

# A Practical Method to Measure and Track Foot Volume

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## Background and Purpose

- Assessing lower extremity limb volume and its change during and after lymphedema therapy is important for determining treatment efficacy and documenting outcomes.
- Although leg volumes may be determined by tape measure methods, there is no similar method that can routinely be used in a clinical setting to assess foot volumes.
- Our research goal was to develop and test a simple metric measurement procedure and algorithm that could be used by the practicing therapist to accurately estimate foot volumes.

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## Methods Overview

- An algorithm was developed based on foot geometry and measurements of foot dimensions of 60 feet in 30 subjects
- The algorithm's foot volume predictions were compared to foot volumes measured by the "gold standard" water displacement method using regression and limits of agreement (LOA) analyses.
- Regression describes the correlation between volume estimates, whereas LOA, is an index used to judge the interchangeability of methods.

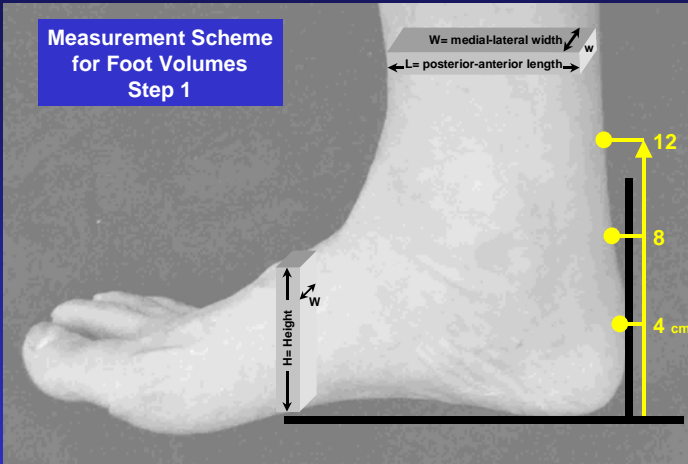
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## Metric Measurement Procedure

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**Measurement Scheme  
for Foot Volumes  
Step 1**

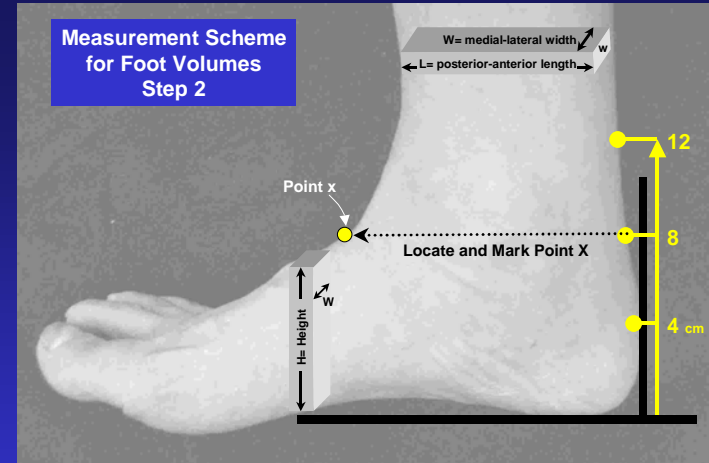


1. Position foot at about 90° flexion and then mark the foot at heights of 4, 8 and 12 cm from bottom.

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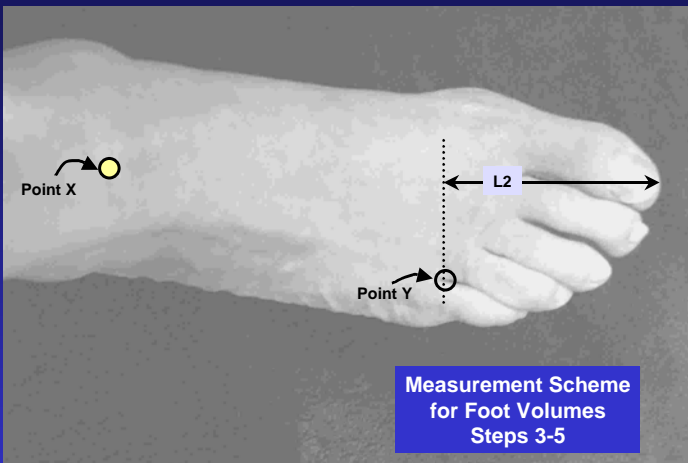
**Measurement Scheme  
for Foot Volumes  
Step 2**



2. At the 8 cm height locate and mark point x. This is determined by the point where a horizontal line, if drawn, would end.

