

# 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.

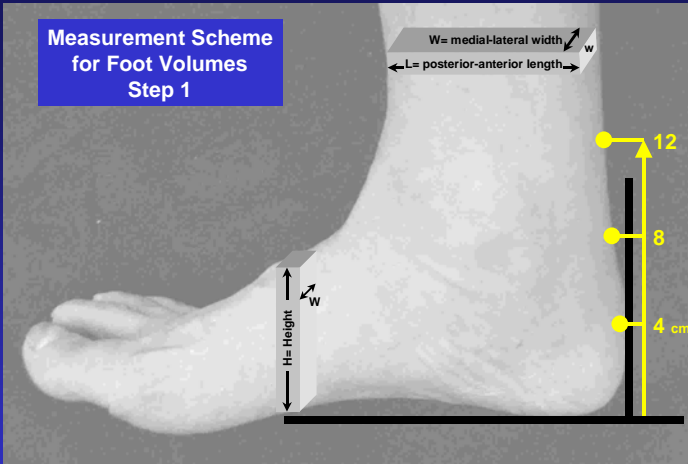
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## Metric Measurement Procedure

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**Measurement Scheme  
for Foot Volumes  
Step 1**

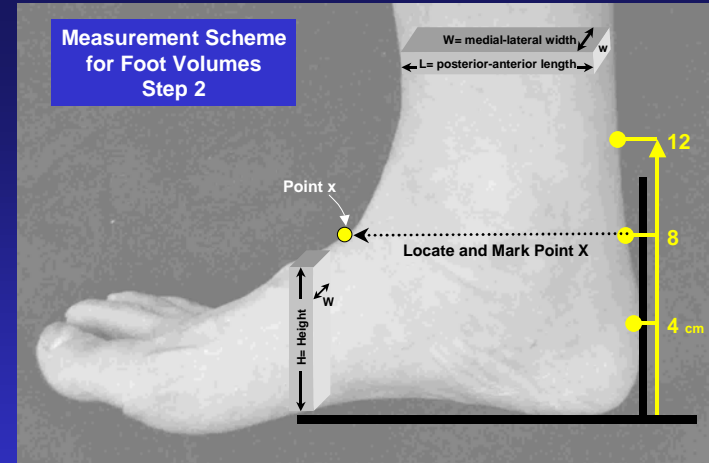


1. Position foot at about 90° flexion and then mark the foot at heights of 4, 8 and 12 cm from bottom.

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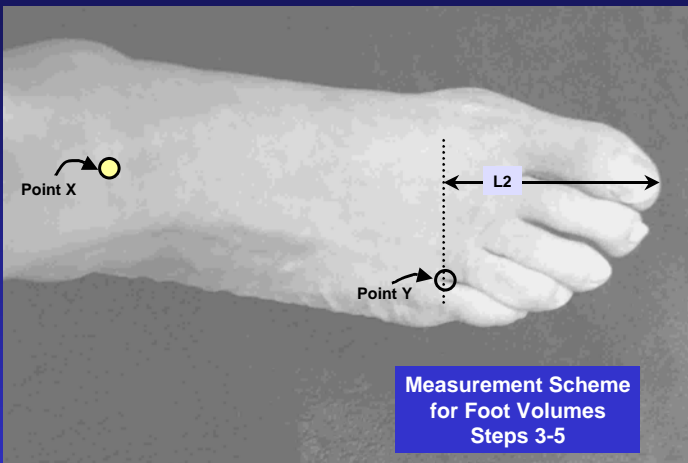
**Measurement Scheme  
for Foot Volumes  
Step 2**



