EVALUATION OF RELIABILITY INTRA AND INTER-EVALUATORS AND INTER-TECHNIQUES FOR THREE INSTRUMENTS THAT MEASURE THE EXTENSIBILITY OF THE ISCHIOTIBIAL MUSCLES

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ABSTRACT

Introduction: The measurement of range of motion (ROM) is important in therapeutic evaluations. It was evaluated the reliability intra and inter-valuators and inter-techniques, for three tools that measured the extensibility of the hamstring. Materials and Methods: The sample was composed of university students (n=20/22.6±1.5 years). It was measured the extensibility of hamstring muscles of the right lower limb, and for this, ROM of the knee was examined by means of three tools: universal goniometer (UG), fixed goniometer (FG) and board goniometry (BO). There were six valuators in all, two by instrument (valuators A and B). The reliability was obtained by the index of correlation interclasses (ICC). Results: The intra-valuators reliability was heterogeneous, being: absent (FGA); moderate (UGB); high (UGA and BOB) and very high (FGB and BOA). The inter-valuators reliability was low for the FG and high for the other tools; while the inter-technique was high between UG and BO, but moderate when involving the FG. Discussion: It was observed that UG and BO are more reliable than FG and, in the clinical practice, allows an examiner to choose the tool that it is more accessible to him.

KEYWORDS

Reproducibility of Results; Arthrometry; Articular; Range of Motion; Articular.

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Avaliação da confiabilidade intra e interavaliadores e intertécnicas para três instrumentos que mensuram a extensibilidade dos músculos isquiotibiais

RESUMO
Introdução: A medida da amplitude de movimento (ADM) é importante nas avaliações terapêuticas. Avaliou-se a confiabilidade intra e interavaliadores e intertécnicas para três instrumentos que mensuraram a extensibilidade dos isquiotibiais. 

Materiais e Métodos: A amostra foi composta por universitários (n=20/22,6 ±1,5 anos), foi mensurada a extensibilidade dos músculos isquiotibiais do membro inferior direito, e, para isto, analisou-se a ADM do joelho por meio de três instrumentos: goniômetro universal (GU), goniômetro fixo (GF) e prancha de goniometria (PR). Ao todo foram seis avaliadores, dois por instrumento (avaliadores A e B). A confiabilidade foi obtida pelo índice de correlação Interclasses (ICC). 

Resultados: A confiabilidade intra-avaliador foi heterogênea, sendo: ausente (GFA); moderada (GUB); alta (GUA e PRB) e muito alta (GFB e PRA). A confiabilidade interavaliador foi baixa para o GF e alta para os demais instrumentos; já a intertécnica foi alta entre GU e PR, porém foi moderada quando envolveu o GF. 

Discussão: Observou-se que o GU e a PR têm maior confiabilidade que o GF e, na prática clínica, isso permite ao examinador escolher o instrumento que lhe é mais acessível.

PALAVRAS-CHAVE
Reprodutibilidade dos Testes; Artrometria Articular; Amplitude de Movimento Articular.

INTRODUCTION
In order to perform most of the daily, occupational and recreational tasks, it is necessary a movement amplitude (MA) without restrictions and pain. The extensibility gain and the adequate mobility of tissues prevent current and recidive osteoarticular lesions, decrease the pain and increase the general muscular performance.

The MA measure is an important component in physical evaluation, because it identifies the articular limitations and allows the professionals to follow quantitatively the efficacy of therapeutic interventions.

The most used instrument to measure the extensibility is the universal goniometer. However, there are other instruments capable of measuring the MA, such as the fixed goniometer used by Carvalho et al. and the goniometry plank developed by Brasileiro, Faria and Queiroz. In order to correlate different instruments, it is necessary that they provide reliable measures.

The reliability of a measure is the consistency between successive measures of the same variable, subject and condition. The use of evaluation instruments that are reliable and reproducible is fundamental to avoid sloping in scientific studies. There are three mistake sources that can make an evaluation unreliable: the instrument of measure, the evaluator and the different characteristics of the volunteers that are being evaluated, who are, undoubtedly, mistake sources hard to control. Considering the individual differences, the obtained measures by equipment can vary, therefore, the reliability of these measures will only be confirmed after the application of specific statistical tests.
Taking into account that the knee articulation is one of the most harmed in humans, different procedures to measure its MA are used\(^9\). Therefore, it is relevant to verify if the measures provided by the different measures means present correlation between them.

