Intraobserver and Interobserver Reliability of a Method to Measure Ankle Plantar-Flexion Range of Motion in the Hook-Lying Position

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Context: Physical therapists often have to measure ankle range of motion (ROM) to decide on intervention and investigate improvements. The most common method of measurement is goniometry, but it has been questioned due to its unsatisfactory levels of reliability. Objective: To investigate the intraobserver and interobserver reliability of a new method of measuring plantar-flexion ROM. Design: Prospective and descriptive. Setting: Laboratory. Participants: 20 healthy participants (12 women and 8 men). Main Outcome Measurements: Ankle plantar flexion was measured by 3 observers (A, B, and C) with 3 methods (goniometry, measurement in hook-lying position [MHP], and static-image analysis [SIA]). Observer A was the most experienced therapist, and C, the least. MHP was performed with the participant in the supine position, knees flexed, and first and fifth metatarsals in contact with the treatment table. SIA was recorded and analyzed in the same position. Goniometry was performed with participant seated, lower legs unsupported, and axis positioned on the lateral malleolus. Results: For the interobserver analysis, the ICC2,1 was high for the MHP (.88), high for SIA (.87), and moderate for goniometry (.57). For the intraobserver analysis, the ICC 2,1 was high or very high for MHP (.91–.92), high for SIA (.79–.83), and low to moderate for goniometry (.18–.60). Conclusion: MHP is inexpensive, fast, and more reliable than goniometry for measuring plantar-flexion ROM.

Keywords: ankle joint, measurement, goniometry, trigonometry, intraclass correlation coefficient
Methods

Participants
Twenty healthy students (mean [SD] age 23.2 [3.7] y) took part in the study, and 40 ankles were analyzed. Participants were excluded if they had any ankle or knee injury, within 2 months before the assessments, that prevented them from being in the hook-lying position and performing ankle plantar flexion. The study was approved by the human-research ethics committee of Santa Catarina State University, Florianópolis, Brazil (reference number 12/2010), and all participants signed an informed-consent form before data collection.

Observers
Three observers took part in the study. Observer A was an experienced physical therapist (over 10 y). Observer B was a physical therapist with intermediate experience (3 y), and observer C was a fourth-year physical therapy student.

Procedures
All participants were measured in 2 sessions (test–retest), with a week interval between sessions. For each session, plantar-flexion ROM was measured by all 3 observers with 3 methods. The methods used by each observer were measurement in the hook-lying position (MHP), goniometry, and SIA. The order of observers, ankle, and methods was randomized. The observers were blinded to the scales used in each method; a fourth researcher recorded all measures. Data were revealed to the observers only after the end of data collection.

MHP. MHP was performed with the participant in supine, knees flexed, and with full contact between the sole of the tested foot and the treatment table. The participant was instructed to slide the foot while extending the knee, keeping the calcaneus and the head of fifth and first metatarsals in contact with the treatment table (Figure 1). The moment the head of the fifth metatarsal lost contact with the treatment table, the observer stopped the sliding motion and asked the participant to sustain the position. The observer then recorded the vertical distance between the highest point on the knee and the treatment table and the horizontal distance between the calcaneus and the projection of the vertical distance (intersection point; Figure 2), forming a 90° angle. Through trigonometry, the right triangle was used to calculate plantar-flexion ROM (Figure 2).

Goniometry. Participants were seated with feet unsupported and relaxed. The universal goniometer was positioned on the lateral side of the foot, with its axis on the lateral malleolus and using the fibula and the fifth metatarsal as the reference point. The angle was measured using the formula \( \tan \alpha = \frac{b}{a} \), where \( a \) is the horizontal distance and \( b \) is the vertical distance. The result was then transformed from radians to degrees.

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**Figure 1** — Final position of the foot for measurement in hook-lying position. Position of contact between the (A) first and (B) fifth metatarsals and the treatment table. (C) The moment contact between the fifth metatarsal and the treatment table is lost, at which point the position is held and the range of motion is recorded.

**Figure 2** — The measurement in hook-lying position. (A) Sides “a” and “b” of the right triangle, the point of intersection between the sides (Y), and angle \( \alpha \), which represents the maximal range of motion for ankle plantar flexion. (B and C) How the sides were blindly recorded with the use of a tape measure. Angle \( \alpha \) was calculated by trigonometry according to the formula \( \tan \alpha = \frac{b}{a} \), then the result was transformed from radians to degrees.
metatarsal as references for passive plantar flexion. The observer applied pressure to the ankle to ensure that full plantar flexion was reached\(^4\) (Figure 3).

