# Use of the sphygmomanometer in the evaluation of the knee joint flexor and extensor muscle strength in militaries

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## ABSTRACT

**Bases and objective:** This is a comparative and descriptive study that aims at analyzing the strength for the different angles of the knee flexion and extension in militaries. The objective of this study was to evaluate the extensor and flexor muscles of the knee joint for different angles by means of the Modified Sphygmomanometer (MS) in healthy militaries. **Methods:** The sample was composed of 31 militaries as follows: 19 male and 12 female with average age of 26.5 ± 5.8 years; respective average height of 162.00 ± 0.06 (cm) and 175.00 ± 0.06 (cm) and average body mass of 56.83 ± 5.85 (kg) and 73.25 ± 10.46 (kg). The evaluation methodology was the one proposed by Helewa, Goldsmith and Smithe (1981) using Modified Sphygmomanometer (MS). The maximal isometric contractions at 30° of flexion and 30°/90° of extension were obtained in the Make test, in the *Inbaf* flexion-extension table and recorded by the MS *Tycos*. The data was analyzed using the "t" Student-test to compare the averages, and the significance level adopted was $p > 0.05$. **Results:** In both the female and the male groups, significant difference was only observed between angles of 30 and 90 degrees of the right knee extension ($p > 0.05$). At angles of 90 degrees for the knee extension and of 30 degrees for knee flexion, no intra-groups significant differences were observed ($p > 0.05$). **Conclusion:** Militaries present strength differences between knee joint anterior and posterior muscular groups at the different angles studied. The methodology used showed to be satisfactory for the strength qualitative evaluation.

**Key words:** Isometric strength. Sphygmomanometer. Knee joint.

## INTRODUCTION

The evaluation of the muscular strength has been objective of study in different knowledge areas. It can be verified in the literature that different subjective (perimetry and manual muscular test) and objective methods (portable dynamometer and isokinetic dynamometer) have been used to measure this physical valence (board 1). In the history of physical therapy, the importance of the strength evaluation can be verified in the rehabilitation process of the body segments[1-3].

**BOARD 1**
**Methods of muscular strength evaluation**

| Subjective methods | Objective methods |
|---|---|
| 1. Perimetry | 1. Portable dynamometer |
| 2. Manual muscular test (MMT) | 2. Isokinetic dynamometer |

The hypotrophy and the strength unbalance between the agonistic and the antagonistic musculature are factors that may influence the muscular dysfunctions and alter the articular stability, leading to new lesions. Thus, it has become priority for physical therapists to perform evaluations that enable prophylactic actions as well as the evolutive treatment of the articular lesions. However, there are controversies regarding to the application and validity of the methods employed, once the perimeter asymmetry does not necessarily indicate strength asymmetry[1,4-8], the manual muscular test presents a reliability of only 60-65%[2,6,9,10], the portable dynamometer is not yet regularly manufactured in Brazil and presents different readings according to the manufacturer[3] and the high-reliability isokinetic dynamometer has as primary limiting factor its high cost and the necessity of adequate physical space[11] (board 2).

**BOARD 2**
**Summarized discussion on the methods of muscular strength evaluation: limitations, feasibility, reliability**

| Method | Discussion |
|---|---|
| 1. Perimetry | The thigh perimeter asymmetry is frequently related to the torque decrease. The association between perimeter and torque is discussed. The perimeter asymmetry does not indicate strength asymmetry[1,4,5,6,7,10]. |
| 2. Muscular test | Main muscular test for many decades. Beasley, for over than 30 years, already supported the application of more objective tests. The MMT may provide a submaximal response if the patient's strength exceeds the physical therapist's. William reported that the reliability of this test is of only 60 to 65%[2,6,9,11]. |
| 3. Portable dynamometer | Although having limitations, its application has been supported in the last decade. Not yet regularly manufactured in Brazil and with high cost, it presents maintenance difficulties and different readings according to model and manufacturer; these are factors that hinder its utilization in the evaluation routine[3]. |
| 4. Isokinetic dynamometer | This device has aided to overcome some difficulties in the muscular tests. Presenting good reliability, has as primary limiting factor high cost and the necessity of proper physical space[8]. |
| 5. Modified sphygmomanometer | Portable, reliable, simple, has low cost, being easy to apply for the muscular strength evaluation in the prophylaxis and monitoring of the rehabilitation process. It can only be used as a comparison mean. It does not provide strength indexes of individualized muscular groups, but asymmetry percentiles[9,10,12,13]. |

