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COMPARISON BETWEEN TWO CLINICAL TESTS FOR THE EVALUATION OF POSTERIOR THIGH MUSCLES FLEXIBILITY

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ABSTRACT

Objective: To compare the results from fingertip-to-floor and straight leg raise tests by means of photogrammetry, investigate the concordance of hip angle findings between the two tests and evaluate the intra and inter-examiner reliability of the photogrammetric analysis procedure. Method: The tests were applied to 35 healthy male subjects (mean age 23 ± 3.4 years, height 170 ± 4 cm and weight 68 ± 11 kg). The subjects were divided into two groups on the basis of the test classifications. Surface markers were placed on bone references in order to calculate the hip, thoracolumbar, leg, knee and tibiotarsal angles. The reliability of the photogrammetric analysis procedure on the angles measured by two examiners was tested. Results: For the hip angle, there were significant differences between the flexibility groups in both tests, and subjects with reduced flexibility had lower angles. There was a significant difference (22.8%) between the classifications designated by the two tests. However, the hip angle showed high levels of concordance between the tests (ICC: 0.89 and mean difference of -0.85°). The photogrammetric procedures presented high reliability rates, both for intra and inter-examiner (ICC ranging from 0.94 to 0.99). Conclusion: The tests presented differences in the classification of the subjects' flexibility. However, considering the hip angle, there was high concordance between the test results. The photogrammetric analysis procedures were reproducible, both for intra and for inter-examiner measurements, thus making this a useful analysis tool for the tests in question.

Key words: Flexibility, passive range of motion, physical examination, musculoskeletal equilibrium, photogrammetry, reliability.

INTRODUCTION

There seems to be no consensual definition for flexibility in the specialized literature. Differently from elasticity, which refers to the property of a tissue to return to its initial format[1], the term flexibility may have the simple definition of "the capacity of bending". In addition, it is found the term extensibility, defined as the range in which the joint may be moved passively, considering the influence of the muscular length[2,3]. The definition adopted, in this study, considers flexibility as the capacity to move a joint through its available range of motion (ROM), without producing excessive myotendinous stress[1].

Based on the flexibility relation and joint ROM[1,4,5], clinical tests are applied to evaluate the presence of limitations in the ROM. These tests are characterized by movements that increase the distance between the origin and the muscular insertion, literally stretching the muscle in question with the objective to test it[5].

The hamstring muscles (HM), group composed by the semi-tendinous, semi-membranous and biceps femoralis muscles, form a large muscular mass that is directly involved in the movements of the hip and knee joints[6,7]. This group performs an important role in the antero-posterior pelvic tilt, indirectly affecting lumbar lordosis. Therefore, altered flexibility of the HM may produce significant postural deviations and affect the functionality of the hip joint and lumbar spine[6,8]. Thus, the execution of flexibility tests becomes necessary in the process of assessment and intervention in physical therapy.

Clinically, HM length may be measured indirectly by having as possible reference the movement of the hip joint[9]. Thus, while observing diminished hip ROM , associated to the evidence of absence of neurological symptoms, it is often considered as a measurement of muscle flexibility[10]. Several tests are clinically used to assess HM flexibility, among them the sit-and-reach[11] and active or passive extension of the knee[9,12]. Two tests widely used, and that were not still submitted to comparisons are the Straight Leg Raise Test (SLR)[9,13-16] and the Fingertip-to-Floor Test (FTF)[4,17,18].

An essential aspect to be considered for the choice of a clinical test is the reliability of the measures[19], and this may be defined as the consistency of measurements of certain phenomenon, that is, the extent to which the measures are

repeated by people and instruments leading to similar results[20]. The fingertip-to-floor test has showed itself reliable and can be considered a valid measurement of the hamstring flexibility[17]. Furthermore, Tully and Stillman[18] suggest it as a valid measurement of this muscle's flexibility. In the same way, the straight leg raise test can be considered as a measurement of the flexibility of the hamstrings[9], possibly possessing clinical validity[3].

An analysis technique that has been used on the last years is photogrammetry[21]. Defined as measurement of certain phenomenon by means of photography. This technique provides innumerous advantages, such as usefulness, low cost, precision[22] and non-invasive characteristics[21]. Furthermore, its use should be planned in a way to prevent mistakes[22]. Thus, establishing the reliability of this measure becomes necessary.