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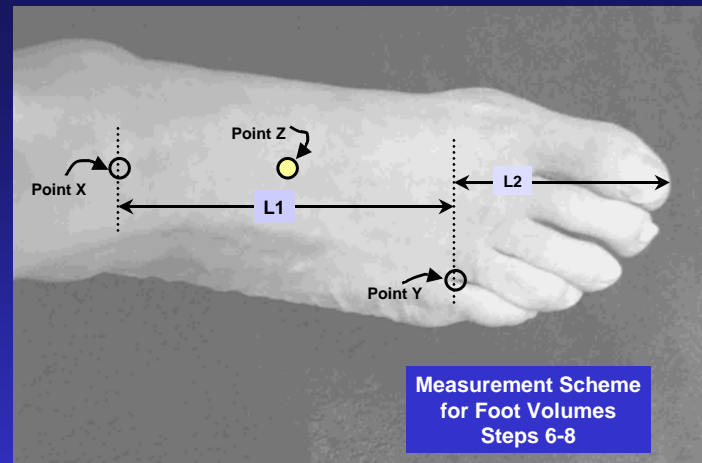
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3. Locate and mark the point Y where the crease between toes 5 and 4 ends.  
4. Draw a line through point Y as shown.  
5. Measure the perpendicular distance (L2) to furthest point on toes  
RECORD L2

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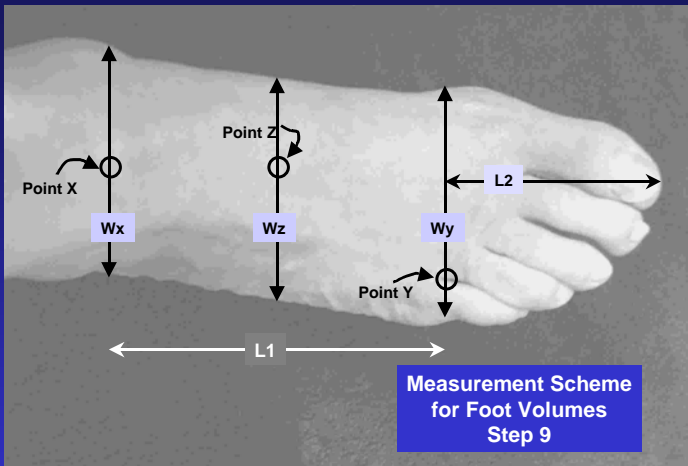
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6. Draw a horizontal line through point X (previously marked) as shown.  
7. Measure the length (L1) between the two lines - RECORD L1  
8. Mark a point (Z) midway between X and Y

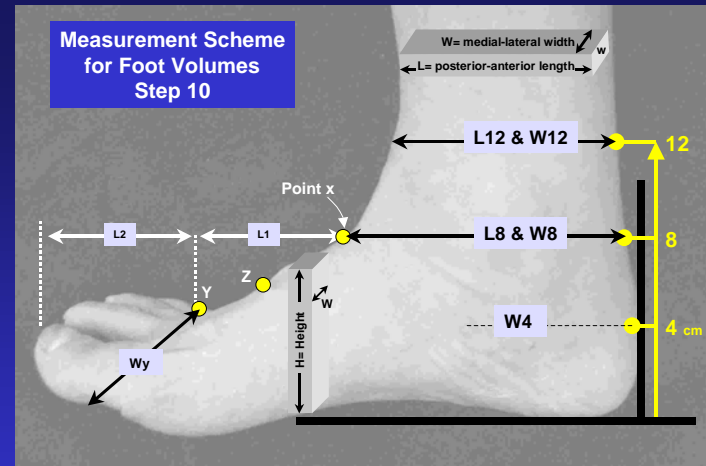
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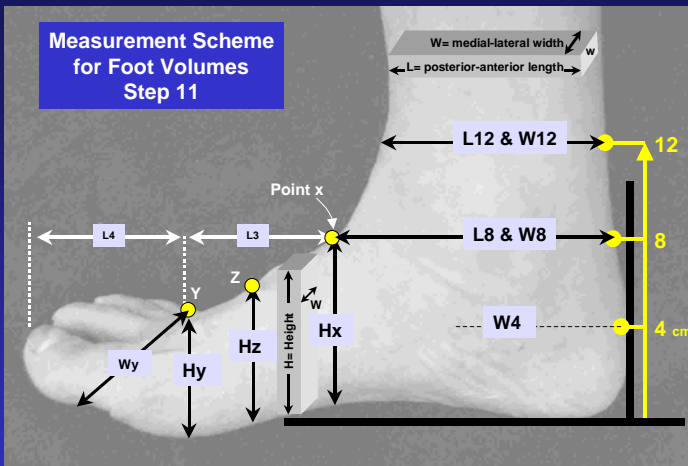
Measurement Scheme for Foot Volumes Step 9