Thus, the objective of the present study was to evaluate the reliability intra and inter-evaluators and intertechniques for three instruments that measure, by a passive method, the extensibility of the ischiotibial muscles: universal goniometer, fixed goniometer and goniometry plank.

**MATERIALS AND METHODS**

**Sample**

All the subjects were informed about the objectives of the study and signed an Informed Consent Form, before being admitted in the experiment. The study was previously approved by the Ethics Committee in Local Research, protocol CR 26969/2009.

The sample was composed by 20 volunteers of both sexes, students of the Physical Therapy graduation course of Universidade Estadual do Oeste do Paraná (UNIOESTE), with a mean age of 22±1 years old.

The inclusion criterion of the sample adopted was the availability of the academicians to participate of the evaluations on pre-determined days and times. Any volunteer that presented any musculo-skeletal disorders in the lower limbs, which hindered the realization of evaluation, were not included.

**Procedures**

**Extensibility evaluation**

Evaluations consisted in measuring the extensibility of the ischiotibial muscles of the right lower limb, and for this, the MA of the knee was analyzed by three instruments: universal goniometer, fixed goniometer used in the paper of Carvalho et al.\(^6\) and the goniometry plank developed by Brasileiro, Faria and Queiroz\(^3\). The measurements were done by six academics, two for each instrument of the evaluation of the Physical Therapy’s course, previously trained. Such evaluations were realized in two successive days in the same time and place.

The participants were submitted to an evaluation, always in the same order: universal goniometer, fixed goniometer and goniometric plank. In each equipment, the patient was evaluated twice by evaluators. After each measurement, the subject turned back to the initial position, and each evaluator positioned the volunteer again for the data collection. The two evaluators of each instrument did not communicate during the evaluations and did not have access to the obtained data.

No heating exercise or maneuver of stretching before the evaluations happened.

**Evaluation instruments**

**Universal goniometer**

For the extensibility evaluation of the ischiotibial muscles with the universal goniometer, the volunteer was positioned in dorsal decubitus with the right hip flexed at 90° and the left extended (Figure 1). Therefore, with adhesive marks in the following structures: greater trochanter of the femur, lateral femoral epicondyle and lateral malleolus of the limb that was assessed. The hip was maintained in this position and the first evaluator realized the passive extension of the right knee until the subject referred discomfort to complete the MA\(^7\). In this moment, the angle obtained in the knee extension was annotated. After doing this, the volunteer was placed in its initial position and the second evaluator repeated the same procedures.

**Fixed goniometer used in the paper of Carvalho et al.\(^6\)**

In this evaluation, the volunteer was positioned in dorsal decubitus with the right hip inflected at 90° and the left extended. The fixed goniometer remained parallel to the articular axis of the knee, with the two arms fixed by wood splints imprisoned to two ranges of tissue of inelastic cotton, and antiallergic with velcro in the two extremities for the adaptation to the different circumstances of the low limb of each assessed (Figure 2).

**Figure 1 - Demonstrative picture of the positioning for the measurement of the hamstring muscle extensibility with universal goniometer.**
A fixed extremity was done in the distal part of the thigh and the other in the proximal part of the leg. The hip was left in this position and the first evaluator did the passive extension of the right knee until the subject referred discomfort to complete the amplitude of the movement. In this moment, the angle obtained in the knee extension was written down. After this, the volunteer was positioned in the initial position and the second evaluator repeated the same procedures.

Plank developed by Brasileiro, Faria and Queiroz

To measure the extensibility of the ischiotibial with the goniometry plank, the volunteer was positioned in dorsal decubitus and had the right hip sustained at 90° of flexion and the lower left limb remained extended in the plank (Figure 3).

The subject was fixed by ranges in the thorax level, pelvic waist, right and left thigh, warranting that the non-evaluated structures kept stabled. The height of the fixed arm of support for the right leg was adapted according to the person’s member dimension. The mobile arm was adjusted, having as basis the lateral malleolus of the right leg. A universal goniometer was fixed to the fixed and mobile axis of the plank to measure the extensor angle of the right knee. The first evaluator did the passive extension of the knee until the subject referred discomfort due to stretching, indicating that this was the maximum amplitude of ischiotibial movements. Therefore, the obtained angle was registered. After this measure, the volunteer was placed in its initial position and the procedure was repeated by the second evaluator.