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Thus, it was verified the necessity of a method of easy applicability and low cost for the strength evaluation with result reliability[12,13]. Among the methods presented by literature, the method proposed by Helewa *et al.*[14] has demonstrated that the application of the Modified Sphygmomanometer (MS) was more sensible in the muscular evaluation than the methodology that uses free weights. They observed that the strength measure methodology with the MS provided qualitative and objective measures more sensible to the different strength standards. These authors concluded that the method presented good reproducibility when the results obtained by different appraisers were observed. Fernando and Robertson[15] showed a difference of less than 2% between the measures obtained by different appraisers using MS in the manual pressure strength test. Helewa *et al.*[14] assured that the MS yet presented good security level, being able to be applied in at least twenty-four muscular groups.

In the specialized literature, reports of two types of muscular test in which the MS may be used are found[12,16,17]: a) Break Test – It is a manual test where the MS is placed between the segment of the appraised and the hand of the appraiser, the appraiser's strength overcomes the maximal muscular strength of the appraised and b) Make Test – it is a mechanical test where the MS is placed between the segment of the appraised and an object or a stationary device with appraised performing maximal isometric strength.

This study is justified by the possibility of providing a practical method for the muscular strength evaluation. The body segments, objects of this study, are the lower limbs, more specifically the knee, joint with specific stability features, function and importance that presents high incidence of lesions and dysfunctions especially due to the deficiencies in the periarticular musculature mentioned above, responsible for its dynamic stabilization[18-21].

The objective of this study is to use the MS for the knee flexor and extensor muscle strength evaluation with the application of the Make Test for angles of 30/90 degrees and 30 degrees respectively in adult individuals, apparently healthy.

## MATERIAL AND METHODS

### Methodology

This study presents a descriptive-comparative approach[22]; the evaluation methodology proposed by Helewa *et al.*[14] was used in militaries from both genders and ages ranging from 19 and 31 years, apparently healthy.

### Sample

The sample of the present study was intentionally, composed of 31 militaries from both genders distributed in 19 women and 12 men with ages ranging from 19 and 31 years and with an average of 26.5 ± 5.8 years. The volunteers had no knee lesions or anatomical alterations. All participants were informed about the risks involved in the experiment, being invited to fill and to sign a consent form, according to Brazilian law number 196/96. Data regarding to age, gender, height, body mass, physical activity practice level with regular practice and dominance side were also collected.

### Material

***Modified Sphygmomanometer –*** The device used to assess blood pressure had part of its Velcro tape removed. The inflatable bag was folded in three equal parts and fixed inside an inelastic bag. In this prototype, the sphygmomanometer label Tycos® was used. After modification performed, the device presented the following dimensions: 9 cm width, 14 cm length, 2.5 cm thickness and the aerial tubes presented 48 cm extension (figure 1). The unit was inflated and applied to the positions standardized by Reese[1], Daniels and Worthingham[9] for the test of the muscles investigated. We employed the Make Test, which stabilization is mechanical, to avoid measurement errors.