9. Using calipers measure and RECORD the widths  $W_x$ ,  $W_z$  and  $W_y$ .



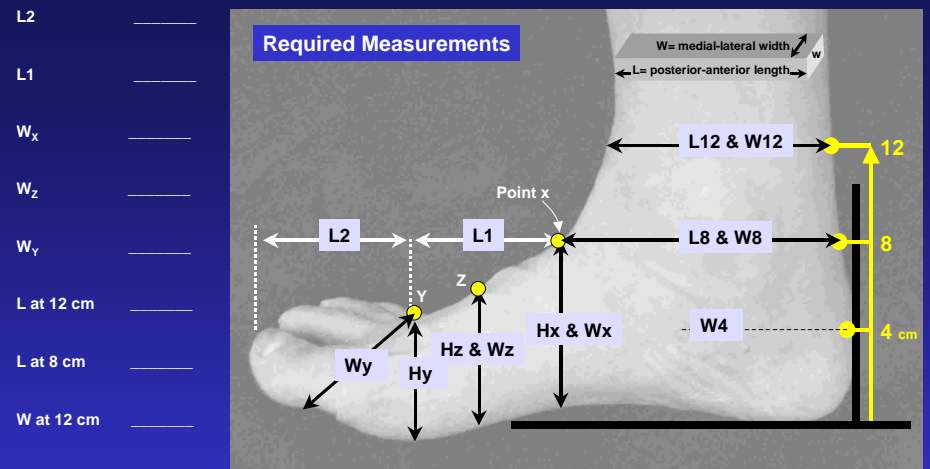
Measurement Scheme for Foot Volumes Step 10

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  $H_x$ ,  $H_z$  and  $H_y$  as indicated.



Required Measurements

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

# Foot Volume by Water Displacement

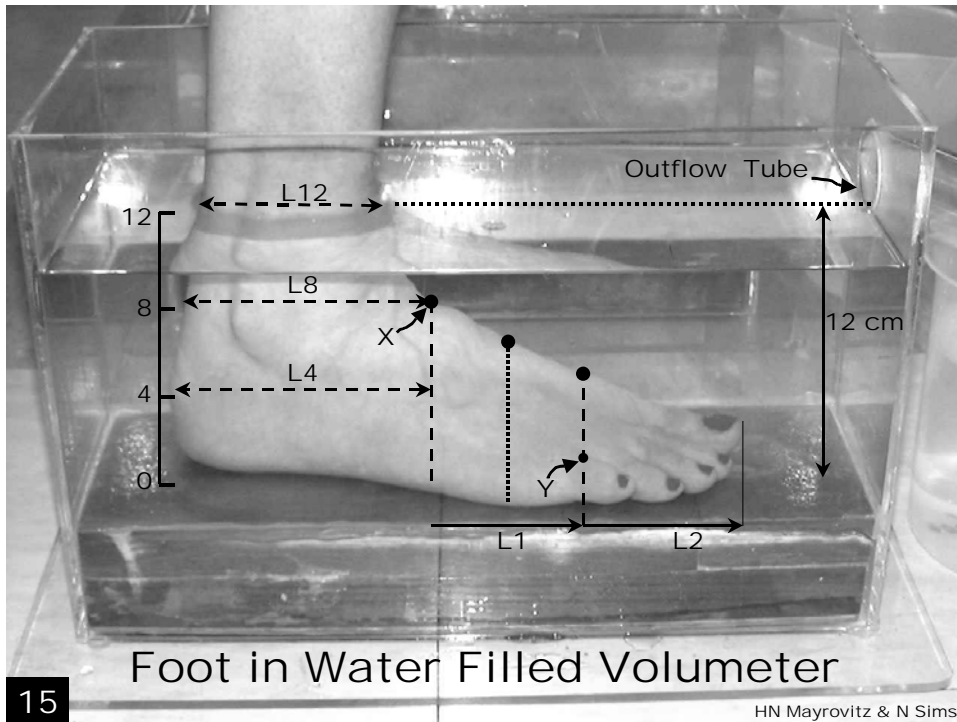
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Foot in Water Filled Volumeter