Statistical analysis

For the statistical treatment, a SPSS software, version 15.0 was used, with the descriptive statistics presented in means and standard deviation. For the inferential statistics, the ANOVA one-way with Tukey’s post hoc was used to analyze the differences in the intragroups means. To assess the reliability, the interclass correlation index (ICI) was used, the correlation power was assessed by the following criterion: 0-0.25, few or none; 0.26–0.49, low; 0.50–0.69, moderate; 0.70–0.89, high; 0.90-1.00, very high. The normality test used was the Shapiro Wilk and for all the tests, the significance level adopted was $\alpha < 0.05$.

RESULTS

In the intragroups comparison, no significative differences were observed in the gathered angles among
the evaluators and the evaluation days (p>0.05) for the three used instruments, demonstrating that data were homogeneous. The means and standard deviations for each instrument and assessor can be seen in Table 1.

The results of the intra-examiners reliability correlation power varied from few or none to very high, and can be seen in Table 2. In the inter-examiners comparisons, the obtained results changed from low to high reliability, and are in Table 3. In Table 4, it can be seen the inter-techniques correlation, which varied from moderate to high reliability.

### DISCUSSION

The manual goniometry is a broadly method used in the physical therapeutic clinic, and between the advantages of this methodology, it can be cited the low cost of the instrument, the easy mensuration and since it is a non-invasive method\(^11\).

The reliability and validity of the measures using the goniometry to assess the MA of the knee have been largely researched and its results vary\(^12\). Considering the three assessment instruments used in this study, these changed from few or none to a very high reliability for the intra-examiner condition of the goniometry measures.

Gajdosik\(^12\) found high intra-examiner reliability for the ADM's measure of the knee, using a universal goniometer with correlation changing from good to excellent. In the present study, similar results to this test were found for both evaluators only in the goniometry plank.

According to Moseley, Crosbie and Adams\(^13\) and Cardoso et al.\(^14\), possible mistakes can interfere in the intra-examiners results, as an alteration of the volunteer’s positioning, touching and anatomical references placement and skin movement over the osseous prominences delimited during the goniometry mensuration. These mistake types can have occurred and would be one of the most probable explanations for the intraevaluator results oscillations, obtained, specially, in the fixed goniometer, since this instrument presented in one of its evaluators, the smallest correlation power.

Many studies that found high inter-evaluator reliability do not see an importance in the intra-examiner reliability analysis. However, it is important to record how much a technique is reliable for the same evaluator in another moment\(^15\).

When assessing the interevaluator reliability, results demonstrate low reliability for the fix goniometry, and high reliability in the universal goniometer and in Brasileiro, Faria and Queiroz’s\(^3\) plank. One of the suppositions for the goniometry plank’s reliability would be the stabilization that it enables, which minimized the compensations that can interfere in the measure’s results. This factor could be the mistake’s source of the fixed goniometry, since it was observed by the two examiners of this instrument that its attachments disordered the realization of the measures, because close to the end of the ADM, the goniometer did not remain aligned to the referential anatomic points, and it could have been repositioned. But, the study’s methodology did not predict to realign the goniometer during the assessment.

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**Table 1 - Averages and standard deviations of the range of motions amplitudes of the hamstring muscles, collected by the two assessors in the two days of collection**

<table>
<thead>
<tr>
<th>Tool</th>
<th>Assessor</th>
<th>Day 1 Average</th>
<th>sd</th>
<th>Day 2 Average</th>
<th>sd</th>
</tr>
</thead>
<tbody>
<tr>
<td>UG</td>
<td>A</td>
<td>148.1</td>
<td>12.27</td>
<td>144.7</td>
<td>10.33</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>145.2</td>
<td>12.89</td>
<td>147.4</td>
<td>10.08</td>
</tr>
<tr>
<td>FG</td>
<td>A</td>
<td>137.5</td>
<td>13.03</td>
<td>135.4</td>
<td>11.96</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>138.3</td>
<td>11.43</td>
<td>136.3</td>
<td>10.48</td>
</tr>
<tr>
<td>BG</td>
<td>A</td>
<td>155.7</td>
<td>9.82</td>
<td>156.5</td>
<td>8.38</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>154.5</td>
<td>9.73</td>
<td>155.9</td>
<td>9.44</td>
</tr>
</tbody>
</table>

UG: universal goniometer; FG: fixed goniometer; BG: board goniometry; A: assessor A; B: assessor B; first day of evaluation (1); second day of evaluation (2).