Assuming that the practice of the physical therapist should be scientifically based, which, among other aspects, involves the quality and the reproducibility of the measures used in evaluation procedures, it becomes relevant to assess the reliability of two tests widely employed in the measurement of the HM's flexibility. Therefore, the objectives of the present study were to compare the results of the FTF and SLR tests by means of photogrammetry; to verify the agreement between the findings of the hip angle between both tests, and to assess intra- and inter-observer reliability of the photogrammetric analysis procedure.

MATERIALS AND METHODS

Subjects

Thirty-five healthy male individuals participated in this study (mean age 23 years ± 3.4; mean height 170 cm ± 4; and mean weight 68 kg ± 11). All subjects practiced physical activities twice or three times a week. The sample was composed of students recruited at the University, and, in order to be included, they were submitted to a postural assessment and were selected according to the *Inclusion criteria*: age between 18 and 35 years and height between 1.65 and 1.75 m, and according to the *Exclusion criteria*: Trauma history and any kind of musculoskeletal surgery in the lower limbs or spine; presence of postural asymmetries; lumbar pain on the last six months and neurological disorders, such as diagnosed disc herniation.

The individuals that fulfilled the criteria were clarified about the objectives of the research and the procedures, and were invited to participate in the study. They signed a free and clarified consent term according to Resolution 196 of the CNS and approved by the Ethics Committee of Federal University of São Carlos (report nº 059/04).

Clinical assessment of muscle flexibility

Participants were subjected to the SLR (Figure 1) and the FTF (Figure 2) tests, assessed by the same examiner. Both provide dichotomic results, that is, subjects' distribution in normal or reduced flexibility.

The following bone markers were placed on the skin: Femoral Greater Throcanter (FGT), Lateral Maleolus (LM), Femoral Lateral Epicondilus (FLE), Anterior Superior (ASIS) and Posterior Superior (PSIS) Iliac Spines, and spinal processes of T12 and C7 (Figures 1 and 2). The lines connecting PSIS-T12 and T12-C7 represented the thoracolumbar angle[15] (TLº) (Figure 2). Hip angle (Hº) was based on Kapandji[7] and measured as the angle between the ASIS-FGT and FLE-FGT lines. Knee angle[7] (Kº) was represented by the angle between the LM-FLE and FGT-FLE, and the tibia-tarsus angle[7] (TTº), was calculated as the crossing of the line parallel to the feet's sole with the tibia axis (FLE-LM) (Figure 2). Hip's rotation (Rº) was represented as the crossing between the horizontal line and the ASIS-FGT, and measured from subtraction of the angle during resting posture with the angle on the elevated lower limbs. Leg angle (Lº) was determined as the angle between absolute horizontal and leg's line (FGT-LM) (Figure 1).

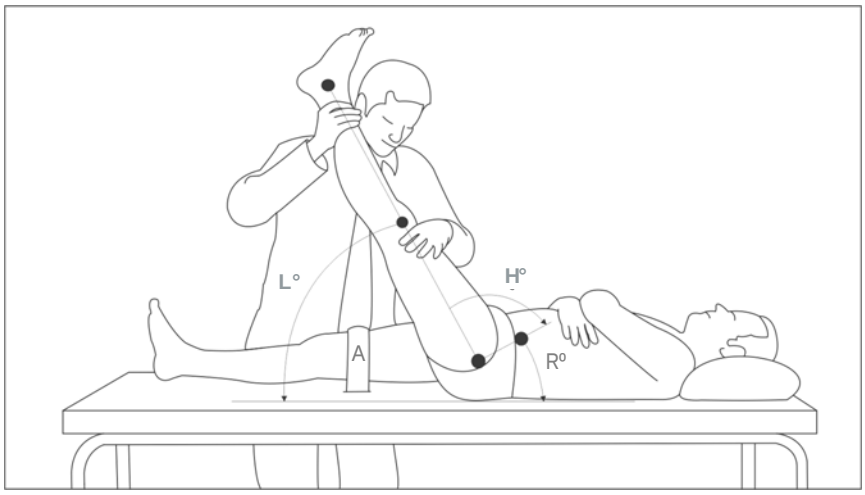

Figure 1. Straight-leg raise test (H°: Hip angle, L°: Leg angle, R°: Hip rotation angle, A: Strap at the contralateral limb).