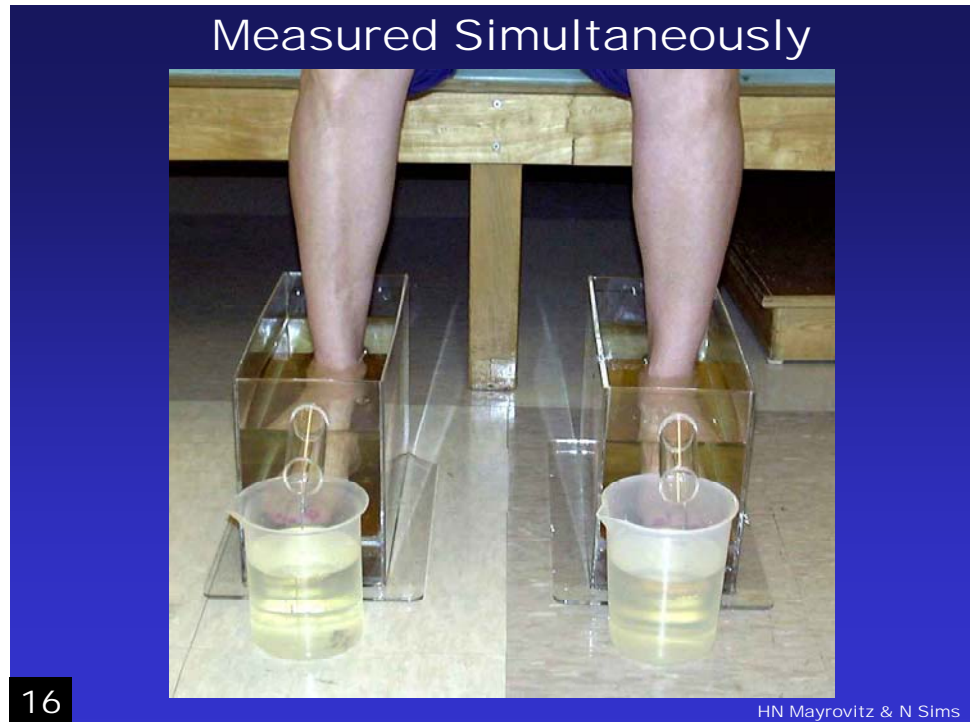
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Foot in Water Filled Volumeter

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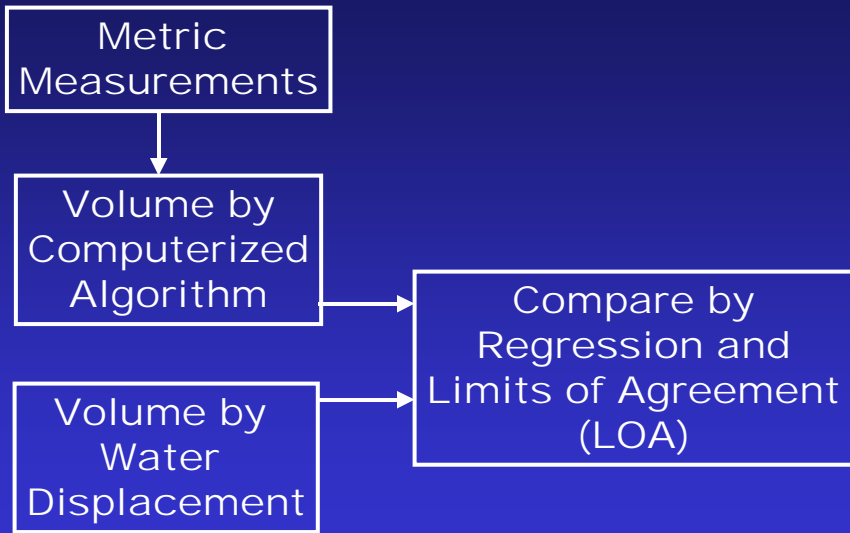