**Table 2 - Intraclass correlation coefficient (ICC) for the comparisons intra-evaluators**

<table>
<thead>
<tr>
<th>Tool - evaluator - time of assessment</th>
<th>ICC</th>
<th>Power of the correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UGA 1X2</td>
<td>0.82</td>
<td>High</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>UGB 1X2</td>
<td>0.649</td>
<td>Moderate</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>FGA 1X2</td>
<td>0.157</td>
<td>Little or none</td>
<td>0.242</td>
</tr>
<tr>
<td>FGB 1X2</td>
<td>0.931</td>
<td>Very high</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BGA 1X2</td>
<td>0.905</td>
<td>Very high</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BGB 1X2</td>
<td>0.858</td>
<td>High</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

UG: universal goniometer; FG: fixed goniometer; BG: board goniometry; A: assessor A; B: assessor B.

**Table 3 - Intraclass correlation coefficient (ICC) for the comparisons inter-evaluators**

<table>
<thead>
<tr>
<th>Tool - evaluator</th>
<th>ICC</th>
<th>Power of the correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UG AXB</td>
<td>0.704</td>
<td>High</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>FG AXB</td>
<td>0.494</td>
<td>Low</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BG AXB</td>
<td>0.88</td>
<td>High</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

UG: universal goniometer; FG: fixed goniometer; BG: board goniometry; A: assessor A; B: assessor B.

**Table 4 - Coefficient of correlation inter-techniques**

<table>
<thead>
<tr>
<th>Tool</th>
<th>ICC</th>
<th>Power of the correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UG X FG</td>
<td>0.539</td>
<td>Moderate</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>FG X BG</td>
<td>0.527</td>
<td>Moderate</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>UG X BG</td>
<td>0.709</td>
<td>High</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

UG: universal goniometer; FG: fixed goniometer; BG: board goniometry.
In this research, the goniometry measures were passively carried out. According to Lessen et al., the passive measures are less reliable than the actives, due to the power's change that is arranged by the therapists. Still, it can not be affirmed that additions in the analyzed reliability would be found in the present study if the goniometry measures were actively done.

Other relevant aspect related to the low goniometry's reliability that in this clinical investigation was found in the fixed goniometer can be the fact that this instrument is a dependent examiner, i.e., there is the need of a previous training and a methodological hardness so that these measures are consistent. Although in the present study, the examiners have received previous training, maybe the acquired experience has not been sufficient to promote relevant reliability in all the assessment instruments.

Menadue et al. assessed the reliability of the ankle's plant and dorsi flexion, carried out by three examiners, who had different experiences and familiarity with the technique, that were evaluated in two different positions (ventral decubitus and sitted). It was not concluded that the position of each measure done does not make any difference for the reliability, nor the observer's experience or training, since they are familiarized with the technique, opposed to other studies.

The reliability results found in literature for goniometry are controversy, this fact can have happened because of methodological differences. An example of this is the difference of the statistical analysis used among authors, since in the study of Cardoso et al., besides ICI, also used in the present study, the concordance test of Bland and Altman is used, justifying that the ICI, isolated, does not promote sufficient information about the measures' reliability due to the magnitude's influence of variation among the subjects. Maybe this a limitation of the study.

In the intertechnique comparisons, the reliability was moderate when the fixed goniometry was compared with other instrument, and high when the goniometry planks and the universal goniometry were compared. In the clinical practice, this allows to the professional to choose the most accessible instrument, and over the one that it has more experience.

It can be inferred that, in this study, the extensibility’s mensuration of the ischiotibial muscles done by different goniometry instruments presented reliability varied both in intra or inter-evaluators. There is the need of new researches, as similar materials and methods and experienced examiners, in order that it can be affirmed that these instruments are more reliable in the MA's evaluation of the knee.

The passive’s measure extensibility of the ischiotibial muscles using the universal and fixed goniometry and goniometry plank presented intraevaluator reliability, which varied from few or none to very high, with the results found in the interevaluator query presented from low to high reliability and intertechnique from moderate to high. Thus, it was showed that the universal goniometry and the goniometry plank have higher reliability than the fixed goniometry. In the clinical practice, this allows the examiner to choose the most accessible instrument.

**REFERENCES**

15. Cardoso JR, Azvedo NCT, Cassano CS, Kawano MM, Ambar G. Confiabilidade intra e interobservador da análise cinemática angular do


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