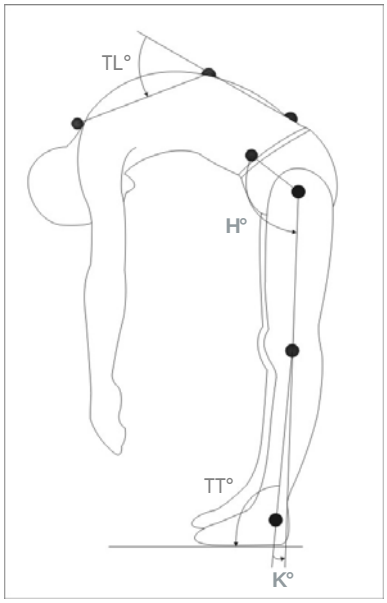

Figure 2. Fingertip-to-floor test (H°: Hip angle, K°: Knee angle, TL°: Thoracic-lumbar angle, TT°: Tibio-tarsal angle).

Procedures were directed to obtain quality pictures[23]. A digital MAVICA photographic camera and a tripod were placed at 2.75 m of the test area, directed at the height of the hip. The optical axis of the camera was perpendicular to the sagittal plane of the individuals.

Initially, a Thomas[5] test was applied in order to verify the flexibility of the iliopsoas muscle. In case the result indicated a reduction in flexibility of this muscle, a pillow was placed under the thigh of the counterlateral limb, with the objective to keep a slight flexion of the hip. This procedure facilitated the support of the lumbar spine during the test application, reducing possible influences from this segment in the test results. Afterwards, the HM flexibility measuring tests were applied. The participants did not perform any kind of warm-up or stretching before each test's administration.

Straight leg raise test

The test was applied passively, based on Kendall et al.[5] and Gajdosik et al.[15]. The subjects were classified into two groups according to the angle between the long axis of the leg and the horizontal line. Thus, individuals that obtained values equal or greater than 65º were classified as with normal flexibility, while the subjects that obtained values lower than 65º were classified with reduced flexibility. Precautions were taken during the test's execution: counterlateral thigh fixation of all individuals with a tape, instructions for the subject to relax and standardization of a slow raising velocity. Final leg raising position was photographed, that is, the moment in which the subjects reported a muscular tension sensation that caused great discomfort in the HM. Measured angles were the leg segment in relation to the horizontal, hip and hip rotation, which must be monitored to prevent over-estimation of results[17,24].

Fingertip-to floor

The test was applied according to Magnusson et al.[4]. The subjects were asked to keep the knees completely extended, and, from then on, to flex the trunk towards the floor, with head and arms relaxed. Final flexion position was indicated by a sensation of muscular tension that caused great HM discomfort and, in this moment, pictures were taken. Individuals that could reach a distance smaller than 10 cm in relation to the ground were classified as with normal flexibility, and the ones who stayed beyond the distance of 10 cm from the ground were classified as with reduced flexibility. Fingertips distance from the ground (in cm) was measured based a known linear measure, placed on the same visual field from the individuals. Measured angles were the thoracolumbar, hip, knee and ankle. Only left side measurements were considered, and care was taken to remind the subjects to keep their knees extended.

Reliability procedures

In order to assess measurement reliability it was planned a parallel study with a transversal design, with two examiners. The reliability of the photogrammetric analysis procedure was assessed by means of 30 pictures selected randomly, for evaluation of the angles of the hip, thoracolumbar, leg, knee, and ankle, totalizing thirty measurements for each angle. Each examiner made analyses at two different moments, separated by a 10-day interval between them. AutoCAD® 2000 software was used for angle photogrammetric analyses.

Statistical analysis

SPSS version 10.0 software was used and the results were analyzed adopting a 5% significance and confidence interval (CI) of 95%. Data relative to age, height, weight and angular measures were presented in relation to the mean and standard deviation.

Regarding the leg raise test, paired t-test was applied to verify differences between the elevation angles of right and left leg. In case of lack of significant difference, the mean between the right and left angles would be calculated. This value was used as reference for each subject's flexibility classification. From the results, subjects were classified into two groups: normal and reduced flexibility. Angular measurements of the thoracolumbar, hip, knee, ankle, leg elevation and hip rotation segments between both groups were compared for differences using the t-student's test. McNemar's test for dichotomous nominal variables was applied for comparing distribution of subjects according to the classification on both flexibility tests.

