ORIGINAL ARTICLE

FEASIBILITY AND VALIDITY OF A MOBILE APPLICATION GONIOMETER FOR ASSESSING KNEE JOINT RANGE OF MOTION

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ABSTRACT

Objective: To determine the feasibility and validity of Goniometer Records (GR), a mobile app goniometer for knee joint range of motion (ROM).

Material & Methods: A total of 72 undergraduate physiotherapy students participated in this study. Knee flexion and extension was taken simultaneously with the Universal goniometer (UG) and GR, and the Mobile Application Rating Scale (MARS) and System Usability Scale (SUS) were used to assess the feasibility of GR.

Results: The mean age of participants was 22.2 ± 1.6 years. There was a weak but significant correlation between UG and GR ($r = 0.251$; $p = 0.030$) for knee flexion but not for extension ($r = 0.105$; $p = 0.37$). The feasibility ratings of GR on MARS for all the sections were 17.6±2.7 (out of 25), 15.4±2.0 (out of 20), 11.4±1.3 (out of 15), 25.4±2.6 (out of 35), 14.8±2.2 (out of 20) and 21.2±2.1 (out of 30) for engagement, functionality, aesthetics and information respectively. Based on SUS statements about app usage, 63.9% of the respondents rated the App low.

Conclusion: GR showed weak validity in knee flexion assessment but none with extension compared to UG. GR for knee ROM assessment had moderate feasibility but low usability rating.

Key Words: Goniometry, Goniometer app, Knee, Mobile applications, Range of motion

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INTRODUCTION

Assessment of range of motion (ROM) is vital to evaluate the movement available/possible at a joint in comparison to baseline, contralateral limb or reference norms, which may give insight into an individual's state of health or disease. Assessment of the ROM is a valid method of evaluating dysfunctions within the joint or capsular structures congruent to a joint.[1] For example, limitation in active ROM when passive movement is unaffected may indicate diminished muscle strength resulting from a nerve problem.[1] In patients with knee pathology, the presence or absence of limitation in ROM is an important indicator clinicians consider[2] in diagnosing, evaluating disease progress or deterioration, and determining the extent of functional independence and quality of life.[2] Also, examination of knee joint mobility is a precursor in choosing the interventions.[3] Furthermore, joint movement is needed to assess joint integrity or function, which may also serve as an objective outcome measure of treatment efficacy.[4]

Most commonly, a goniometer is the primary tool used to evaluate knee ROM in clinical settings owing to its low cost and portability.[5-9] However, goniometry is limited because of the need for the assessor to use both hands to locate anatomical landmarks, thereby making it difficult to stabilize and possibly introducing errors of measurements due to inaccurate reading or incorrect placement[5,

[7, 10] leading to low validity and reliability in traditional goniometry.[9]

Traditional goniometry is even more error-prone when assessing the knee. This is because the goniometer may not be long enough to align directly with the appropriate landmarks on the adjacent upper and lower anatomical landmarks.[2] In fact, the measurement errors of goniometer in joint motion assessment are more pronounced with less experienced clinicians who find it challenging to locate the appropriate landmarks correctly.[11, 12] With the recent advancements in technology, some devices and applications (apps) have evolved.[13] Smartphone apps presents clinicians with a quick and low-cost alternative in the measurement of joint motion,[2] which can be utilized in various settings such as acute care, home, and health facilities owing to their being portable and without requiring extensive skills.[14] The use of smartphone apps for functions such as goniometry can make practicing in less conventional settings more convenient, and thereby foster good therapist-client relationships. However, the use of mobile app goniometer to assess the ROM is yet to be commonplace among clinicians. Thus, empirical evidence on the validity and applicability of digital goniometers is needed. Therefore, this study aimed to determine the feasibility and validity of a mobile app goniometer *(*The Goniometer Records (GR) for knee ROM assessment.

MATERIAL AND METHODS

Undergraduate physiotherapy students in the second clinical year at the Department of Medical Rehabilitation, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria, participated in this validation study. Ethical approval for the study was obtained from the Health Research Ethics Committee of the Institute of Public Health, Obafemi Awolowo University, Ile-Ife, Nigeria. Students with any impairment affecting the knee joint were excluded from the study. Based on the formula by Yamane,[15] n= N/1+N (e)^2, where n= sample size, N= Population size (88) and e= Error margin estimated at 0.05 (i.e. n= 88/1+88(0.05) ^2), a sample size of 72 was determined. The Exercise Therapy Laboratory of the Department was the venue of the study.

