



Analysis of the Figure-of-Eight method and volumetry reliability for ankle edema measurement

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ABSTRACT

Edema's measurements on ankle injuries are necessary as part of the evaluation and diagnostic check. The present study was designed to analyze the Figure-of-Eight method and volumetry measurements and check their intratest and intertest reliability. Twenty asymptomatic healthy male volunteers from 15 to 30 years of age, were randomly examined by three clinical examiners. Each examiner performed three measurements following each method. It was used standardized positioning and measurement techniques. The results showed reliability in both methods (ICC = 0.99). The Pearson product-moment correlation coefficients showed reproduction between examiners, where values of $r = 0.91$, $r = 0.95$ and $r = 0.96$, respectively were found. These findings suggest the Figure-of-Eight method and volumetry are reliable measurements.

INTRODUCTION

Ankle lesions resulting from traumas are frequent during sportive practices, many times dismissing the athlete from competitions. Most of these lesions result in acute inflammatory process in which the edema is one of the most relevant symptoms⁽¹⁻⁴⁾.

The presence of edema indicates tissue inflammatory reaction, alteration on the capillaries normal dynamics and inadequate or hindered functioning of the venous pumping and the lymphatic system^(5,6).

It is a process indicated by liquid excess in the interstice or in serous cavities, being unchained by histamine, bradycinin, leukotrienes and other classes of chemical mediators that may correspond to an exudates or transudate. The exudate is the extravascular inflammatory liquid with high protein concentration and high amount of cellular residues; on the other hand, the transudate is a liquid with low protein content mostly composed by albumin^(7,8).

Petersen *et al.*⁽⁹⁾ classified the ankle edema through visual method as: light, moderate and severe. The light edema occurs when all bone marks (malleolus, navicular bone and the base of the fifth metatarsus) are well visible; the moderate edema is verified when the bone marks are less visible and the severe, when the bone marks present difficult visualization.

Gabriel *et al.*⁽¹⁰⁾ report that, in case the edema is not corrected, it will lead to a functional incapacity state due to the limitation on the muscular elasticity, decrease on the articular arcs, aponeurosis shortening and, in some cases, tissue necrosis.

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With association of edema measurement methods, it is possible to evaluate the lesion seriousness and the treatment effectiveness and several methods are used to measure the limbs volume, among them: circumference measurement, volumetry, bioelectronic impedance and computational model^(9,11,12).

The Figure-of-Eight method and the volumetry are the standardized evaluation processes most used for ankle edema measurement with the objective of quantifying treatment efficiency^(5,11-15).

Since the age of Archimedes, the water displacement has been used to measure the body mass and literature reports indicate that it has been useful to distinguish gold from other metals for the creation of the Hiero King^(5,12).

Volumetry is important technique to measure articular edema in uneven surfaces such as foot and ankle. The measurement is performed with the volumeter, a translucent recipient specially designed, containing water inside and with a gutter for the outflow of this liquid^(12,14-17).

The Figure-of-Eight method, developed by Esterson⁽¹⁸⁾ consists of the perimetry with tape measure of the areas of higher ankle edema concentration, in other words, the region of the anterior talofibular, calcaneofibular and anterior tibiofibular ligaments⁽¹¹⁾.

Mawdsley *et al.*⁽¹³⁾ determined that the Figure-of-Eight method presents reliability based on the Intraclass Correlation Coefficient, however, its validity in relation to the volumetry method was not yet determined.

Thus, the present study was designed to analyze the Figure-of-Eight method and volumetry measurements and check their intratest and intertest reliability.

CASUISTIC AND METHODS

Sample

Twenty male volunteers with ages ranging from 15 to 30 years ($\bar{X} = 21.8$) with no trauma history were recruited through verbal invitation. The volunteers who presented previous trauma-orthopedic dysfunctions (fractures, tendinopathies), previous surgical procedures and other systemic pathologies were excluded from the sample selection.

Before the beginning of the experiment, all volunteers were informed about the research's procedures and signed an Informed Free Consent Form, according to the Norms and Guidelines of Researches involving Human Beings, according to resolution of the Health National Agency 196/96.