For intra- and inter-examiners reliability of the photogrammetric analysis procedures and agreement of the hip's angle between the tests, Intra-Classes Correlation Coefficient (ICC one-way random) and the agreement limits of Bland and Altman[25] were employed.

RESULTS

The result of the photogrammetric analysis for the Fingertip-to-floor test has shown that only the hip's angle was significantly different (P = 0.004) between the flexibility groups (106º ± 14 and 94º ± 13, respectively, for the groups with reduced and normal flexibility). The group with reduced flexibility presented a smaller hip flexion in comparison to the group with normal flexibility.

Regarding the leg raise test, only the leg and hip elevation angles presented significant differences between the flexibility groups (P = 0.001). Similarly, subjects with reduced flexibility (hip: 107º ± 10 and leg elevation: 54º ± 7) presented lower hip flexion and lower leg raising values in relation to the individuals with normal flexibility (hip: 88º ± 9 and leg elevation: 72º ± 6).

Table 1. Results for the comparison between the distributions of subjects classified with reduced or normal flexibility by the two tests. (N= 35 subjects).

		Straight-leg raise test*		
		Reduced	Normal	**Total**
Fingertip-to-	Reduced	12	1	**13**
floor test	Normal	9	13	**22**
	Total	**21**	**14**	35

*Classification considered the mean value between left and right leg angles. Straight-Leg Raise Test: *Sensitivity* of 60% and *Positive Predictive Value* of 92%.

Comparison of the results between the SLR and FTF tests is presented in Table 1, according to the classification criteria. A significant difference of 22.8% (P < 0.02) was found in the distribution of flexibility defined by both tests. The straight leg raise test has identified a grater number of subjects with flexibility reduction than the fingertip-to-floor test.

The results Leg elevation on the flexibility groups, corrected with reference to hip's rotation, have shown that, in average, subjects with normal flexibility have reached 53º of leg elevation. On the other hand, subjects with reduced flexibility have presented in average 33º of elevation. Monitoring was relevant, as it has confirmed that the leg angle values used for flexibility classification were overestimated because of influence of the hip rotation.

Table 2 presents the ICC values and mean difference (± SD) for intra and inter-examiners reliability measures of the photogrammetric analysis procedure employed at the study. All analyzed angles presented good reproducibility, both intra and inter-observers.

Comparison of the hip's angular values of each test presented a good agreement score (ICC= 0.89, CI= 0.78-0.94). The mean difference between both tests was –0.85º ± 6.8º (CI= -1.6 – 3.3) and the agreements limits between 14.2 to -12.5 (mean ± 2SD).

DISCUSSION

The 22.8% significant difference found in the comparison of the tests indicates that the flexibility

Table 2. Intraclass Correlation Coefficients (Confidence Interval) and mean difference (mean ± Standard Deviation) for intra and inter-tester reliability of the photogrammetric analysis procedure.

	Intra-tester			
	Tester 1		**Tester 2**	
	ICC	**Mean Difference**	**ICC**	**Mean Difference**
Hip	0.98 (0.98 – 0.99)	-0.2° (4)	0.99 (0.98 – 0.99)	-0.5° (2.5)
Leg raise	0.96 (0.82 – 0.99)	3.2° (3)	0.94 (0.77 – 0.98)	1.1° (3.1)
Thoracolumbar	0.998 (0.994 – 0.999)	-0.1° (0.9)	0.998 (0.994 – 0.999)	-0.1° (0.9)
Knee	0.99 (0.97 – 0.99)	-0.1° (0.5)	0.99 (0.98 – 0.99)	-0.1° (0.6)
Tibio-Tarsal	0.98 (0.94 – 0.99)	-0.2° (1.3)	0.98 (0.96 – 0.99)	0.1° (1.1)
	Inter-tester			
	1º Measurement		**2º Measurement**	
Hip	0.94 (0.88 – 0.97)	-0.3° (1.9)	0.95 (0.90 – 0.97)	0.1° (1.2)
Leg raise	0.94 (0.75 – 0.98)	-0.1° (0.6)	0.94 (0.77 – 0.98)	-2.2° (3.1)
Thoracolumbar	0.99 (0.98 – 0.99)	-0.3° (1.4)	0.998 (0.994 – 0.999)	-0.3° (0.9)
Knee	0.98 (0.95 – 0.99)	0° (0.6)	0.99 (0.98 – 0.99)	0° (0.3)
Tibio-Tarsal	0.96 (0.89 – 0.98)	0.1° (1.8)	0.98 (0.95 – 0.99)	0.3° (1.2)

measurement based on the distance parameters from fingers to the floor and leg angle in relation to the horizontal line were responsible for different classifications of the assessed subjects. In fact, distance of the fingers to the floor may be influenced by anthropometrical characteristics, such as arm size and spinal range of motion[11]. In the same way, the resulting leg angle measurement may have been influenced by the hip rotation[24,26].