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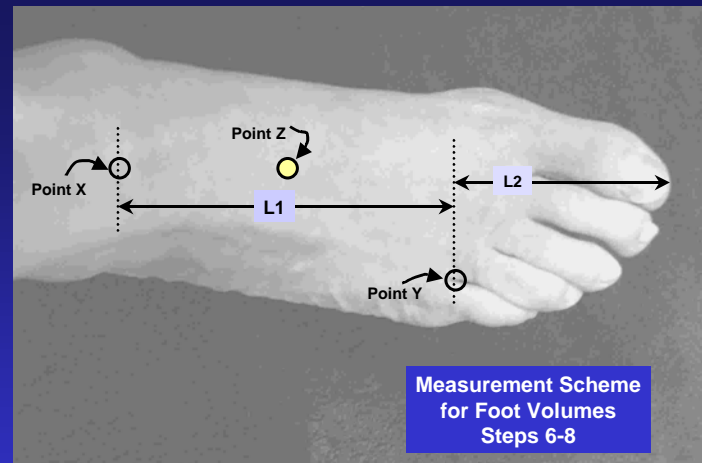
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3. Locate and mark the point Y where the crease between toes 5 and 4 ends.  
4. Draw a line through point Y as shown.  
5. Measure the perpendicular distance (L2) to furthest point on toes  
RECORD L2

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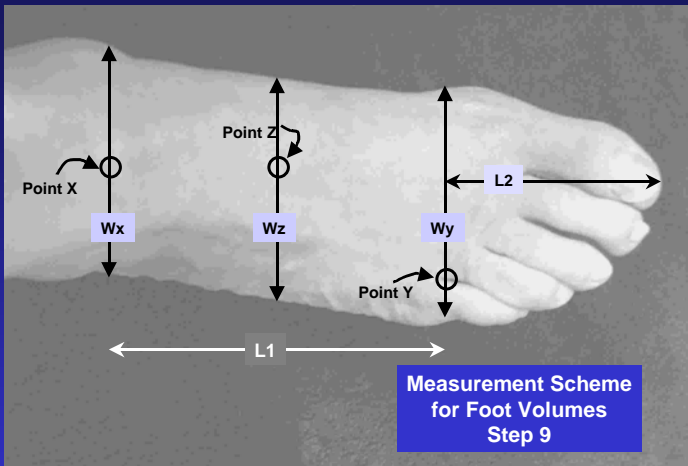
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6. Draw a horizontal line through point X (previously marked) as shown.  
7. Measure the length (L1) between the two lines - RECORD L1  
8. Mark a point (Z) midway between X and Y

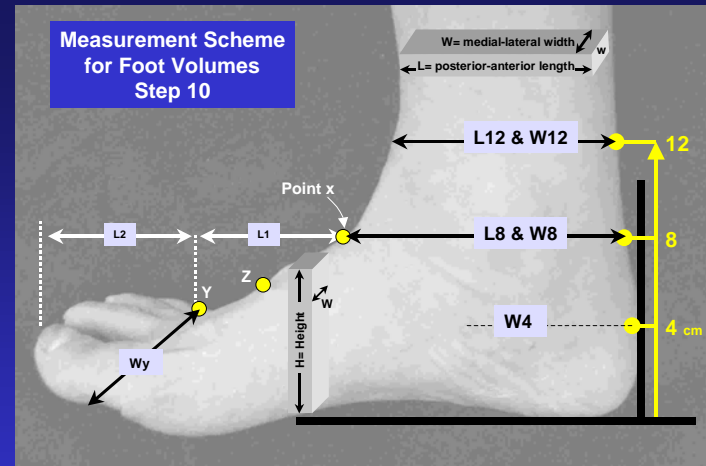
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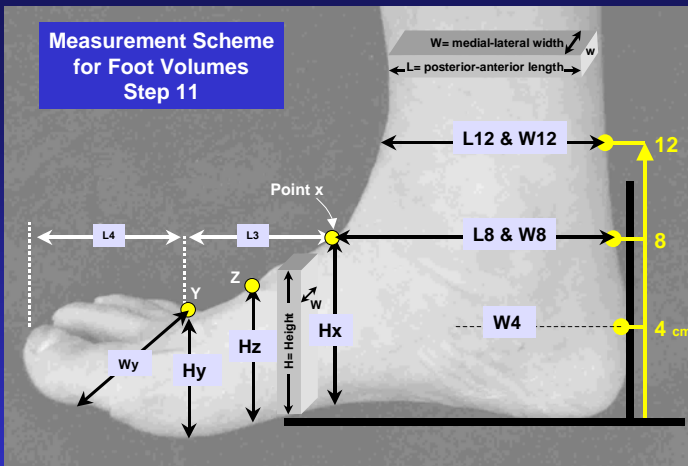
Measurement Scheme for Foot Volumes Step 9

