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Reliability of two Smartphone applications to measure the hip range of motion in asymptomatic patients

Luis Ceballos-Laita, Teresa Mingo-Gómez, Mari Mar Latorre-Balsa, Sandra Jiménez-del-Barrio
Faculty of Physiotherapy, University of Valladolid. Soria, Spain.

Abstract

Hip range of motion (ROM) is a common variable used by clinicians to assess the hip function. Smartphones are present in the daily life of almost the entire population and most of health practitioners own one of them. Smartphones allow to download different applications to measure the ROM. However, there is a lack of studies evaluating the intra- and inter-rater reliability of two Smartphone applications from different operating systems. Thus, the aim of this study was to evaluate the intra- and inter-rater reliability of two Smartphone applications (Clinometer for Android and Measures for iOS) for the evaluation of passive hip ROM in asymptomatic patients. A cross-sectional study was conducted between September 2018 and April 2019. The Android application "Clinometer" and iOS application "Measures" were used to measure the hip ROM following a described protocol. 15 asymptomatic patients (30 hips) were assessed for internal rotation, external rotation, flexion and extension ROM by two independent examiners. The Intraclass Correlation Coefficient was used to calculate the intra- and inter-rater reliability. The results showed that both Smartphone applications, Clinometer and Measures, presented excellent intra-rater reliability for all the hip ROM measurements. The inter-rater values showed that both applications presented excellent inter-rater reliability except the Measures application for hip extension ROM. In conclusion, Clinometer and Measures are reliable tools for hip ROM assessment.

Keywords: Smartphone application, reliability, hip
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Introduction

Hip range of motion (ROM) is one of the main variables used by clinicians to assess the function of the hip joint. According to the normative values described for each joint, the hip ROM could classify the ROM as pathologic or physiologic.

Several pathologies such as hip osteoarthritis use the ROM variable to diagnose the pathology according to the clinical criteria described by the American College of Rheumatology. This fact could prevent unnecessary radiation and costs derived from the imaging tests. Also, ROM is commonly used to quantify the intra- and inter-session effects of a treatment [1].

For this reason, the tools that clinicians use to measure the hip ROM need to be reliable, to diagnose clinically several hip pathologies and to evaluate the effects of the intervention session to control the progression of the function of the patient.

The two arm-goniometer is still the most commonly used economical and portable device for the evaluation of the hip ROM. The universal goniometer has shown to be valid and an excellent intra-rater Intraclass Correlation Coefficient (ICC) for the measurement of hip ROM [2-5]. However, the universal goniometer presents several limitations: the examiner needs both hands

to measure hip ROM and specific training to control the starting position, the centre of rotation, the long axis of the limb and the true vertical and horizontal positions.

Nowadays, 97% of the Spanish population have Smartphones [6]. And a recent study has concluded that the majority of health practitioners own a Smartphone [7]. Smartphones allow clinicians to download different applications to assess the hip ROM. These apps are usually free, simple and accessible tools to assess the hip ROM. Therefore, they have to be reliable to avoid the risk of bias.

Some authors have used Smartphone applications to measure the ROM of different body parts such as the spine [8], shoulder [9] and ankle [10] in asymptomatic subjects. However, there is a lack of studies evaluating the reliability of two different Smartphone applications from different operating systems to assess the hip ROM in asymptomatic patients.

Therefore, the aim of this study was to evaluate the intra- and inter-rater reliability of two Smartphone applications (Clinometer for Android and Measures for iOS) for the evaluation of passive hip flexion, extension, internal rotation and external rotation ROM in asymptomatic participants.

Methods

Study design

A cross-sectional study was conducted between September 2018 and April 2019 in Soria, Spain. The Android application "Clinometer" and iOS application "Measures" were used to measure the hip ROM. For the study of both, inter- and intra-rater reliability, a descriptive correlational research was designed. Patients provided written and informed consent to participate in this study. The study was carried out according to STROBE guidelines [11].

Participants

Fifteen asymptomatic participants (30 hip joints) (53.3% male) with a mean age of 19.81(2.13), 1.74 (8.82) meters of height and 68.84 (17.22) kilograms of weight were recruited from the University of Valladolid.