A 12-inch full-circle plastic universal goniometer (66fit™) with three separate and validated scales calibrated according to the International Standards of the Measurement System was used to assess the knee ROM. Goniometer Records Mobile App (Indian Orthopedic Research Group, www.iorg.co.in/2013/05/goniometer-records-mobile-app/) was used to assess the ROM. The Goniometer Records mobile app is available on iOS and Android platforms. The reliability of the app has been tested and found acceptable in a previous study.[16] System Usability Scale (SUS) was applied to evaluate the feasibility of the mobile app goniometer. Specifically, SUS was applied to appraise user experience in terms of engagement, satisfaction, and complexity of the App. This questionnaire contains ten statements about the perceived usability of the app assessed on a scale of 0-4. The score obtained from each participant was multiplied by 2.5 with an SUS score of 0 indicating low usability and 100 indicating high usability. Mobile App Rating Scale (MARS) was used to classify and rate the information quality of the mobile app, as part of the feasibility testing. MARS is a reliable multidimensional scale in the determination or rating of information quality of mobile app.[17]

The procedure was described to the consenting participants. Participants were instructed to relax on a plinth while the proximal (greater trochanter) and distal (lateral malleolus) landmarks for the measurement of knee ROM were identified. To assess the knee flexion and extension, participants were asked to lie prone with their test-side ankle off the plinth. The knee flexion and extension were assessed with the universal goniometer following standard procedure.[6] While the participants were still in the same position, the knee flexion and extension ROM were assessed again with the Gonimeter Records. Using the app, the phone's edge was placed on the anterior thigh at the starting point, and then the participant was asked to flex or extend the knee while the telephone was aligned with the participant's knee motion and end clicked. The value of knee flexion and extension displayed on the screen was recorded. After each assessment, the value on the smartphone screen was cleared before the subsequent measurement. Afterwards, the MARS and SUS questionnaires were administered to the participants. The same assessor trained in the use

of traditional goniometry and Goniometer Records mobile app carried out all the measurements.

Data analysis was carried out using SPSS version 21.0. Independent t-test was used to compare measurements from Goniometer Records and universal goniometer, while Pearson correlation was used to assess the relationship between universal goniometer. Alpha level was set at $p<0.05$.

RESULTS

The mean age, weight, height and body mass index (BMI) of participants were 22.2 ± 1.6 years, 68.4 ± 11.6 kg, 1.75 ± 0.1m and 22.4 ± 3.4 kg/m² respectively. The mean for flexion and extension ROM using the universal goniometer were 122.7 ± 5.6° and 2.2 ± 1.4°, while the mean flexion and extension ROM using Goniometer Records were 125.9 ± 8.2° and 2.8 ± 2.1°. There was no significant difference ($P>0.05$) between universal goniometer and Goniometer Records in assessment of flexion and extension. **(Table 1)**

The results of Pearson correlation analysis showed that there was a significant but weak correlation between universal goniometer and Goniometer Records in the evaluation of knee flexion. **(Figure 1A)** However, there was no significant correlation between both devices in the assessment of knee extension. **(Figure 1B)**

App quality rating, App subjective quality and App-specific mean scores were; 17.6 ± 2.7 (out of 25), 15.4 ± 2.0 (out of 20), 11.4 ± 1.3 (out of 15), 25.4 ± 2.6 (out of 35), 14.8 ± 2.2 (out of 20) and 21.2 ± 2.1 (out of 30) respectively. Based on the System Usability Scale (SUS) of 10 statements about application usage, Forty-six (46) participants rated Goniometer Records App low, four (4) participants rated it moderate and twenty-two (22) rated it high.

Table 1: Comparison between Universal Goniometer and The Goniometer Records in the assessment of Knee Flexion and Extension

Range of Motion	Universal Goniometer	The Goniometer Records	t-cal	p-value
Flexion	122.7±5.6	125.9±8.2	3.05	0.39
Extension	2.2±1.4	2.8±2.1	2.13	0.37