**SIA.** SIA was performed in the same position as MHP. The head of the fibula, the lateral malleolus, and the lateral view of the fifth metatarsal were marked to calculate maximal plantar-flexion ROM. The image of the lateral view for each ankle was recorded using a digital camera that was positioned 1 m from the treatment table and 0.85 m above the floor. SIA was performed with *Software para Avaliação Postural—SAPO* version 0.68.\(^9\)

**Data Analysis**

All 40 ankles from the 20 participants were used for analysis. Intraclass correlation coefficients (ICC\(_{2,1}\)) with 95% confidence intervals were used to determined intraobserver and interobserver reliability. For inraobserver reliability, data from the first and second sessions (test–retest) were analyzed. For interobserver reliability, the results from the second session were used. To classify the strength of correlation, we used the following scheme: 0 to .25 represents little if any correlation, .26 to .49 low correlation, .50 to .69 moderate correlation, .70 to .89 high correlation, and .90 to 1.00 very high correlation.\(^10\) We also calculated the standard error of the measurement (SEM)\(^11\) and the minimum detectable change at the 95% confidence level (95% MDC).\(^12,13\)

**Results**

Table 1 presents the means and SDs for the first and second sessions for each measurement method, and Table 2 presents the results for interobserver and intraobserver reliability and the SEM and MDC for each measurement method.

**Discussion**

The current study presents a trigonometry-based method to measure plantar-flexion ROM that uses the hook-lying position to obtain a consistent measure and compares its reliability levels with those of goniometry and SIA. Our findings regarding the intraobserver reliability for goniometry reinforce the concept that greater observer experience will yield higher levels of reliability. In our study, the observer with less experience and incomplete professional training had low levels of reliability while the experienced observers had moderate reliability (Table 2). In contrast, MHP seems to be a method easily learned, as all 3 observers showed very high reliability for the method.

Because goniometry, although inexpensive and fast, frequently presents unsatisfactory levels of reliability, SIA has been considered an alternative to improve reliability when measuring ROM. As SIA and now also MHP seem to be methods that can have their procedures easily standardized, the different levels of difficulty in standardizing the procedures for each method could be the main explanation for the disparity seen between SIA, MHP, and goniometry. In the current study, SIA and goniometry were performed using the same landmarks, and SIA had very high reliability, similar to the reliability seen for the MHP (Table 2). The landmarks used for SIA differed from those used in MHP, but the positioning for both methods was the same. This fact could be

<table>
<thead>
<tr>
<th>Table 1 Range of Motion (°) Recorded During the First and Second Sessions, Mean ± SD</th>
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<td><strong>MHP</strong></td>
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<td><strong>Session 1</strong></td>
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Abbreviations: MHP, hook-lying position; SIA, static-image analysis.
interpreted as an indication that the landmarks chosen to analyze plantar-flexion ROM are not as important as the development of standardized procedures regarding the positioning, the instruments, and the rationale when measuring plantar-flexion ROM.

The final ROM achieved by MHP differed substantially from those with goniometry and SIA. While the literature expects a dorsiflexion ROM close to 20° and plantar flexion close to 50°,4 Bennell et al6 reported dorsiflexion close to 50° with the trigonometry-based measure and the current study presented plantar flexion close to 35°. Therefore, considering that MHP is the complement of the dorsiflexion measurement proposed by Bennell et al,6 if we add the 2 trigonometry-based measures, the total ankle ROM for the sagittal plane will replicate values suggested in the literature.4 It is important to note that the discrepancy found between the ROM measured by MHP and SIA is a consequence of the landmarks used by each method. MHP is not a direct analysis of the bone movement during plantar flexion, but an indirect measure, yet highly reliable. In addition, one may say that the SEMs presented here are a consequence of smaller measured ROM than with goniometry; however, the SEMs for dorsiflexion presented by Bennett et al6 were also smaller than the SEMs reported for goniometry in other studies.3 Overall, the SEMs associated with the trigonometry-based measure were 1.4° for dorsiflexion6 and 1.9° for plantar flexion (current study), while the SEMs associated with the goniometric measure were 4.3° for dorsiflexion3 and 5.5° for plantar flexion (current study). In addition, the 95% MDC analysis reinforces the findings related to ICCs and SEMs, as the lower 95% MDC found for MHP than for goniometry gives us an indication that MHP, as for reliability, is better than goniometry to detect changes (responsiveness).

Overall, MHP can be used reliably by one or more therapists to measure plantar-flexion ROM. The method has the advantages of requiring little training and being as inexpensive and fast as goniometry.

Limitations and Future Research

Although the MHP presented as a reliable method to measure plantar-flexion ROM, it has only been investigated in a population of healthy adults. Future research on populations with specific impairments (eg, high arch, fractures, neurological diseases, etc) would further clarify in which situations a therapist could apply this method.

References