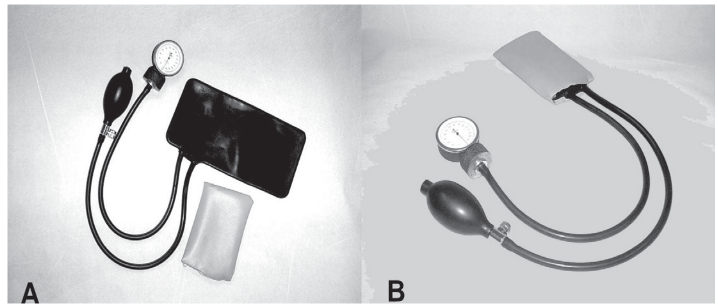


***Fig. 1** – **A)*** *Latex inflatable part used in traditional sphygmomanometers to assess the blood pressure and inelastic bag that will be employed in the equipment adaptation.* ***B)*** *Final aspect of the modified sphygmomanometer after folding of the inflatable part into three parts contained in the inelastic bag.*

***"Inbaf" flexion-extension table*** – The equipment was set to its maximal load of 80 kg and for some volunteers who achieved dislocating this load, a manual stabilization strength performed by the appraiser at the device's arm crowbar extremity was added. The following positions for the strength test in the *Inbaf* equipment were adopted: extension from 90º and flexion from 30º.

### Procedures

Before performing the strength test, the volunteer was informed of how to proceed, also being requested to perform the desired movement one single time in each segment for apprenticeship, before the MS was positioned and the strength test was performed.

The MS was positioned at the distal extremity between the leg and the support point of the leg with the device's arm crowbar. The test was composed of three repetitions in each limb for each position adopted and the volunteer was induced to perform maximal effort through verbal stimuli and encouragement.

***Calculation of the general values obtained –*** The test's final values for each position adopted previously described were calculated through the arithmetic average of the value obtained in each one of the two positions adopted.

Example: If, in the extension from 90º, the volunteer reached values of 58, 50 and 52 for the right lower limb, the arithmetic average would be 53.3.

***Calculation of the asymmetry percentile –*** Comparative calculations were performed to establish the right and left thigh antagonistic-agonistic asymmetry percentage at positions of 90º of extension and 30º of flexion. For each position, the highest arithmetic average was subtracted by the lowest arithmetic average and the result obtained from the subtraction (X) was divided by the highest arithmetic average (B) and this result (Y) multiplied by 100, thus finding the specific percentile for each case.

$$B - A = X \qquad X/B = Y.100 = \%$$

With the objective of making this evaluation method simpler and feasible in the daily clinics as evaluation control and treatment evolution, no correlation between pressure (mmHg) and strength (N) was performed. The values obtained were only used as reference unit in order to establish the asymmetry index.

### Statistics

For data analysis, the descriptive analysis and the "t" Student test was used to compare the averages. The statistical significance level adopted was $p > 0.05$. To do so, the "Statistical Package for the Social Sciences" (SPSS 11.0) was used.

## RESULTS

### Sample characterization

The average height of the female group was of 162.00 ± 0.06 (cm) with body mass of 56.83 ± 5.85 (kg). In the male group, average height of 175.00 ± 0.06 (cm) and body mass of 73.25 ± 10.46 was observed.

With regards to the regular practice of physical exercise, it was verified that from the total number of individuals, 54.8% did practice regular physical exercise while 45.2% did not.

The average values and standard deviation (SD) for the angle analysis studied in the knee flexion and extension are presented in table 1.

**TABLE 1**
**Descriptive values of the knee extension and flexion strength test in men and women for angles of 30/90 and 30 degrees**

| Variable | Women | | Men | |
|---|---|---|---|---|
| Extension | Average ± SD | | Average ± SD | |
| | Right knee | Left knee | Right knee | Left knee |
| 30° | 73.76 ± 21.96* | 75.16 ± 19.31* | 85.46 ± 20.74 | 90.64 ± 22.03 |
| 90° | 83.37 ± 19.84* | 85.96 ± 13.35* | 109.15 ± 22.04* | 110.35 ± 35.87* |
| Flexion | Average ± SD | | Average ± SD | |
| | Right knee | Left knee | Right knee | Left knee |
| 30° | 66.44 ± 16.28* | 65.14 ± 16,90* | 81.55 ± 12.50 | 76.91 ± 70.93 |

* ($p < 0.05$)
No correlation between pressure (mmHg) and strength (N) was performed. The values obtained were only used as reference unit in order to establish the asymmetry index.