9. Using calipers measure and RECORD the widths Wx, Wz and Wy.



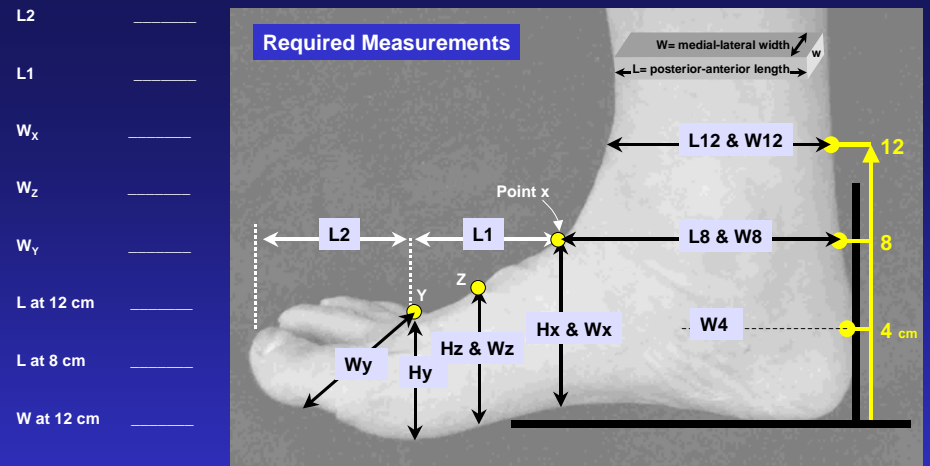
Measurement Scheme for Foot Volumes Step 10

10. Using calipers measure and RECORD the Lengths at 12 and 8 cm and the widths at 12, 8 and 4 cm as indicated.



Measurement Scheme for Foot Volumes Step 11

11. Measure and RECORD the Heights Hx, Hz and Hy as indicated.



Required Measurements

For ease of data entry and consistency, data were entered in mm

# Foot Volume by Water Displacement

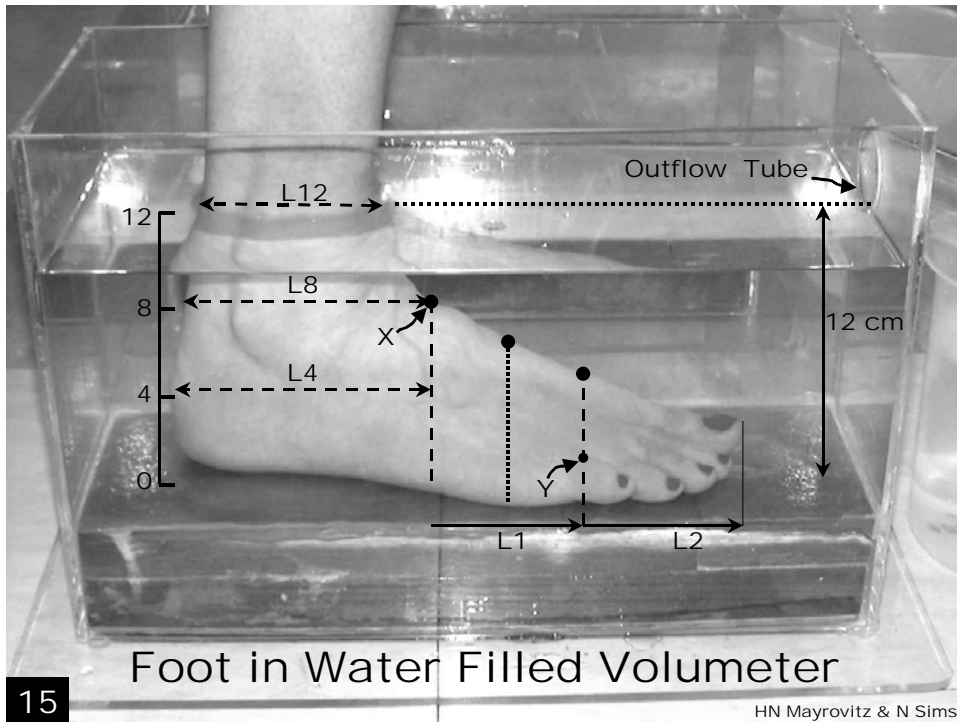
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Foot in Water Filled Volumeter