The inclusion criteria were: asymptomatic hip ROM and age between 18 to 25 years.

The exclusion criteria were: hip pain, previous lower limb physiotherapy or medical treatment, neurological, vascular or musculoskeletal disorders in the hip joint or other regions, inability to understand the instructions and complete the study assessments.

Instruments

The protocol described by Pua et al. [12] was performed with both Smartphone applications. The measurements were taken following the same order: internal rotation, external rotation, flexion and extension. For each movement, the point was recorded when the examiner felt the firm or stiff end feel. The mean of 2 trials was recorded [12].

Smartphone applications

The smartphone applications used in this study were the Android application "Clinometer", a free application available for download from Google Play (http://play.google.com/store/apps), and the iOS application "Measures", a free and basic application of iPhone. Both Smartphones were positioned according to Pua et al. [12].

To measure hip internal and external ROM patients were in the sitting position with the hips and knees flexed at 90º. The Smartphone was placed along the fibula with the distal part positioned 5 cm proximal to the lateral malleolus to measure hip internal rotation, and along the tibia with the distal part positioned 5 cm proximal to the medial malleolus to measure hip external rotation.

To measure hip flexion ROM patients were in the supine position. The Smartphone was attached to a plastic strip and the movement was performed with knee flexion. The Smartphone was placed parallel to the femur between the great trochanter and the lateral femoral condyle. The measurement was stopped if the pelvis rotated dorsally.

To measure hip extension ROM patients were in the supine position and their hip joints positioned at the edge of the treatment table. Participants first flexed both hips and knees, and the hips were slowly extended by the examiner until the lumbar spine was flattened. The contralateral hip was held passively by the participants. The Smartphone was attached to a plastic strip and the movement was performed with knee flexion. The Smartphone was placed parallel to the femur between the great trochanter and the lateral femoral condyle. In this position, hip extension movement was stopped if the pelvis rotated ventrally.

Procedures for assessing reliability

Patients were assessed independently by two examiners. Examiner 1 was a physical therapy student and Examiner 2 was an experienced examiner with more than 7 years of clinical experience in orthopaedics. Examiner 1 performed the protocol with both Smartphone applications, whereas the other assistant recorded the measures to maintain blinding. When the examiner 1 had taken two measures of each movement, the examiner 2 performed the same protocol with both Smartphones for inter-rater reliability. Each hip joint was measured independently.

To assess intra-rater reliability, the examiner 1 assessed the entire protocol again with both Smartphones after a rest period of 30 minutes. No previous warm-up was carried out.

Sample size calculation

Based on two observations made on each subject a sample size of at least 18 hips was required to achieve statistical significance for an alpha-value set to be 0.05 and with a power more than 80.0%. However, due to the presence of high level of variability in the way the subjects would response to the mobility, we obtained 30 hips for the sample in order to offset the high level of variability found [13].

Statistical analysis

Statistical analysis was performed using SPSS 20.0 for Windows. The average value and the repeatability of each of ROM measurements were calculated prior to the reliability analysis.

Intra and inter-rater reliability were estimated with the intraclass correlation coefficient (ICC) and their 95% confidence intervals (CI). The interpretation of the ICC values following Fleiss et al. [15] included >0.75 = excellent, 0.75 – 0.40 = fair to good, and < 0.40 = poor.

95% CI was constructed around the estimated point to account for sample variation [14,15]. Standard error measurement (SEM) was calculated in relation to standard deviation (SD) of each measurement using the formula:

$$SEM = DT \times \sqrt{(1–ICC)}$$

SEM measures the accuracy of the score in repeated measures. A SEM < 7% is an indicator of reliability, > 12.5 % indicates poor reliability. Finally, the minimal detectable change (MDC) was calculated based on the formula:

$$MDC = 1.96 \times (\sqrt{2} \times SEM).$$

The MDC provides evidence regarding the smallest change between two measurements that could be considered statistically significant [16].

Results

Intra and Inter-rater reliability

In the ICC analysis, both Smartphone applications showed excellent intra-rater reliability in all movements with ICC values > 0.75 (range, 0.89-0.97). The SEM and MDC values for intra-rater reliability are shown in Table 1.

