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ARTIGO ORIGINAL

Reliability of two evaluation methods of active range of motion in the ankle of healthy individuals

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ABSTRACT

The measurement of the range of motion is an important parameter used in physical therapy evaluation and follow up. Thus, the reliability this measurements as well as instruments utilized to this purpose to need be evaluated. Objective: to evaluate and compare the intra-tester and inter-tester reliability of the range of motion measure (ROM) of active ankle dorsiflexion utilizing a universal goniometer and a digital inclinometer. Methods: Two students evaluated the range of dorsiflexion of the 28 volunteers with aged between 18 and 30 years utilized a digital inclinometer and a universal goniometer. Results: The results displayed mean and standard deviation the range of motion the 18.1±3.1 e 18.6±3.8 degrees to the measures obtained for the goniometry and inclinometer, respectability. The intraclass coefficient (ICC) obtained to the intra-session condition to the measures with the inclinometer was the 0.91 to 0.97 for the examiners A and B, respectively. ICC for the goniometry was the 0.91 and 0.97 to the examiners A and B, respectively. The inter-session condition demonstrated moderate reliability to the measures of the goniometry and adequate reliability to the inclinometer measurements. However, the inter-examiners reliability was moderate to the measures of the goniometry and high for measures with the inclinometer. Conclusion: The results of this study demonstrated the big reliability to the measures of the digital inclinometer when compared with universal goniometry, principle when the inter-examiner was evaluated.

KEY-WORDS

goniometry, range of motion, ankle, reliability, joint physiology

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Introduction

The measurement of the range of motion (ROM) is an important parameter used in physical therapy evaluation and follow-up. Many times, the ROM evaluation is part of the definition of propedeutics and prognosis in an individual undergoing physical therapy[1].

The ankle joint is the most compromised one in the musculoskeletal system. The main dysfunction affecting this joint is the lateral ankle sprain, which affects one in 10,000 per day, and corresponds to 80% of all ankle joint dysfunctions[2]. The limitation of ROM dorsiflexion is one of the parameters utilized in the evaluation and evolution of the physical therapy approach in this dysfunction.

Range of movement (ROM) varies from individual to individual according to age, gender, physical activity practice, presence or absence of dysfunction and the degree of muscular strength when the individual undergoes the active ROM evaluation[3].

Additionally, the instrument used and the methodology standardization are important sources of error to be controlled in order to provide a reliable measurement[3,4]. There is no consensus in literature regarding the measurement standardization of some joints[5]. The position at the test, the measurement procedure, and the anatomical points of reference, vary from study to study for the same joint[6].

Regarding the instruments used in the evaluation of the measurement of joint ROM, the goniometer[1,7,8], the electrogoniometer [9], the inclinometer[10,11] and the fleximeter1 can be cited. Some of these instruments have been broadly utilized in physical therapy clinics, especially the goniometer[12].

The goniometer is the most commonly used instrument in clinical practice[5,13]. Goniometry depends on the points of reference utilized as standards for positioning the arms of the goniometer and that varies according to the tested joint[6,14]. Despite its advantages regarding its use and low cost, this measurement presents a limitation concerning its use by different examiners, which impairs its reproducibility in this condition[3].

On the other hand, the digital inclinometer is a useful, easy-to-use instrument, but it is not widely known among physical therapy professinals[6]. Additionally, it is a more expensive instrument when compared to the universal goniometer. The digital inclinometer is easy to be used by the examiner and does not depend on the anatomical references utilized in goniometry[6].

Reliability is the calculation of a measurement error, that is, how much the obtained value varies in relation to the real value. Therefore, it demonstrates the uniformity of the measurements obtained with the use of an instrument or by an examiner under the same evaluation conditions[1]. The variation of error obtained under such conditions is called systematic error. A highly reliable measurement is used to determine the existence of a joint ROM limitation, to assess the progress of a patient regarding his or her functional recovery and the effectiveness of the therapeutic intervention[1].

Thus, the reliability of a measurement is essential to warrant data uniformity, allowing these data to be used in scientific research and the evolution of physical therapy treatments. The response variability obtained by one or by different examiners needs to be controlled according to the reliability assessment of different instruments[11,15,16]. Rothstein classifies the different types of reliability as intra-examiner and interexaminer[8]. The intra-examiner reliability is usually higher than the interexaminer one, as it is easier to reproduce the procedures when a single examiner is carrying them out[17].

Objectives

To evaluate and compare the intra and inter-examiner reliability of the ROM measurement of active ankle dorsiflexion using a universal goniometer and a digital inclinometer.

Material and methods

The present study was developed at the Physical Therapy Clinic of the Pontificia Universidade Catolica (PUC), Minas/Betim. The research project was previously approved by the Ethics Review Board of the Institution and all volunteers signed an informed consent form.