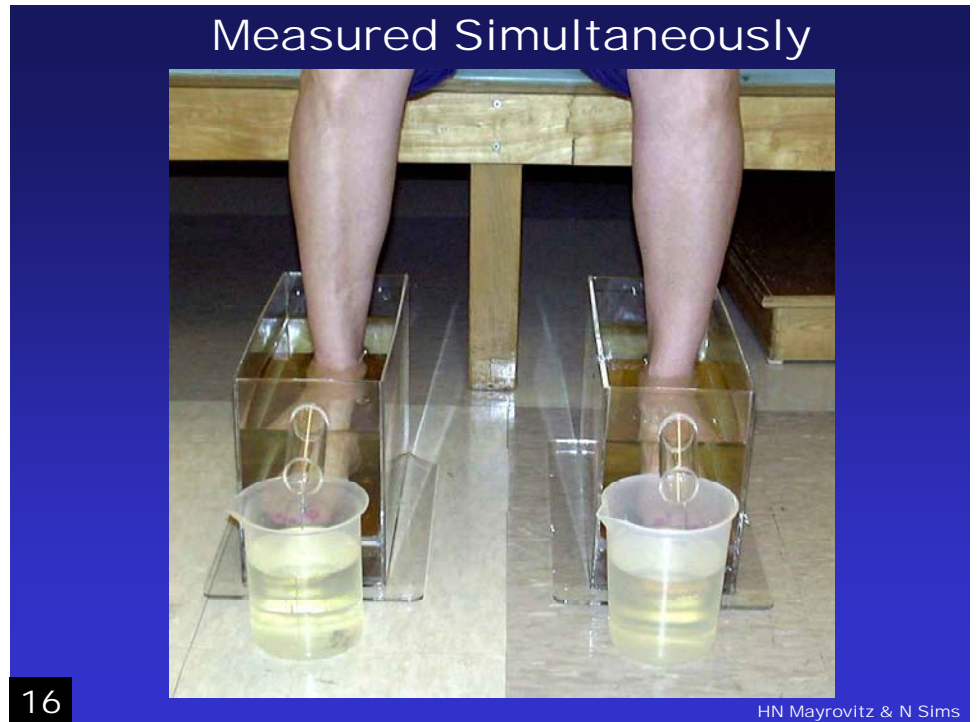
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Foot in Water Filled Volumeter

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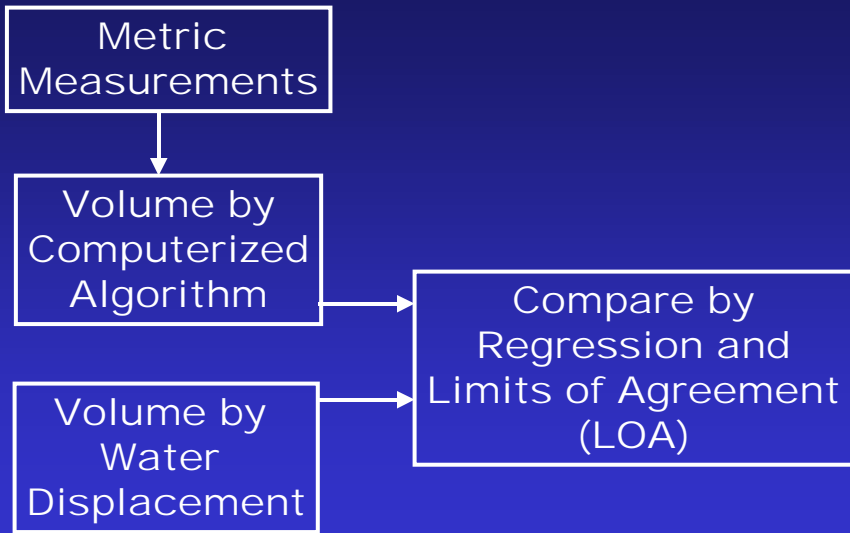


