INTRA AND INTER EXAMINER RELIABILITY AND MEASUREMENT ERROR OF GONIOMETER AND DIGITAL INCLINOMETER USE

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ABSTRACT

Introduction: Articular range of motion (ROM) is one of the important components measured during physical assessment. Goniometry is employed to measure and to register ROM available in a joint; however, it is necessary that it supplies reliable and standardized measures. Objectives: To verify theinter and intra-examiners reliability of the measures performed by the goniometer and inclinometer in the knee and elbow flexion and extension ROM and to determine the measurement standard error (MSE) of the instruments in question. Methods: The knee and elbow flexion and extension ROM was evaluated in a sample of healthy young males aged between 18-30 years, using a digital inclinometer and a universal goniometer. Results: The interexaminer reliability ranged from small to very high for both instruments presenting ICC of 0.24 to 0.96 for the measures performed with the goniometer and of 0.02 to 0.98 for the inclinometer. The only movement which presented very high reliability for both products and examiners was the knee flexion. The MSE performed with the goniometry and the inclinometry ranged between 0.21 and 12.75 degrees. Conclusion: The present study presented higher reliability for ROM measures obtained with the digital inclinometer when compared with the goniometer. Only four measurements were considered appropriate to be clinically used: those which obtained high ICC and SEM below two degrees, all of these were made with the inclinometer.

Keywords: test reproducibility, goniometry, range of motion.

INTRODUCTION

Measurement of range of motion is a crucial parameter used in the physiotherapeutic evaluation and follow-up. Many times the range of motion evaluation is part of the propedeutics and prognostics definition of an individual submitted to physiotherapy [1,2]. The articular range of motion (ROM) is defined as the "angle dimension of the body dislocation or its segments between certain points of conventionally chosen orientation"[3]. There are many valid instruments for ROM measurement, among which the most widely used is the universal goniometer, but other instruments can be used, as the digital inclinometer, an electronic device for angle measurement[4,5].

A measurement method must provide reliable and standardized measurements to be used. According to Dvir[6], the reliability of a measurement is the consistence among the successive measurements of the same variable, in the same subject and in the same conditions. The goniometer is a device of articular angle measurement which presents reliability for plane measurements of the movement already described in the literature[7], being considered gold standard in ROM measurement. Validity and reliability of the digital inclinometer use in ROM measurement has already been described as well through its intraclass correlation coefficients (ICC)[8] and can hence be theoretically applied in practice.

The reliability studies of continuous measurements are traditionally evaluated by the ICC. The ICC despite being spread and allowing the reliability comparison between different instruments is incomplete and prone to measurement variations in distinct samples, since it considers the measurement by the sample variance. Thus, the same instrument used intwo populations will present different ICC depending on the variance of each sample[9].

As a way of complementing the ICC, it is important that reliability studies assess the values dispersion of the measurements in the same unit of the instrument, since this way, an absolute value of the variation of the same measurement, and not an accuracy percentage is obtained. In other words, in the case of the ROM, to analyze of how many degrees is the variance of the repeated measurements; hence it is possible to determine if during the treatment a real clinical alteration has occurred in one individual. The dispersion of repeated measurements given in degrees can be obtained by the measurement standard error (MSE)[9,10].

Thus, the aims of the present study were to verify theinter and intraexaminer reliability through the ICC and MSE, the measurements performed by the goniometer and inclinometer in the knee and elbow flexion and extension ROM.

METHODS

Study outlining and sample

A methodological study of measures reliability was developed in the School Clinic of the Newton Paiva University Center. The study was developed after approval by the Ethics in Research Committee

of the Newton Paiva University Center(100/2008) andall participants signed a Free and Clarified Consent Form agreeing on participating in the study. The sample was selected by convenience. 10 male volunteers, aged between 18 and 30 years, healthy and sedentary were recruited. The exclusion criteria were pain or any muscle skeletal or neurological disorder in the last six months which affected the joints selected in the present study.

Instruments

Goniometer

The ROM measurements were taken in a passive manner with a universal goniometer (Baseline®, Aurora, IL, USA). In order to measure the ROM with the goniometer, the joint should be positioned and the proximal segment stabilized, isolating hence the articular movement evaluated. The goniometer handles are aligned with the proximal and distal segments of the joint having bone anatomic references close to the joint as a starting point[11,12].