The data from the statistical analysis demonstrated that for knee extension in the female group, a significant difference between angles of 30° and 90° was observed in the right leg ($p > 0.05$) while for the left leg, no significant difference was observed ($p > 0.05$); and the same behavior was observed for the male group.

For the Extension 30° x Flexion 30° in the female group, a significant difference was observed ($p < 0.05$) for both segments. The male group presented no significant difference ($p > 0.05$) in the same case observed.

In the Extension 90° x Flexion 30° analysis, both female and male groups presented no significant difference for both segments ($p < 0.05$).

When the Extension 30° x Extension 90° of the right leg is compared, a significant difference for both groups was observed ($p < 0.05$). In the left leg, no significant differences were observed between groups ($p > 0.05$).

In the comparison of Flexion 30° x 30°, according to the analysis of results, no significant differences were observed ($p > 0.05$) for segments both in the female group and for the male group.

The strength asymmetry average percentile index between the knee flexors and extensors (ischiotibial/quadriceps) found with the use of methodology described was:

### In men (n = 12)

*Right knee* – In 83.3% of cases, the extensor group (quadriceps) presented strength predominance in relation to the flexor group (ischiotibial), with an average percentile index of 26.4% (figure 2). In 16.7% of cases, the flexor group presented strength predominance in relation to the extensor group with average percentile index of 18.8%.

*Left knee* – In 66.6% of cases, the extensor group presented strength predominance in relation to the flexor group (ischiotibial) with an average percentile index of 33% (figure 3). In 26% of cases, the flexor group presented strength predominance in relation to the extensor group with average percentile index of 6%, and in one case, the extension strength was equivalent to the flexion strength.

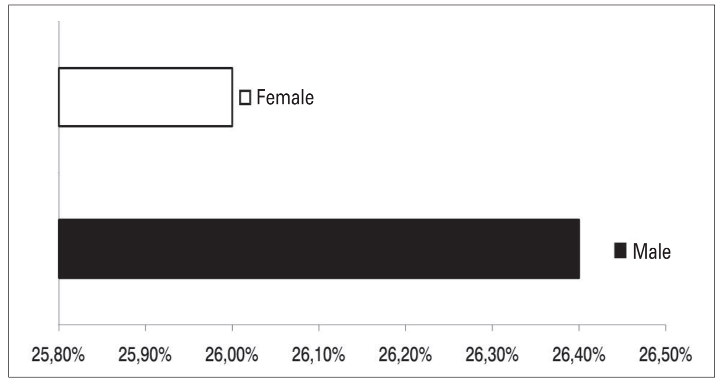


***Fig. 2*** *– Right knee. Strength asymmetry average percentile of the dominant extensor group (n = 25).*

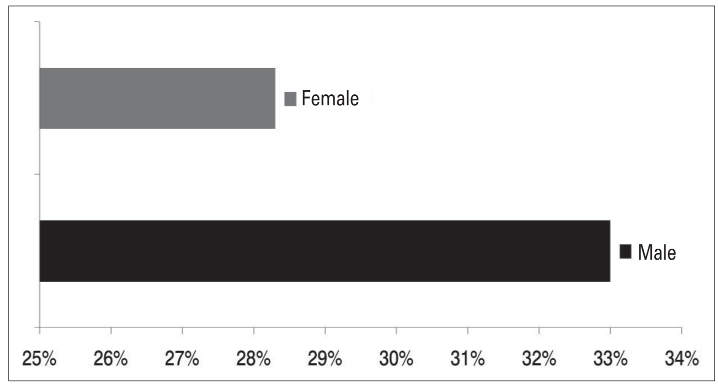


***Fig. 3*** *– Left knee. Strength asymmetry average percentile of the dominant extensor group (n = 22).*

### In women (n = 19)

*Right knee* – In 78.9% of cases, the extensor group presented strength predominance in relation to the flexor group (ischiotibial), with average percentile index of 26% (figure 2). In 21.1% of cases, the flexor group presented strength predominance in relation to the extensor group with average percentile index of 9.5%.