Table 1. Intra-rater reliability criteria with Smartphone applications

	Examiner 1, 1st measurement (mean ± SD)	Examiner 1, 2nd measurement (mean ± SD)	ICC	95% CI	SEM	MDC
Clinometer						
Internal rotation	32.97 (7.42)	32.50 (7.59)	0.97	0.93-0.98	2.21	4.33
External rotation	37.73 (5.25)	37.57 (5.77)	0.89	0.78-0.94	2.10	5.82
Flexion	102.83 (8.12)	102.97 (7.36)	0.92	0.84-0.96	2.44	6.75
Extension	11.97 (5.75)	11.50 (4.86)	0.87	0.76-0.85	2.30	6.36
Measures						
Internal rotation	32.40 (8.16)	32.43 (7.74)	0.97	0.93-0.98	1.14	3.16
External rotation	37.73 (5.23)	37.97 (5.23)	0.90	0.80-0.95	1.48	4.09
Flexion	102.87 (8.02)	103.23 (8.02)	0.95	0.90-0.97	3.21	8.87
Extension	11.07 (6.65)	10.77 (5.72)	0.90	0.81-0.95	3.52	9.72

Table 2. Inter-rater reliability criteria with Smartphone applications.

	Examiner 1, 1st measurement (mean ± SD)	Examiner 2, 1st measurement (mean ± SD)	ICC	95% CI	SEM	MDC
Clinometer						
Internal rotation	32.97 (7.42)	30.93 (7.36)	0.91	0.83-0.95	2.23	6.15
External rotation	37.73 (5.25)	36.87 (5.96)	0.84	0.69-0.92	2.10	5.80
Flexion	102.83 (8.12)	102.97 (7.36)	0.89	0.78-0.94	2.69	7.44
Extension	11.97 (5.75)	12.97 (7.36)	0.84	0.69-0.92	2.30	6.36
Measures						
Internal rotation	32.40 (8.16)	30.37 (7.19)	0.86	0.73-0.93	3.05	8.44
External rotation	37.73 (5.23)	36.57 (6.50)	0.92	0.66-0.91	1.48	4.09
Flexion	102.87 (8.02)	103.30 (7.82)	0.84	0.70-0.92	3.21	8.87
Extension	11.07 (6.65)	10.83 (7.82)	0.72	0.49-0.85	3.52	9.72

Inter-rater reliability showed excellent reliability in all movements for Android application "Clinometer" with ICC values > 0.75 (range 0.84-0.91). Inter-rater reliability showed excellent reliability for flexion, internal and external rotation for iOS application "Measures" with ICC values > 0.75 (range 84-92) and good reliability for extension ROM with ICC value = 0.72. Table 2 shows the results with the SEM and MDC for the measurements of the examiner 1 and the examiner 2.

Discussion

This is the first study to examine the intra- and inter-rater reliability of "Clinometer" and "Measures" applications for measuring the passive hip ROM in asymptomatic subjects according to the procedure described by Pua et al. [12].

Overall, previous studies have assessed the hip ROM with several instruments in asymptomatic subjects. The data obtained in this study for each hip movement are similar to the data presented by other authors [2,17].

Although a few studies were already performed on the validity of Smartphones for the measurements of hip ROM [2,17], no previous studies have assessed the intra- and inter-rater reliability of the Android application "Clinometer" and the iOS application "Measures" for the measurement of passive hip ROM in asymptomatic subjects.

Intra-rater reliability

The outcomes obtained in this study estimated excellent intra-rater reliability, showing that when the hip ROM is measured with the Smartphone by one examiner, similar results can be expected from one session to the next. This finding allows clinicians to control the changes after a treatment session.

To our knowledge, no study examining the intra-rater reliability of the "Clinometer" and "Measures" Smartphone applications for assessing the hip ROM in asymptomatic subjects has been published.