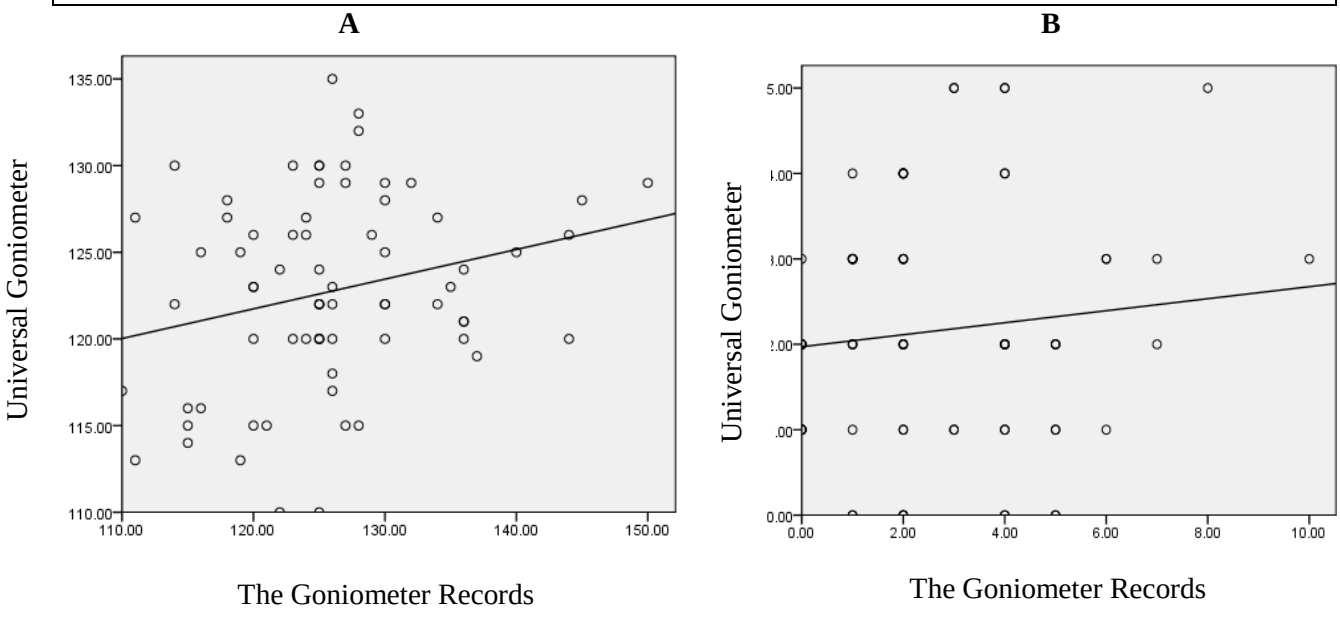

Figure 1: A scattered diagram showing knee flexion (A) and knee extension (B) assessment with universal goniometer and the goniometer records

DISCUSSION

There is a proliferation of different types of mobile apps in clinical settings,[18] including mobile app goniometer.[19, 20] Yet, there are limited studies on validation and clinical applicability of these apps before utilizing most of them in patients' care. This study aimed to determine the feasibility and validity of a mobile app goniometer (Goniometer Records) in the measurement of knee ROM. A homogeneous sample involving undergraduate physiotherapy students was used in this study. The mean age of the students was 22.3 ± 1.6 years.

In this study, the universal goniometer and Goniometer Records mobile app were used simultaneously to measure the knee joint ROM of the same limb. The result of the validity test showed a significant correlation in the flexion ROM between the two devices but not with the extension ROM. This observation may imply the need for further studies on the development of a mobile-app goniometer that may be comparable significantly with the universal goniometer. However, the mobile-app goniometer may be influenced by factors that may make it prone to variability. For example, smartphones have various Android versions with different specifications and capabilities in motion sensing.[16] This means that a smartphone with a higher-grade Android version having the mobile app goniometer may be more sensitive than phones with lower Android version, hence the likelihood of error. In this study, the latest version of the Goniometer Records mobile app was used. Also, the low/no correlation between the universal goniometer and the Goniometer Records mobile app measures of knee ROM flexion/extension may be due to the dependency of the universal goniometer on high clinical experience for accuracy. Experience is a factor in assessing ROM with a traditional goniometer.[21] It has been reported earlier that the reliability and validity of goniometer-app, compared with a traditional goniometer, appear lower when assessed by assessors with limited experience.[4]

According to results of the Mobile Application Rating Scale (MARS) obtained in this study, the Goniometer Records mobile app had scores higher than average of the total obtainable score, implying that the mobile app is considered excellent and usable in the clinical setting. The mobile app store is proliferating rapidly, and many of these apps require frequent updates for optimal functioning.[19] Many users do not have the urgency to regularly update their apps if it is functioning. The fact that apps and Android phones need updates will mean that after a while, the current version will become obsolete, and developers will have to provide updates to the mobile app goniometers. Even though the Goniometer Records app is well rated on MARS by the participants, however, to enjoy an optimum level of the mobile app goniometer usage, at least a seldom update is inevitable. However, based on the SUS, most of the undergraduates rated Goniometer Records mobile app low in usability. Further studies may be needed to ascertain the validity and feasibility of Goniometer Records in other populations, especially in disease states.

CONCLUSION

Goniometer Records showed weak validity in the assessment of knee flexion but none with extension compared to universal goniometer. However, Goniometer Records for knee ROM assessment had moderate feasible but low usability rating.

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