Procedures

Volumetric measurement

A volumeter manufactured with translucent material (glass) was used, according to standard of the label Baseling Volumetric Edema Set, Idyllwild, CA with the following dimensions: 33.5 cm of length, 13 cm of width and 24 cm of height (figure 1).



Fig. 1 – Volumetric measurement: **A)** volumeter, **B)** recipient, **C)** test tube, **D)** Becker flask.

Wearing adequate clothes to show legs and ankles, the volunteers were positioned in chair maintaining left knee flexion, randomly selected in approximately 90°. Before immersion, a water layer was manually applied to the left lower limb (MIE) in order to minimize the amount of air underneath the hair⁽¹⁵⁾.

Following, the volunteers were instructed to lower MIE gently into the volumeter containing five liters of water at room temperature until foot rests comfortably at the bottom. The water volume displaced was discharged by a gutter into a Becker flask and transferred to a 1000 mL test tube (graduation of 10 mL).

Three clinical examiners (A, B and C) were randomly selected for the volumetry individual collect. Each examiner performed measurements three times in each volunteer and recorded values in standardized form.

Figure-of-Eight method

The examiners instructed the volunteers, also randomly, to remain seated with knee in complete extension and ankle at neutral position. The measurement was then performed with the zero of the tape measure kept on the middle point between the articular projection of the anterior tibial tendon and the lateral malleolus. The tape measure was guided to the center of the foot medial longitudinal arch on the navicular bone, touching lightly the plantar region towards the lateral malleolus, calcaneus tendon and medial malleolus up to reaching the point zero of the tape measure (figure 2).

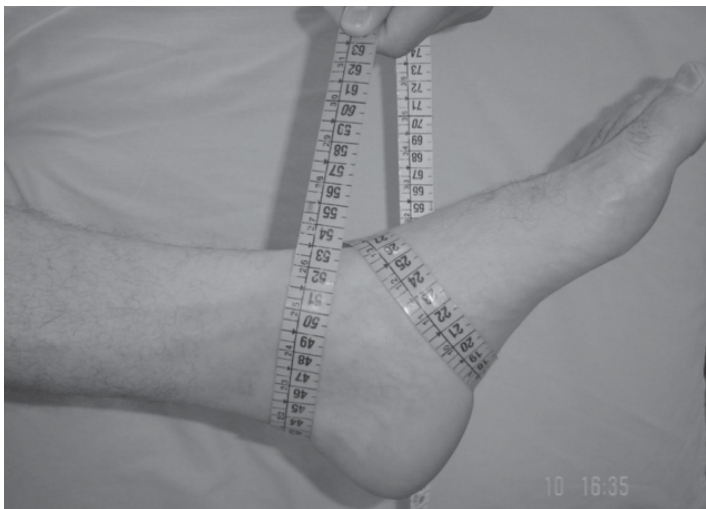


Fig. 2 – Figure-of-Eight method: **A)** tape measure, **B)** foot medial longitudinal arch, **C)** calcaneus tendon, **D)** medial malleolus.

Each examiner performed the measurement three times in each volunteer and recorded values in standardized form.

Statistical analysis

The analysis of variance ANOVA was applied with the objective of comparing the averages individually and between each other.

The Pearson product-moment correlation coefficient was calculated to measure the linear relationship degree between measures collected through volumetry and the Figure-of-Eight method for each examiner.

For the evaluation of the methods' reliability the F test was applied to determine the difference between variances, in other words, to determine which method presented the lowest variation in the data collection. Other test used to verify the collect methods' reliability was the Intraclass Correlation Coefficient (ICC) in which values near to 1 indicate excellent test reliability.

