. Various methods have been used to evaluate the joint range of motion. The traditional method used to evaluate the ROM is by the Traditional universal goniometer. Recently, after the progression of information technology with an increased number of smartphone users, several web developers has also developed goniometry application including visual estimation electro goniometers gravity digital inclinometers digital compass goniometer and digital-photographic goniometric methods. [4]. As a result, a universal goniometer is most typically used in clinical practice to measure joint angles and range of motion. For functional and sports activities, knee bending and extension motion range (ROM) are necessary. Loss of full ROM can be damaging to lower

extremity function in the knee joint and therapy is necessary to recover complete ROM function. ^[5]. The minimum knee bending required by specific work activities has been assessed in previous studies: 57-69° for walking levels, 83-99° for stairs, 84-120° to sit and elevate from a chair, 131-138° for bathing in and out of a bath, 155° for squatting, kneeling or elevating from a floor. for squatting activities. ^[1]. A healthy adult is assessed to have an acceptable active knee flexion of 135°. At least 110° knee bending is required for the majority of elderly in daily life to function successfully.

Knee flexion at least 110° is needed to guarantee that most seniors do their everyday duties satisfactorily. Low, moderate, or high knee flexion is yet undetermined. ^[6]. Restoration of range of motion following injury and surgery requires close monitoring for Measurement error and instrument error are the two principal potential sources of error in joint angle assessment. A precise universal measurement is dependent on the positioning of the center of the knee joint rotation and the right alignment of the arm with proximal and distal bony landmarks. ^[7]. The technology of smartphones is one of the most often used alternatives. It is available readily; it costs nearly no additional expenses and can be more useful than specific digital procedures, which can enhance measuring accuracy and precision. It is also easier to use than special digital technology. ^[8]. In earlier studies, the validity and reliability of various ROM smartphone measuring applications have been examined. This research has demonstrated that the validity and reliability of smartphone ROM measuring applications in different joints.

Many smartphone programs (Dr. Goniometer and I Gonio 2011) are using the smartphone for measuring x-ray or digital pictures joint angles and therefore are susceptible to the limits of conventional digital and photographic photography goniometric measurement. ^[9]. The assessment can be inaccurate from three mistake sources namely distinct subject features, examiner error and instrument measurement error. The measurement of ROM however should be objective and trustworthy, as a tool to minimize errors of measurement is required for patients to be reviewed and reviewed by different physiotherapists at different periods during the therapy process. ^[10]. It should be compared to a previously tested method that is regarded as a reference measure to determine the dependability of an evaluation tool. ^[11]. When examined the knee radiologic and goniometric measurements from different angles with healthy people, the reliability of the universal goniometer was evaluated in the 1980s and a high correlation was observed between both methods. ^[12]. The golden standard for measuring joint ROM is believed to be the universal goniometer with its well-known dependability and is the most often used in clinical practice because it is no inventive, economical, and easy to use ^[13] The knee ROM assessment is of

significant clinical value because the knee is one of the most commonly damaged joints and is affected by several disorders. Studies have shown that the reliability of a goniometer regarding this joint is high. In addition, studies using goniometric smartphone apps show that there is a high level of reliability in knee-controlled patients in external tibial rotation angle measurement and a comparison between experienced and new evaluators and inexperienced students. ^[14].

The Goniometer records are a smartphone application that uses accelerometry to assess knee joint angles to take a fresh goniometry method. This research aimed to determine the reliability between the Goniometer and Universal Goniometer smartphone applications. ^[15].

METHODOLOGY

The healthy subjects were recruited using a simple random sampling method. The total number of participants was 100 of the age group between 20-60 years. The subjects recruited were free from any neurological and musculoskeletal conditions. Subjects having recent injuries were also excluded. Patients who had fixed deformities of lower limbs or were excluded. Ethical approval was obtained following the ethical principles. The instruments included Universal Goniometer and a Smartphone application named Goniometer records.

Procedure

We continued the research after the approval of the Institutional Ethical Committee. All topics got verbal and written information on the study including the procedure, purpose, before commencing the investigation. The subjects they had to sign to participate in the study received a formal consent form. A total of 100 subjects (N=100) between the age of 20 to 60 participated in the study and were selected by simple random sampling. This study was single-blinded. Three qualified physiotherapists were the observer. The left knee of all the subjects was chosen for determining the ROM. Knee flexion movement was measured for 100 subjects three times with two methods by each physiotherapist. Then all the data were recorded in datasheets. The Universal Goniometer was considered as a clinical standard technique. The 3 physiotherapists were unaware of the readings taken by the other 2 therapists.

Patient's Position and Point of Reference for Universal Goniometer

The subject was apparently in the knee-flexed posture, the centre of the universal goniometer on the lateral femur condyle, and the steady arm had to be parallel to the femur shaft and the moving arm to the fibula.