On the other hand, good agreement of the hip angle measurements indicates that the tests may provide similar and consistent classifications, if the hip joint is used as reference. In fact, significant differences on the hip joint between both groups, on both flexibility tests, point out to HM shortening as a limiting factor of motion of this joint[15,17,18]. Other studies support the relationship between clinical measurements and muscular stiffness. In this case, shortened HM may be responsible for changes in stretching tolerance[4,10], and constitutes an important influence in the hip ROM[27].

Hip angle could be the parameter for these flexibility tests based on the direct relation of the HM with the pelvis and hip's functionality[6,8]. The difference found between the tests regarding flexibility distributions, supported by a good agreement, suggests a viability of studies to establish normative values for the hip angle, on both the FTF and SLR tests, which could make them more specific and comparable between one another.

Thoracolumbar angle was analyzed with the intention to detect possible compensation in this region, in response to the hip ROM restriction. As opposed to Gajdosik[15], the findings did not present significant differences, despite the fact that the subjects with reduced flexibility presented higher levels of flexion (46º ± 5) when compared to normal individuals (44º ± 6). Although the angle was based in a Gajdosik[15] study, maybe the inclusion of PSIS could have occasioned the lack of significance. Findings related to knee and ankle angles were positive, because both were used to monitor the position of the subjects according to the directions given. Lack of significant difference between the groups suggests that the individuals kept their knees extended, did not compensate the motion in the ankle's joint and avoided problems in the interpretation of the distance from the fingertips to the floor.

If the application of different tests in the measurement of the same parameter leads to comparable and consistent results, the quality of communication among different professionals increases, providing scientific support to clinical practice[19]. On the other hand, the difficulty in the comparisons of the findings in literature shows the variety of definitions and angles used. In addition, the different ways in which tests are applied confirm the problems reported by Dixon and Keating[16].

The photogrammetric analysis procedure was shown to be practical and useful. However, despite the establishment of the tests' reliability, the findings must be seen with caution. The method's application, in association with the use of surface bone markers, may be prone to measurement errors due to the movement of the markers on the skin[28]. Methodological considerations relative to the establishment of reliability and standardization of markers placement are necessary in the future, in order to offer even more reliable assessment options for clinical practice. Similarly, data obtained with hip rotation monitoring during the leg raise test effectively demonstrated overestimation of the results and reasserted the assumption that this movement may interfere with the flexibility assessment[24,26]. However, these results should also be accepted with caution, since skin movement artifacts may occur, mainly in markers placed at the throcanteric region, during thigh movement[28].

Questionings regarding the validity of the clinical tests, despite difficulties in establishing them[19], are always important. The widespread definition of validity as an evidence that a given test measures what it proposes to measure[19], raises relevant discussions that may justify the HM's influence on the hip function and its consequent assessment. There are several factors than may limit the ROM of a joint (joint capsule, bone contact, ligaments, soft tissues). Among them, myotendinous tissue stretching is the most common factor[29].

The length-tension relationships that dictate the efficiency of a muscle refer to the position of the involved joints. Consensually, it is considered that HM are more efficient hip extensors when the knee joint is extended[7]. Both tests used in the present study were applied in such a way to reproduce the action of the HM as hip extensors, placing this muscular group in its efficient position. Both tests used are widely recommended as stretching exercise[1,8] and as a test for flexibility assessment of the posterior thigh muscles[9,13-18]. Considering that stretching exercises are applied in the same way and that such exercises are the basis of kinesiotherapy teaching, it seems acceptable that the use of clinical tests that reproduce such movements may be considered valid for this finality.

CONCLUSIONS

The two muscular flexibility tests assessed in this study presented differences in the flexibility classification between the individuals. However, when the hip angle was considered on the leg raise test, there was an agreement between the results of both tests. The photogrammetric analysis procedures were reproducible both for intra- and for inter-examiners, constituting a useful tool of analysis for the tests in question, as long as cautions are taken for possible markers movement errors.

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