Sample

Twenty-eight healthy volunteers of both sexes, aged 18 to 30 years, who were students at the Physical Therapy Course of PUC-Minas/Betim, were enrolled in the study. Exclusion criteria included the presence of musculoskeletal signs and symptoms in the lower members at the moment of evaluation, a history of previous disease and surgeries of the foot/ankle complex.

Instruments

CARCI® 35-cm universal goniometer: The universal goniometer was used to evaluate the active ankle dorsiflexion ROM, according to the methodology proposed by Winter[11] and Norkin and White[16]. The points of reference used were the median line of the fixed arm of the goniometer on the line of the fibula and the external line of the movable arm positioned on the head of the fifth metatarsal. After the fixation of the arms of the goniometer, the fulcrum secondarily positioned on the inframalleolar region, so that the movable arm remained parallel to the fifth metatarsal line according to the reference points used by Johnson and Gross, 1997[6].

Baseline® Digital Inclinometer: It was also used to register the ROM measurement of active ankle dorsiflexion. It is a 15.5 long x 3 cm wide x 5 cm high instrument, which has a digital screen and two touch buttons that activate the commands: zero, start and establish the final point for the examiner's reading. It depends on gravity to function, through a sensor that can measure the movement angulation in degrees.

Procedure

Before starting data collection, a pilot study was carried out with 5 individuals, always with the same examiners, to measure the active dorsiflexion ROM of both ankles using a universal goniometer and a digital inclinometer. Initially, two examiners who

were 4th-year Physical Therapy students were trained in the use of the instruments and procedures of measurement. A third examiner was trained to record the data.

The goniometer measurements were always carried out before the inclinometer measurements, to prevent possible influences of instrument reading during its use. The forms used by both examiners were separate ones, thus not allowing the comparison of previously taken measurements.

Subsequently, the first examiner measured the ROM of active ankle dorsiflexion, using the universal goniometer. In order to do so, the volunteer was positioned in ventral decubitus, with the lower limb at 90o of knee flexion according to Norkin and White16. The previously mentioned anatomical points of reference were drawn with a dermographic pencil. Next, the universal goniometer was positioned and then the volunteer was asked to perform the movement of active ankle dorsiflexion, while the examiner observed the movement until the final ROM was achieved. The ROM reading was performed at the end of the ROM and a third examiner was in charge of recording the data. After the measurement was carried out by one examiner (A or B), the marks on the anatomical references were erased and then the other examiner repeated the same procedures, as shown in Figure 1.

Next, one of the examiners positioned the volunteer in ventral decubitus, with the knee joint at 90º, as in the goniometry procedure. After calibrating and zeroing the inclinometer, the examiner positioned the instrument on the plantar fascia, close to the volunteer's calcaneus. The ankle was positioned at zero degree of dorsiflexion indicated in the screen of the inclinometer and the examiner pressed the start button of the instrument. The volunteer was asked to perform the dorsiflexion movement actively, while the examiner observed the movement, according to Figure 2. At the end of the movement, the examiner pressed the button to establish the reading of the inclinometer, which was then carried out by the third examiner. Next, the second examiner carried out the same measurement procedures. As in the goniometer measurements, the lower limb was kept at 90º of knee flexion and the measurements were carried out from 0º of ankle dorsiflexion. The kept position was actively maintained by the volunteer, with no external help or instrument that would guarantee the maintenance of the position.

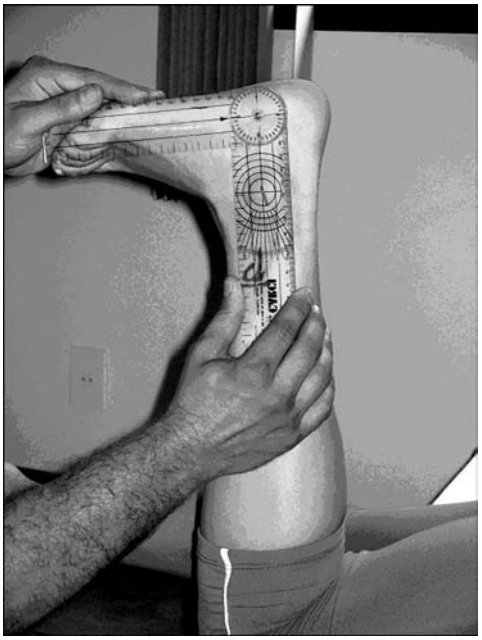

Figure 1
Measurement of active ankle dorsiflexion ROM using a universal goniometer.

The measurements were carried out randomly by examiner A and B, who did not have access to the results. The procedures were repeated by the examiners for three consecutive times, for both the inclinometer and the universal goniometer measurements, in each ankle. The verbal command used to ask the volunteer to perform the active dorsiflexion movement of the ankle was standardized by both examiners.