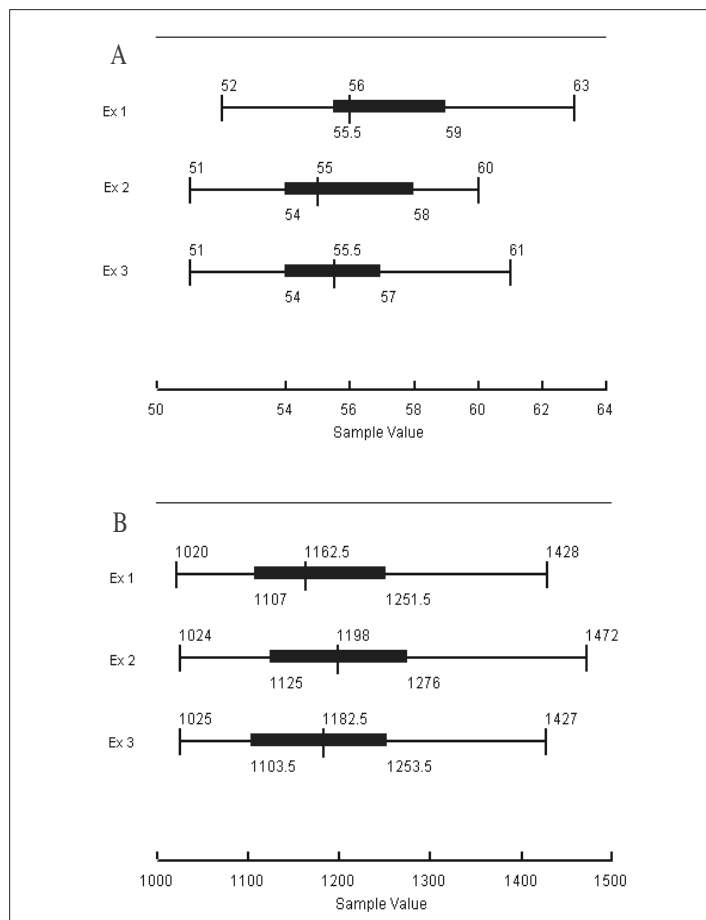
RESULTS

No significant difference for volumetry ($p = 0.87$) and for the Figure-of-Eight method ($p = 0.12$) was verified in the analysis of variance ANOVA.

TABLE 1
Pearson product-moment correlation coefficient (r) between averages from the three examiners

Examiner	r*
A	0,91
B	0,95
C	0,96

* $p < 0,01$



Graphic 1 – Average of values collected by the examiners: **A)** Figure-of-Eight method; **B)** volumetry.

In relation to the Pearson product-moment correlation coefficient, the examiners obtained similarity of results, being the lowest variation in the collect of examiner C (table 1).

The results of the F test presented higher variability in volumetry for 90% of the individuals ($p < 0.05$) and the same variability for 10% of the individuals. In none of the individuals, the volumetry variability was lower if compared with the Figure-of-Eight method.

The set of data after statistical treatment showed the presence of lower variability in data collected by examiners in the Figure-of-Eight method (graphic 1) and the ICC result of 0.99 for both measurement methods corroborates the reliability of both methods.

DISCUSSION

The validation of the results was based on the sample's homogeneity, composed of male young adults with average age of 21.8 years, values that corroborate with data found in literature^(9,13,19-31).

The results indicate that both methods are reliable in the ankle edema measurement, and it is presumed that these results are due to the standardization of the measurements.

It is believed that the volumetry presented higher variability in the F test due to the instability of the liquid mean, once most volunteers could not maintain the MIE still during the measurement performance.

It is supposed that the results similarity was a result of the examiners previous training and the individual technical improvement.

Mawdsley *et al.*⁽¹³⁾ proposed that the Figure-of-Eight method could be reliable, obtaining ICC value of 0.99 when measuring 15

individuals with secondary ankle edema and chronic sprain. Tatro-Adams *et al.*⁽¹¹⁾ obtained equal result when measuring 50 individuals with ankle sprain, obtaining ICC of 0.99.

Wilson *et al.*⁽¹⁵⁾ observed ICC of 0.95 when evaluated 34 athletes with ankle sprain.

According to Esterson⁽¹⁸⁾ and Tatro-Adams *et al.*⁽¹¹⁾, the Figure-of-Eight method is a technique of easy execution also presenting quickness, low cost and reliability and when compared with the volumetry technique, it is also more hygienic.

However, it is presumed that the Figure-of-Eight method should not be selected as measurement method when the edema reaches the entire inferior extremity such as the leg, ankle and foot distal portion, being the volumetry method the recommended technique in these cases.

Other works, comparing different measurement methods, should be conducted for a better comparison between results in function of the lack of works in the literature researched (Medline, Lilacs).

CONCLUSION

One concludes that the Figure-of-Eight method and the volumetry technique present high reliability and easy clinical applicability in the measurement of the ankle joint volume.

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

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