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Measured Simultaneously

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# Analytical Comparisons



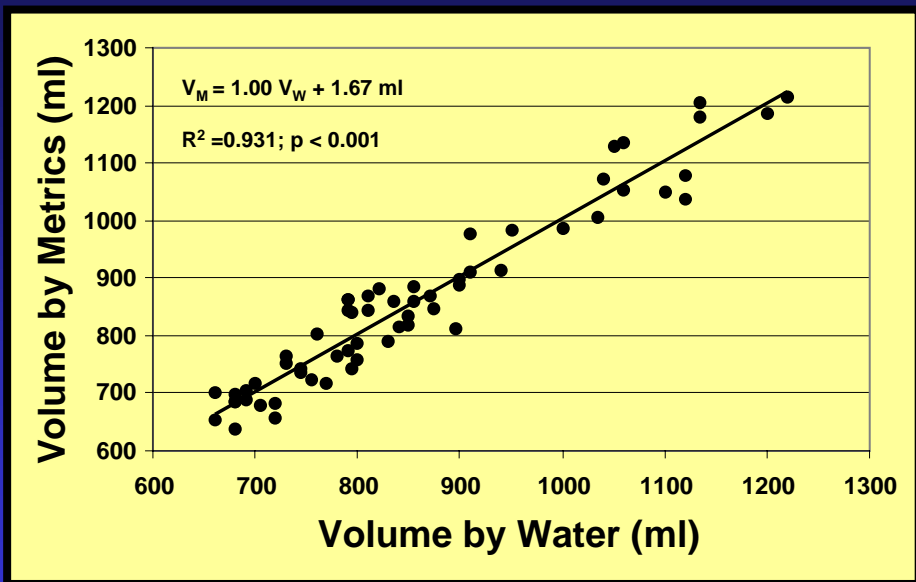
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# RESULTS

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## Relationship Between Methods

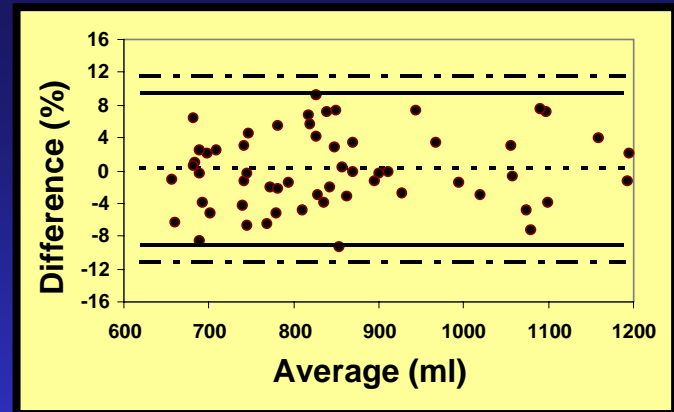


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## Limits of Agreement



	Difference	LOA	95% CI
$V_M - V_W \text{ (ml)}$	$1.62 \pm 39.8$	$\pm 79.6$	+99.1 to -95.8
$(V_M - V_W) / V_W \text{ (%)}$	$0.21 \pm 4.64$	$\pm 9.28$	+11.6 to -11.2

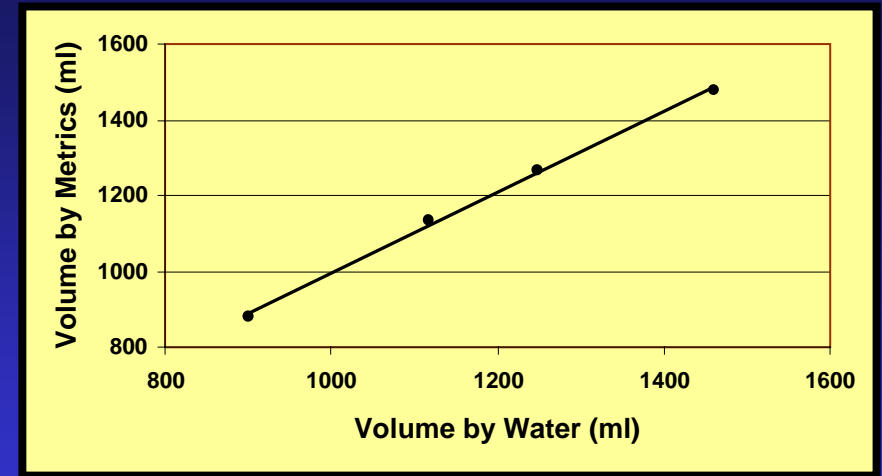
## Simulated Edema



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## Accurate Tracking of Volume Changes



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## 23 Summary and Conclusions

- Based on the small absolute and percentage differences between volume estimates, we conclude that the metric-based algorithm is suitable for use to assess foot volume changes.
- Since the algorithm is easily implemented\*, it provides the therapist with a way to track volumes that is considerably more practical than water displacement procedures.
- Whether the two methods are viewed as fully interchangeable depends on clinical judgment as to an acceptable error based on the LOA between methods.

\* <http://bioscience-research.net/footvolumes.html>

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## Acknowledgements

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