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Measured Simultaneously

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# Analytical Comparisons



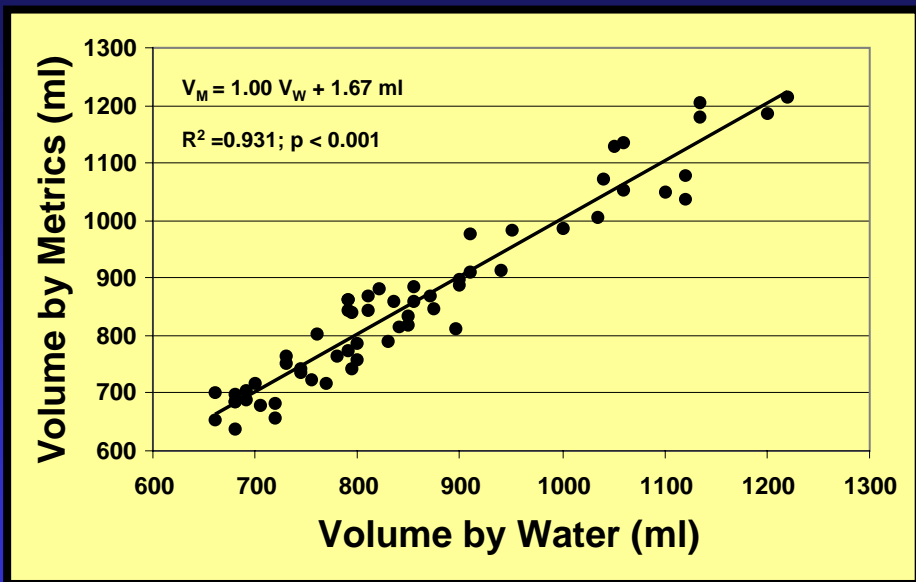
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# RESULTS

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## Relationship Between Methods

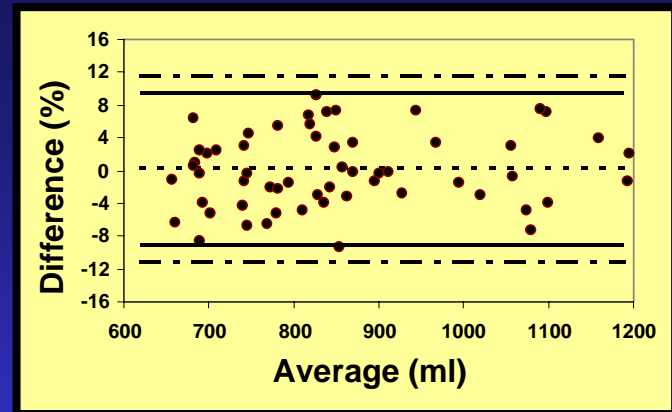


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## Limits of Agreement



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

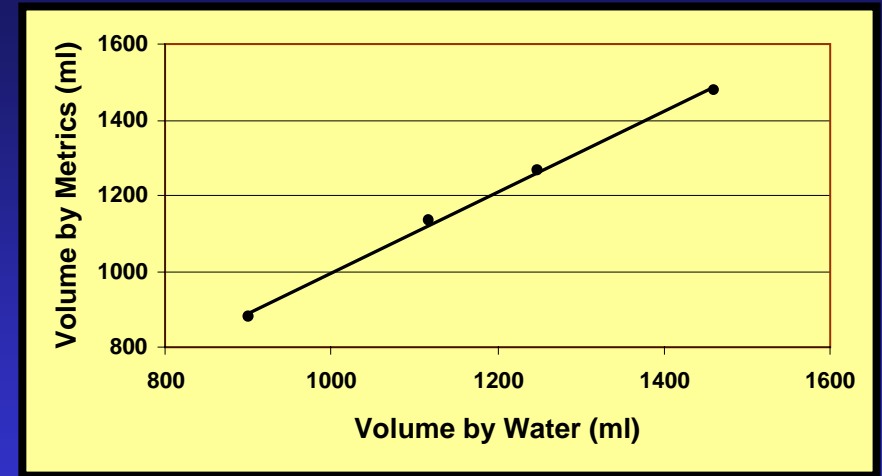
## Simulated Edema



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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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