Digital Inclinometer

A digital inclinometer brand name Baseline® Digital Inclinometer was used. The digital inclinometer is an engineering instrument to measure surface inclination (in degrees) after it has been taken by sensors sensitive to gravity. One of the advantage of the digital inclinometer in the ROM measurement is that its positioning does not depend this much on anatomic references; however, it is an instrument little used in the clinic due to, among other reasons, its higher cost when compared to the goniometer[13,14].

Procedures

The measurements were used by two examiners at the same evaluation conditions. Prior to the data collection, a pilot study was conducted to standardize the research procedures. The measurement procedures for each individual were drawn by the evaluators to randomize them. A five-minute interval was given between the measurement performance of the two evaluators.

A seven-day interval between the two tests of each examiner was given to evaluate the intra-examiner reliability. A third examiner was in charge of the information record in independent forms to avoid comparison between data during the collection.

The volunteers were told not to perform warm-up or any physical activity 48 hours before the time for the collection to avoid viscoelastic adaptation of the muscles involved in the study. All preparation procedures of the volunteers and measurement randomization were repeated, following the same criteria, at the second moment.

Elbow flexion ROM measurement

The test positioning and stabilization were the same for the two instruments. The individual under testing was on dorsal decubitus, with arm positioned along the body and with forearm supination. The humerus was distally stabilized by the examiner's hand, according to description by Norkinand White[3], to avoid shoulder flexion.

The goniometer axis was positioned next to the humerus lateral epicondyle.The static handle of the goniometer was aligned with the humerus, having the acromion center on the shoulder as reference and the mobile handle was aligned with the forearm, using the styloid process of the radius as reference. The digital inclinometer was placed on the forearm proximal and posterior segment[3].

Elbow extension ROM measurement

The measurements were taken with the patient at sitting position, with back and head aligned and arm positioned along the body with forearm supination. The shoulder was manually stabilized in its proximal region, avoiding undesirable movements such as rotations and abductions[3].

Knee flexion ROM measurement

The individual was placed at dorsal decubitus, with 90 degrees of hip flexion. Hip positioning was guaranteed by the use of a thigh device which aided in the maintenance of the pre-set position[3].

The universal goniometer was placed next to the femoral lateral epicondyle.The static handle of the goniometer was aligned with the thigh, having the femoral major trochanter as reference and the mobile handle aligned with the leg, with reference in the fibula lateral malleolus. The digital inclinometer was placed proximal and anteriorly on the leg, resting on the tibial crest[3].

Knee extension ROM measurement

The individual was at dorsal decubitus, with extended legs. The evaluated limb was raised by the heel, with knee stabilization in contact with the stretcher. The instruments positioning in relation to the segment was the same of the measurements performed for knee flexion[3].

STATISTICS ANALYSIS

After data descriptive analysis, the reliability of the measurements was set through the calculation of the intraclass correlation coefficient (ICC) with the statistical program SPSS for Windows version 17.0 and from the ICC the measurement standard error (MSE) was set. The reference values for the ICC in the present study were those described by Jonhson and Gross[23], being considered small reliability until 0.25; low, 0.26-0.49; moderate, 0.50-0.69; high, 0.70-0.89; and very high, above 0.90. An arbitrary value of 2º was chosen so that the MSE value was considered suitable.This value was based on the minimum amplitude of the values set in a standard goniometer. The ROM measurements appropriate for clinical use were those which presented high ICC (above moderate) and low MSE (below 2º) at the same time.

RESULTS

Three individuals were excluded from the study because they missed the second day of the research and in one individual were taken only the elbow measurements due to presence of patellar tendinopathy (figure 1).Thus, 14 elbows and 12 knees were assessed, being performed for each instrument a total of 28 and 24 measurements, respectively (considering both sides independently) in each moment of the research.

The present study evaluated the reliability of the intra and inter examiner measurements and the MSE of elbow and knee flexion and extension and obtained distinct results depending on the movement, examiner and instrument (table 1).

Table 1. Alterations in the translation phase.

