Perometry measurement of lower limb volume: an investigation of criterion-related validity

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Introduction  Limb volume is the primary outcome measure in the management of lymphoedema, often measured using geometric calculations from limb circumferences using a tape measure (TM). The Perometer is an optoelectronic imaging device (Pero-System GmbH, Wuppertal, Germany – Figure 1) that has been developed to describe limb shape as well as volume. A frame is moved along the limb, emitting infra-red beams from two sides, which are interrupted by the limb. Data are used to calculate the summed volume of multiple elliptical discs. Stanton et al (1997) published a validation paper on the horizontal version (300S) of the Perometer (P), focusing on the upper limb, however, in recent years a new upright version (400T) of the Perometer has been developed. To date there has been no validation of 400T and there is a lack of a standardised protocol for its use.

Aims  This study aimed to develop a measurement protocol for the Perometer (400T) and compare it with the tape measure method for the calculation of lower limb volume in healthy individuals. The study was approved by the Physiotherapy Ethics Sub-Committee at Queen Margaret University College.

Method  Pilot work was undertaken to establish a standardised limb position, lower limb landmarks and a percentage of limb length for measurement. Thirty healthy volunteers participated in the study (22 women, 8 men; mean age 26.0; mean height 167.2 cm; mean weight 171.0 kg); individuals were excluded if they had relevant specified past medical history. Participants were requested to avoid vigorous exercise and alcohol consumption 24 hours prior to testing, and food/fluid intake one hour before.

After a 15-minute rest period with the limb elevated to 90 degrees standardised reference marks were placed to indicate the start and end of TM and P volume calculations. The start point was the inferior aspect of the lateral malleolus and the end point was 65% of the total femur length, measured from distal (inferior lateral condyle) to proximal (superior greater trochanter).

The dominant limb was placed within the P frame in a standardised position. The opposite limb was supported in abduction on a 36cm high stool to allow free movement of the frame. The vertical positioning of the limb in frontal and sagittal planes was ensured by using a spirit level. Three P measurements were taken, followed by TM measurements at three-centimetre intervals. The 3-cm disc model was used in preference to the frustrum method as the latter may demonstrate poor fit with the shape of the leg (Stanton et al, 2000).

Volumes in ml were calculated between the two reference marks using the P computer software and using the TM Disc model method (Man et al, 2004). Statistical analysis involved testing for normality of distribution before using parametric inferential statistics: an ICC (3,1) was used to assess the correlation, and limits of agreement were calculated to assess the degree of agreement, between P and TM limb volume estimates.

Results  Limb volume calculations (mean of 3 readings) were 8560 ml (P) and 8717 ml (TM), with a difference of 157 ml. Data were normally distributed (Shapiro-Wilk: p=0.268 P; 0.602 TM). While the ICC (3,1) indicates good associations between the two measures (ICC=0.952, p<0.001), Limits of Agreement analysis (Bland and Altman, 1986) is illustrated in Figure 2 and indicates that 95% of the time P limb volume estimates will be between 519 ml (6.01%) greater and 834 ml (-9.66%) less than TM estimates.

When the P and TM calculations of limb volume for each individual are averaged the mean of these values is 8638.26 ml. Therefore, the total range from upper to lower limits of agreement constitutes 15.67% variation between the volume calculations by P and TM, demonstrating poor agreement.

Discussion  Results indicated poor agreement and therefore measurement methods are not interchangeable. Results cannot determine the respective accuracy of each method. However, further interpretation is possible; in 21 out of the 30 data sets the perimeter calculations were lower than the tape measure. This is expected as the tape measure can overestimate the circumference due to the cross sectional area deviating from the circular. This is accommodated to a greater degree by the Perometer, which bases its calculations on elliptical cross-sections. The discrepancy between methods is greater than that found by Stanton et al (1997) in their investigation of the upper limb.
Conclusion  This was the first study to calculate limits of agreement between TM calculations of limb volume and the upright 400T model of Perometer. Further work is needed in relation to different aspects of validity and reliability to determine which method is more accurate and should therefore be used as a gold standard. Results of the validity and the reliability of the Perometer 400T are presented elsewhere.

References

Figure 1: The Perometer (400T)

Locations also at Clerwood Terrace Edinburgh EH12 8TS and Gateway Theatre Elm Row Edinburgh EH7 4AH
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Figure 2: The limits of agreement between Perometer and Tape Measure circumferential estimates of lower limb volume.