After 48 hours, the same procedures performed on the first day of data collection were repeated, to evaluate the reliability between the sessions. The volunteers were requested not to perform physical activities during the study period. The examiners had no access to the data records until data collection was finished.

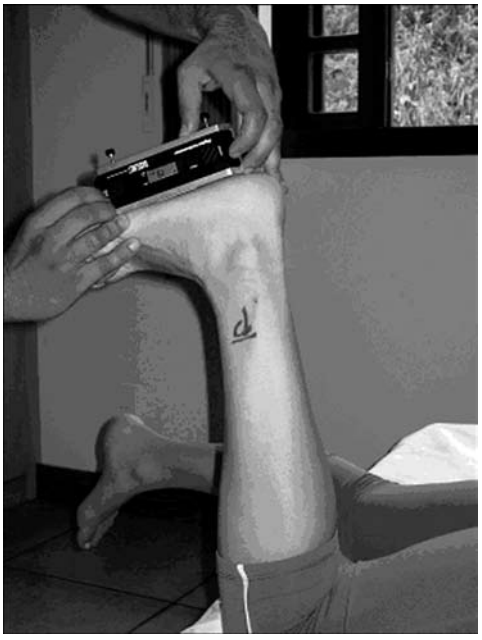

Figure 2
Measurement of the dorsiflexion ROM using a digital inclinometer.

After he descriptive analysis of the data, the reliability of the dorsiflexion ROM was determined by the calculation of the Intraclass Correlation Coefficient (ICC). The paired t test and the independent t test were used to evaluate the stability of the means between the sessions and between the examiners, respectively. Statistical significance level was set at $p< 0.05$.

Statistical analysis was carried out with SPSS (Statistical Package for Social Science) software, version 10.1. In the present study, ICC values were considered low when ICC was < 0.50, moderate when it was between 0.50 and 0.75, high when ICC > 0.75 and very high when ICC>0.90, according to Portney and Watkins (2000)[1].

Results

The results of the present study showed mean ± SD values of 18.1±3.1 and 18.6±3.8 degrees for the goniometry and inclinometry, respectively. The results of the intra-session reliability study for the goniometry and inclinometry measurements showed high reliability for examiner A as well as for examiner B. The ICC was 0.91 and 0.83 for the inclinometer measurements regarding examiners A and B, respectively. The ICC for the goniometry measurements was 0.91 and 0.97 for examiners A and B, respectively.

The reliability between sessions of goniometry measurements varied according to the examiner, as shown in Table 1.

Table 1
Reliability between sessions of the dorsiflexion ROM measurements obtained with the goniometer and the inclinometer.

	ROM 1	ROM 2	p	ICC (CI)
Examiner A (G)	18,1 ±3,1	20,4 ± 3,6	0,00	0,65 (0,68 – 0,84)
Examiner A (I)	18,6 ±3,7	19,6 ± 3,8	0,009	0,84 (0,71 – 0,91)
Examiner B (G)	16,6 ±3,6	18,5 ±3,7	0,00	0,77 (0,38 – 0,87)
Examiner B (I)	18,8 ±4,8	19,8 ±4,1	0,022	0,95 (0,92 – 0,97)

* goniometer (G) and inclinometer (I); ROM 1 (range of movement on the first day of data collection); ROM 2 (range of movement on the second day of data collection); ICC (CI): intraclass correlation coefficient and confidence interval.

The interexaminer reliability results of the dorsiflexion ROM measurements using the universal goniometer was 0.72, indicating moderate reliability. The reliability of the same measurement using the digital inclinometer was high, with an ICC of 0.83, according to the results shown in Table 2.

Table 2
Interexaminer reliability of the dorsiflexion ROM measurements obtained with the goniometer and inclinometer.

	ROM Examiner A	ROM Examiner B	p	ICC (CI)
Goniometer	18,1 ± 3,1	16,6 ± 3,6	0,020	0,72 (0,47 –0,85)
Inclinometer	18,6 ±3,7	18,8±4,8	0,868	0,83 (0,70 – 0,90)

* Interexaminer condition. ROM Examiner A / B (Measurement of ROM evaluated by examiner A / B).

Discussion

The results of the present study showed high intra-session reliability for ankle dorsiflexion measurements performed by both examiners with the goniometer as well as with the digital inclinometer. These results are in accordance with Johnson and Gross (1997), who also found high intra-session reliability for the dorsiflexion ROM measurement6. These authors evaluated the individuals with a universal goniometer, using a similar methodology, but with the knee in extension, whereas in the present study, the knee was kept at 90º of flexion[16].