Patient Position and Point of Reference for Smartphone Goniometer

The subject was in a supine position. The smartphone was set on the zero points of the horizontal line along with the knee. The

patient was requested to bend his knee and the angle was assessed along the subject leg by the phone. A reference point for the lower leg was below the tibial tuberosity and for the thigh was the mid-thigh.

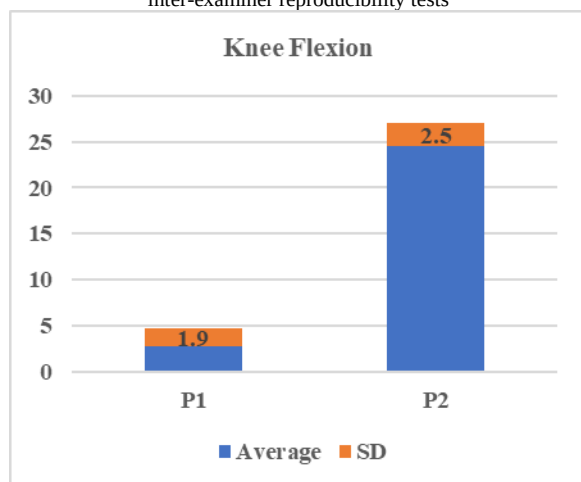
RESULT

The data were analyzed by SPSS (ver. 20) statistical software. The intraclass correlation coefficient was calculated to assess the intra-rater correlation of both Universal Goniometer and Goniometer Records. Intraclass correlation coefficient value for GONIOMETER RECORDS was higher than 0.90 considered adequate to ensure reasonable validity. Upon confirmation of the usual data distribution, contract limitations (LoA) were utilized to determine the agreement between the 2 instruments (Bland and Altman, 1986). The limit of agreement (LoA) defines the range within which 95% of differences between measurements by the 2 methods are predicted to lie. For the study population, 100 healthy volunteers were chosen. Table 1 provides a summary of descriptive data. Significant correlations were found between the application Goniometer Records ($R=0.9409$) and Universal Goniometer ($r=0.8149$) methods for the mean of 3 trails. The two-tailed paired t-test indicated a significant difference between the application Goniometer records mean and universal goniometer mean. The ICC and 95% confidence interval (CI) for Smartphone Goniometer was 0.9409 (95% CI, 0.9133-0.9599) and that for Universal Goniometer was 0.8149 (95% CI, 0.7363-0.871), graphically described in figure 1.

Table 1: knee joint angle measurements in inter-examiner reproducibility tests

	P1	P2
Average	2.8	24.5
SD	1.9	2.5

Figure 1: Graphical representation of the knee joint angle measurements in inter-examiner reproducibility tests



DISCUSSION

In comparing its measurement of knee connection angle with that of a Universal Goniometer, this study aimed at checking the confidence of the Goniometer application. [4]. We believe that the present research is the first reported study to investigate the

inter-rater reliability of this specific application. [6]. The three trails for each of the two approaches exhibiting strong reliability between the Smartphone Goniometer and the Universal Goniometer were highly correlated. All the ICCs were larger than 0.70 indicating a clinically acceptable level of reliability and Bland Altman's smartphone goniometer showed good 95% dependability (Figure 1) (Bland and Altman 2007, 1986). Significant correlations were found between the application Goniometer Records ($r=0.9409$) and Universal Goniometer ($r=0.8149$) methods for the mean of 3 trails. The two-tailed t-tests showed that the mean Smartphone Goniometer was significantly different from the Universal Goniometer. The ICC and 95% confidence interval (CI) for Smartphone Goniometer was 0.9409 (95% CI, 0.9133-0.9599) and that for Universal Goniometer was 0.8149 (95% CI, 0.7363-0.8718). It is vital to differentiate between relative and absolute reliability when assessing reliability since this may simplify the distinguishing between measurement error and treatment effectiveness. In the previous study, the mean of the three trials for each of the two techniques showed a good grade of correlation ($r = 0.932$) that reflected relative dependability between the goniometer and the LAG. All ICCs had a clinically acceptable degree of reliability greater than 0.70, and the Bland and Altman thresholds of 95% were considered to have good absolute reliability. Despite its strong relative and absolute reliability, the goniometer was shown to have lower than the quoted levels for experienced testers with ICCs above 0.90. [16].

CONCLUSION

The Goniometer Records demonstrated acceptable test-retest reliability. The Goniometer Records exhibited high reliability.

CONFLICT OF INTEREST

All authors declared no conflict of interest.

AUTHORS CONTRIBUTION

PPD, WMN conceptualizes the topic. PPD collected the literature and data under the supervision of WMN. CAK and SPA help in statistical analysis. PPD, WMN drafted the final manuscript.

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