The ICC values obtained in this study (ICCs= 0.89-0.97; 95% CI: 0.76-0.98) were similar to other Smartphone applications in other joints in asymptomatic subjects [8,9,14,17-19]. A reproducible and accurate measurement method is essential for the assessment of ROM in joint mobility [20]. In people with or without hip pathology a reliable tool to assess the hip ROM is crucial. This variable is important for the diagnosis of different pathologies such as hip osteoarthritis [1,21] and for the control of the optimal hip ROM.

The SEM and MDC values achieved for intra-rater reliability for both applications (range, 1.14º-5.51º for SEM; 3.16º-9.72º for MDC). The hip extension ROM presents the highest MDC value when the measurement was performed with iOS application "Measures". The "Measures" application may be more accurate for assessing the hip flexion and extension ROM.

Inter-rater reliability

The outcomes obtained in this study demonstrated excellent inter-rater reliability for the "Clinometer" application and excellent inter-rater reliability for the "Measures" application for hip flexion, internal and external rotation and good reliability for extension ROM. These results showed that when the hip ROM is measured with the "Clinometer" Smartphone application by two different examiners, similar results can be expected. Moreover, the, same results can be expected with the "Measures" application, but clinicians should pay special attention in hip extension movement.

To our knowledge, no previous studies have evaluated the inter-rater reliability of the Smartphone applications in asymptomatic subjects.

In the ICC values obtained for both Smartphone applications showed excellent inter-rater reliability (ICCs= 0.84-0.92; 95%CI: 0.69-0.95), except for hip extension measured by the "Measures" application (ICC= 0.72; 95%CI: 0.49-0.85). Previous studies assessing the inter-rater reliability of Smartphone applications in other joints have demonstrated similar results [8,9,18], and other authors have reported worse results in asymptomatic population [14,19].

The results of SEM and MDC analyses for inter-rater reliability of both Smartphone applications ranged from 1.48 to 3.52 for SEM and from 4.09 to 9.72 for MDC. To our knowledge, no studies have assessed the inter-rater reliability of the Pua et al. [12] protocol in asymptomatic patients. For this reason, the comparison of the results becomes complex. The "Clinometer" application presented lower values for SEM and MDC compared to the "Measures" application for all the hip movements except for external rotation.

The main issue of this study is to determine whether a single therapist can measure the mobility of the hip without the help of another therapist. A reliable tool allows clinicians to diagnose and

to control the evolution of the patient without economical cost and large appliances. The results of this study confirm that the Android application "Clinometer" and iOS application "Measures" can be used for hip ROM measurements in asymptomatic population by different examiners and by the same examiner following the Pua et al. [12] protocol.

There are limitations to consider in this study. Although we measured hip movements in different planes, the abduction and adduction movements were not measured. Another limitation is the lack of between-day reliability data. It is well known that outcomes of the studies in which repeated tests are performed at short time intervals can markedly differ from those obtained in the studies in which tests are performed at longer time intervals. Moreover,, no concurrent validity has been assessed.

Conclusion

The results of the current study have shown that two Smartphone applications, "Clinometer" and "Measures", presented excellent intra-rater reliability for the measurement of internal rotation, external rotation, flexion and extension hip ROM in asymptomatic participants. The "Clinometer" application demonstrated an excellent inter-rater reliability for all the measurements and the "Measures" application showed an excellent inter-rater reliability for all the measurements except for hip extension ROM.