*Left knee* – In 73.7% of cases, the extensor group presented strength predominance in relation to the flexor group (ischiotibial) with average percentile index of 28.3% (figure 3). In 26.3% of cases, the flexor group presented strength predominance in relation to the extensor group with average percentile index of 9.2%.

The strength predominance of the extensor muscle group may be observed in 78% of men and 76.3% of women, with an asymmetry average index in relation to the flexion of 26.4% in the right knee and 33% in the left knee in men and 26% in the right knee and 28.3 in the left knee in women.

The flexors presented predominance in relation to the extensors in 21.9% of men and 23.7% of women, with an asymmetry average index of 18.8% in the right knee and 6% in the left, in men. In this group, which a large asymmetry difference between segments was observed, one may speculate that this fact might have occurred due to the type of physical activity practiced by the group. In women, the asymmetry index was of 9.5% in the right knee and 9.2 in the left knee.

Through the results obtained, one cannot corroborate the relation between manual dominance and strength dominance in the lower limbs. This relation was observed in 31.5% of the total of individuals tested, which majority was right-handed, however, it was observed that the strength asymmetry average index between flexors and extensors was higher in the left knee, maybe due to the fact that it is not the support segment and the musculature is not properly used.

## DISCUSSION

We can emphasize as limiting factors for this study: 1) the number of individuals evaluated and 2) in function of the strength levels variation observed, it is not possible to extrapolate the results in such way to create normative values.

The strength asymmetry between agonistic and antagonistic has already been object of discussion in some studies. The study performed by Safran *et al.*[23] affirms that athletes with strength differences of 60% in one leg when quadriceps and ischiotibial are compared have high chances of suffering a muscular lesion. Heiser *et al.*[24] showed that a team of athletes presented an incidence of 7.7% of ischiotibial lesions with a recurrence rate of 31.7%. However, after the muscular unbalance was recognized and corrected, the lesions incidence dropped down to 1.1%.

In function of these studies, one may suggest that the same could occur to non-athlete individuals, as in the sample investigated in this study. This strength inequality between the knee joint agonistic and antagonistic musculature is favorable when we observe Heyward[25], who presents the studies of Golding, Meyers and Sinning (1989), where the authors suggest a higher strength normal difference of the thigh anterior portion in relation to the posterior portion of around 25%. Other authors[26-28] suggest that this difference is of the order of 30 to 40%.

In the present study, part of the sample presented behavior similar to results found in literature[25]. The order which the tests were performed is also pointed as limiting factor in this study, once the agonistic/antagonistic action may have influenced on the loss of strength at maximal effort in function of the resistance generated by the antagonistic, factor also known as Lombard[29,30] paradox. Among other factors that may be considered as limiting factors, we emphasize the percentage of individuals who did not perform regular physical exercises or which the physical fitness level was not measured. The effectiveness of the intramuscular coordination and the coordination between muscles is related to this exercise practice[31]. Such factors are associated to the high incidence of lesions in the thigh posterior muscular group[24,26-30,32-34]. Thus, it is observed that the posterior musculature must not present strength values close or similar to the anterior musculature.

The results obtained in this study demonstrated that the most participants presented strength equivalence suggested for the prophylaxis of muscular lesions.

We know that the pressure is proportional to the contact area and that this factor may have influenced the results when we established an asymmetry normal index, fact that requires further investigations.

## CONCLUSION

Militaries present strength differences between anterior and posterior muscular groups of the knee joint at the different angles studied.

The use of the MS as a low-cost practical method for the strength evaluation between knee flexors and extensors was emphasized, being applicable as a comparison parameter when the prophylaxis of muscular lesions or the monitoring of a knee surgery recovery is the objective.

It is suggested that other studies be conducted with the objective of investigating the strength relation obtained between the MS method and values standardized by isometric tests at the different angles for the knee flexion and extension.

*All the authors declared there is not any potential conflict of interests regarding this article.*

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