Joint	Moviment	Intra examiner Evaluator 1				Intra examiner Evaluator 2				Inter examiner			
		Goniometry		Inclinometry		Goniometry		Inclinometry		Goniometry		Inclinometry	
		ICC	MSE (degrees)	ICC	MSE (degrees)	ICC	MSE (degrees)	ICC	MSE (degrees)	ICC	MSE (degrees)	ICC	MSE (degrees)
Elbow	Flexion	0.06	3.20	0.87*	2.18	0.69*	2.60	0.59*	3.69	0.52*	2.76	0.70*	3.18
	Extension	0.01	0.98⸸	0.84*	0.42⸸	0.29	0.70⸸	0.22	0.41⸸	0.24	0.78⸸	0.02	0.82⸸
Knee	Flexion	0.95*	4.65	0.97*	3.99	0.91*	4.30	0.98*	12.75	0.96*	2.96	0.98*	3.21
	Extension	0.49	0.87⸸	0.89*	0.46⸸	0.46	0.72⸸	0.70*	0.21⸸	0.55*	0.76⸸	0.69*	0.79⸸

G=Goniometry; I=Inclinometry; ICC=Intraclass correlation coefficient; MSE=Mean standard error; *=ICC from moderate to very high ; ⸸=MSEup to 2º.
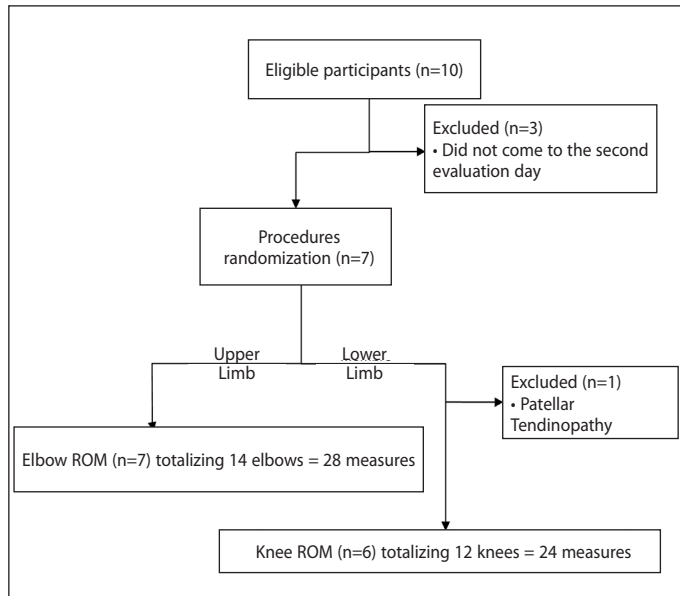

Figure 1 – Flow chart of the placement process of the individuals for analysis.

DISCUSSION

This study was performed with the aim to verify the reliability of the elbow and knee ROM measurements obtained with the instruments used in clinical practice, the goniometer and digital inclinometer, as well as determine the measurement standard error of the instruments.

The results demonstrated great variability in the reliability indices, with the intra examiner reliability from evaluator 1 ranging between small and very high and between low and very high from evaluator 2 for the goniometer measurements. Previous studies presented distinct data for intra examiner reliability using goniometry. Brosseauet al.[15] found ICC of 0.99 for knee flexion and 0.97 for knee extension. The data by Watkins et al.[16] corroborate the findings from this previous study, since very high reliability levels have been verified for the knee ROM measurements (ICC> 0.90). Rothstein et al.[17], when evaluated the intra examiner reliability of the knee and elbow movements also obtained very high ICC (> 0.91).

The lower reliability values obtained in the present study, compared to data in the literature, can be attributed to the difficulty in handling the instrument as well as identifying the reference anatomic points. The error of some millimeters in the determination of an anatomic point may compromise the angle values obtained as well as any undesirable movement during its use[18,19]. Before the data collection, a pilot study was conducted with the evaluators involved in the study. However, the measures reproducibility with

the goniometer may have been partly affected by the lack of experience and ability of the evaluators here. The use of goniometry, as traditionally done in the clinic, is also prone to these factors.Thus, before a clinical use of the goniometer, a reliability test should be performed with the professional who uses it. Such measurement property should not be considered intrinsic to the instrument and this fact can contaminate all the data for good when not observed.