The intersession reliability was evaluated within a 48-hour interval between the tests. The results of the present study showed that the reliability found for the measurement carried out with the goniometer was moderate and high, for examiners A and B, respectively. Regarding the measurements performed with the inclinometer, the results showed high reliability for both examiners. This is possibly due to the fact that the digital inclinometer is easy to handle and use and that the examiner does not depend on the anatomical references of the ankle to perform the measurement, as it happens with the universal goniometer.

On the other hand, when the variability of the means of the measurements performed on the two testing days was analyzed, we found a variation of measurement error obtained by the two examiners, with a 48-hours interval between the measurements.

The evaluation of concordance of the two measurements obtained by different examiners is an important variable in some clinical scenarios, where different therapists evaluate and re-evaluate a same patient at different moments. Rodrigues *et al*. reported that the measurements must always be registered by the same person, who must have been previously trained, in order to maintain the standardization and allow less variability of the obtained measurements[9].

The present study showed moderate reliability regarding the interexaminer condition for the measurements obtained with the goniometer and high reliability for those obtained with the digital inclinometer. Hence, these results suggest that the digital inclinometer presents a higher interexaminer reliability when compared to the goniometer, which must be taken into account in the clinical practice at physical therapy centers or in clinical scenarios that engage the work of several physical therapists in patients' evaluation and follow-up.

The results of the present study are in accordance with Youdas et al., who evaluated the intra-examiner and interexaminer reliability of the active dorsiflexion ROM of the ankle using a universal goniometer. These authors demonstrated that there is a considerable measurement error when two or more examiners repeat the goniometer measurement of the dorsiflexion ROM of the ankle in the same volunteer[18]. In the present study, a measurement error variation was also demonstrated by the statistically significant difference between the means of the goniometer measurements for both examiners. On the other hand, no statistically significant difference was found between the means of the measurements obtained by both examiners with the digital inclinometer. The results support the high ICC found in this analysis, indicating good stability of the measurements obtained by both examiners with the digital inclinometer.

In the present study, both examiners were inexperienced and underwent only two weeks of training. WE know that the reliability of the measurements depends on the examiner and his or her experience[1,10]; however, the duration of training possibly had a positive interference in the results obtained.

We can also observe that the reliability of the digital inclinometer showed a higher reliability rate for the measurements of the active dorsiflexion ROM of the ankle when compared to the goniometer. These results can be due to the easier handling and positioning of the digital inclinometer, which does not need a standardization of the anatomical references[12,13,19]. Possible errors

caused by the inadequate positioning of the digital inclinometer were minimized by the standardization of its positioning on the plantar fascia from the calcaneus, which was kept throughout data collection. In addition, it is an easy-to-handle instrument and the obtained ROM is easy to be read.

There is a great variability among the studies in literature that assessed the measurement of the active dorsiflexion ROM of the ankle, but there is no consensus regarding the methodology utilized, especially concerning the points of reference used for the positioning of the universal goniometer and the standardization of the movement[3,6,7,8,10].

A measurement cannot be considered significant if it is not valid or reliable[6,10,16]. In the clinical scenario, the patients can be evaluated several times, and sometimes even by different therapists. Thus, the reliability of the examiner is extremely important to allow data uniformity throughout the outcome of the proposed therapy. Therefore, according to the results obtained in the present study, one can infer that it is recommended that the same examiner performs the patients' goniometry measurement in the beginning, during and at the end of the treatment, which is in accordance with Portney and Watkins1 and Winter *et al*[11]. Additionally, the digital inclinometer can be utilized by different examiners throughout the follow-up of patients with foot and ankle complex disorders.

One of the improvement parameters of dysfunctions such as lateral sprains or trauma sequelae such as in fractures is the evaluation and follow-up of the ankle dorsiflexion ROM evolution. Therefore, the use of the reliable and easy-to-handle instruments such as the goniometer and the inclinometer can allow the daily assessment of these patients' evolution, and especially, verify the efficacy of the procedures on dorsiflexion ROM[3,16].

Although the inclinometer and the goniometer are instruments used to measure ROM, they should not be used randomly, as different instruments can generate different results, which does not allow comparisons between the measurements[16,20,21]. The digital inclinometer is still underused in the physical therapy clinic. This is possibly due to its higher cost when compared to the universal goniometer and the lack of information on the instrument. In addition, the literature is scarce regarding studies that establish its reliability and thus indicate its use in clinical practice.

Conclusion

The present study demonstrated that the measurement of the active dorsiflexion ROM of the ankle using the digital inclinometer was more reliable when compared to the one obtained with the universal goniometer. The intra-session reliability was high for the measurements obtained with both instruments, whereas the interexaminer reliability was moderate and high for the measurements obtained with the universal goniometer and digital inclinometer, respectively. Additionally, the intersession reliability was high, for the measurements obtained with the digital inclinometer and moderate for those obtained with the universal goniometer.

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