References

1. Altman R, Alarcón G, Appelrouth D, Bloch D, Borenstein D, Brandt K, et al. The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip. Arthritis Rheum. 1991 May;34(5):505–14.
2. Roach S, Suprak DN, Lyda M, Roach S, St O. Concurrent validity of digital inclinometer and universal goniometer in assessing passive hip mobility in healthy subjects. Int J Sports Phys Ther. 2013;8(5):680–8.
3. Nussbaumer S, Leunig M, Glatthorn JF, Stauffacher S, Gerber H, Maffiuletti NA. Validity and test-retest reliability of manual goniometers for measuring passive hip range of motion in femoroacetabular impingement patients. BMC Musculoskelet Disord. 2010;11.
4. Sprigle S, Flinn N, Wootten M, McCorry S. Development and testing of a pelvic goniometer designed to measure pelvic tilt and hip flexion. Clin Biomech. 2003;18(5):462–5.
5. Gajdosik RL, Bohannon RW. Clinical measurement of range of motion. Review of goniometry emphasizing reliability and validity. Phys Ther [Internet]. 1987;67(12):1867–72. Available from: https://pdfs.semanticscholar.org/9dc7/67d20fcb87936b350f1ec9f591a026aaf0f4.pdf
6. (INE) IN de E. Encuesta sobre Equipamiento y Uso de Tecnologías de Información y Comunicación en los Hogares. 2018; Available from: https://www.ine.es/prensa/tich_2018.pdf
7. Franko OI, Tirrell TF. Smartphone app use among medical providers in ACGME training programs. J Med Syst. 2012;36(5):3135–9.
8. Jacquot F, Charpentier A, Khelifi S, Gastambide D, Rigal R, Sautet A. Measuring the cobb angle with the iphone in kyphoses: A reliability study. Int Orthop. 2012;36(8):1655–60.
9. Shin SH, Ro DH, Lee OS, Oh JH, Kim SH. Within-day reliability of shoulder range of motion measurement with a smartphone. Man Ther [Internet]. 2012;17(4):298–304. Available from: http://dx.doi.org/10.1016/j.math.2012.02.010
10. Williams CM, Caserta AJ, Haines TP. The TiltMeter app is a novel and accurate measurement tool for the weight bearing lunge test. J Sci Med Sport. 2013;16(5):392–5.
11. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ. 2007 Oct;335(7624):806–8.
12. Pua YH, Wrigley TW, Cowan SM, Bennell KL. Intrarater Test-Retest Reliability of Hip Range of Motion and Hip Muscle Strength Measurements in Persons With Hip Osteoarthritis. Arch Phys Med Rehabil. 2008;89(6):1146–54.
13. Walter SD, Eliasziw M, Donner A. Sample size and optimal designs for reliability studies. Stat Med. 1998 Jan 15;17(1):101–10.

14. Tousignant-Laflamme Y, Boutin N, Dion AM, Vallée C-A. Reliability and criterion validity of two applications of the iPhone™ to measure cervical range of motion in healthy participants [Internet]. Vol. 10, Journal of NeuroEngineering and Rehabilitation. 2013. Available from: http://www.plaincode.com/products

15. Fleiss JL. The Design and Analysis of Clinical Experiments [Internet]. Hoboken, NJ, USA: John Wiley & Sons, Inc.; 1999 [cited 2018 May 29]. Available from: http://doi.wiley.com/10.1002/9781118032923

16. de Bruin ED, Rozendal RH, Stüssi E. Reliability of phase-velocity measurements of tibial bone. Phys Ther. 1998 Nov;78(11):1166–74.

17. Charlton PC, Mentiplay BF, Pua YH, Clark RA. Reliability and concurrent validity of a Smartphone, bubble inclinometer and motion analysis system for measurement of hip joint range of motion. J Sci Med Sport [Internet]. 2015;18(3):262–7. Available from: http://dx.doi.org/10.1016/j.jsams.2014.04.008

18. Ferriero G, Vercelli S, Sartorio F, Muñoz Lasa S, Ilieva E, Brigatti E, et al. Reliability of a smartphone-based goniometer for knee joint goniometry. Int J Rehabil Res. 2013;36(2):146–51.

19. Vohralik SL, Bowen AR, Burns J, Hiller CE, Nightingale EJ. Reliability and validity of a smartphone app to measure joint range. Am J Phys Med Rehabil. 2015;94(4):325–30.

20. Cleffken B, van Breukelen G, Brink P, van Mameren H, Damink SO. Digital goniometric measurement of knee joint motion. Evaluation of usefulness for research settings and clinical practice. Knee. 2007 Oct;14(5):385–9.

21. Cibulka MT, Bloom NJ, Enseki KR, Macdonald CW, Woehrle J, McDonough CM. Hip Pain and Mobility Deficits-Hip Osteoarthritis: Revision 2017. J Orthop Sport Phys Ther. 2017;47(6):A1–37.

Corresponding author:

Luis Ceballos-Laita. Luis.ceballos@uva.es