Concerning the measurements taken with the inclinometer, the ICC found ranged between 0.84 and 0.97 for evaluator 1 and between 0.22 and 0.98 for evaluator 2. The inclinometry had a tendency to present higher ICC values than the goniometry, except for elbow flexion and extension measurements of examiner 2. Thus, it can be stated that the inclinometer was more reliable in the majority of the measurements taken. It is believed that these results are due to the easiness of the inclinometer use as well as lack of need of anatomic references to be aligned with the segments to be evaluated.

Similar results with inclinometer reliability values higher than in the goniometer were also observed by Venturiniet al.[13]. They found high reliability for the digital inclinometer when evaluating the ankle dorsiflexion ROM. These findings agree with the data by Kolberet al.[20], who also reported high ICC levels using the digital inclinometer for shoulder movements.

The interexaminer reliability ranged from small to very high for the two instruments, presenting ICC from 0.24 to 0.96 for measurements taken with the goniometer, and from 0.02 to 0.98 for the inclinometer. The interexaminer measurements with small reliability were the elbow extension measurements, moderate for the knee extension measurements and the elbow flexion with goniometer, high for elbow flexion measurement with inclinometer and very high for all knee flexion measurements. Many authors report that the intraexaminerreliability presents higher values than interexaminer reliability[16,21]. The findings of the present study partially agree with the data from the literature, since even in the inter examiner evaluation of the present study it was possible to observe expressive results.

Thus, considering all the previous information, it is possible to state that the ROM measurements reliability is examiner-dependent in both instruments, being this fact more remarkable in the measurements with the goniometer. Moreover, the measurements are articulation-dependent and movement-dependent. The only movement which obtained very high reliability for both instruments and examiners was the knee flexion, which is similar to the findings in other studies[15,17]. This was the only measurement which used an external apparatus which helped the volunteer's positioning. The cost-benefit of the application of stabilizing apparatus, that is,

instruments which keep the evaluated individual steady and hence release the evaluator from positioning the instrument and instead concentrate on the localization of the reference anatomic points should be considered. Such instruments potentially influence on the reliability indices in the ROM measurement and other joints in future studies as well as clinical practice.

The flexion measurements presented standard error of 2.18 to 12.75 degrees. That is to say, differences of the pre and post-treatment means of up 12 degrees can be, in some cases, attributed to the measurement error and not to ROM improvement of the articulation. This is a fairly high value, which almost does not deserve the use of the measurement instrument at this condition.

All extension measurements presented measurement standard error lower than 1º, indicating that these measurements present lower dispersion when repeatedly taken by one or more examiners. It can partly be attributed to the kind of stop of the articular movement, that is, sudden stops (bone to bone or capsular) tend to cause lower variation in degrees at the end of the movement compared to stops by proximity of soft tissues.

Nevertheless, the reliability measurements assessed by the ICC and measurement dispersion, evaluated by the MSE, should be analyzed as a whole, since it does not make sense to use an instrument with good reliability percentages, but which presents high values dispersion between measurements. Likewise, an instrument which presents inadequate reliability indices is not commonly recommended, even if it presents low dispersion in the measurement absolute values.

It is possible to observe that the measurements which presented small dispersion (such as extension measurements) tended to present small reliability. The measurements with higher dispersion (as knee flexion, which ended up presenting MSE of 12.55º) presented

very high reliability when analyzed from the ICC. Thus, it can be said that a reliable instrument is not necessarily accurate. This fact is due to the statistical analyses performed, classical in the literature, for reliability determination, which consider the variabilityof the sample to determine reliability of an instrument[22,23].

More than one measurement Therefore, the study of the measurement properties of an instrument should lead into consideration more than one reliability measurement to recommend or reject its clinical use. The joints, movements and appropriate instruments appropriate to the clinical use according to the present study are in bold in table1.

CONCLUSION

The present study demonstrated that the reliability and measurement standard error of a measurement depend on the ability of the examiners, the instrument used, the articulation evaluated and the movement tested. In this study, the majority of the measurements taken with the inclinometer was more reliable that the ones taken with the goniometer, since only four measurements all of them with the inclinometer, were considered appropriate to be clinically used.The reliability measurement should be associated with the measurement standard error for analysis of the measurement properties of an instrument. Despite being fundamental in the clinic, the ROM measurement is not a measurement intrinsically reliable and accurate; thus, it is fundamental that the evaluator tests his capacity in the performance of this measurement and that further studies try to improve and facilitate the performance of this evaluation procedure.

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