Speed and Efficiency: Advancing Mobile PAD Assessment with Digital Volume Plethysmography

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Introduction

Peripheral Artery Disease (PAD) impairs limb perfusion and complicates wound healing, particularly in elderly populations. Early detection of PAD is crucial for guiding therapy and improving outcomes.[1] Traditional tools like Ankle-Brachial Index (ABI) and Toe Systolic Pressure (TSP) have significant limitations, including poor sensitivity in calcified vessels, operator variability, and extended test durations.[2] Digital Volume Plethysmography (DVP) offers a potentially faster, non-invasive alternative. This study evaluates the diagnostic effectiveness, speed, and feasibility of DVP compared to ABI and TSP in mobile wound care settings for point-of-care decisions.[3]

Methods

Mobile wound care clinicians performed DVP, ABI, and TSP during the same patient visit. Each test was timed independently to assess efficiency. Data underwent Box-Cox transformation to achieve near-normality. Statistical analyses included Shapiro-Wilk and D'Agostino Tests, Pearson's and Spearman's correlations, ANOVA, Kruskal-Wallis, and Mann-Whitney U tests. Non-inferiority testing utilized Two One-Sided Tests (TOST) with p-values, effect sizes, and confidence intervals. Regression analysis was performed to examine the relationship between test results, ensuring validity through residual plots and multicollinearity checks.

References

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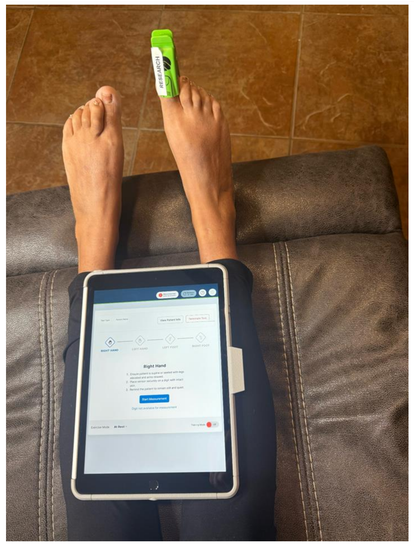
Figures

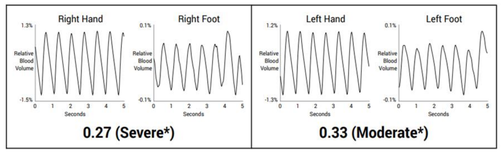


Digital Volume Plethysmography (DVP)

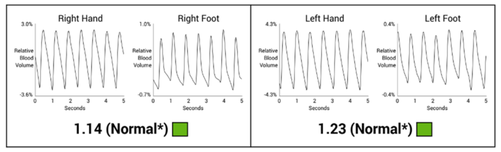
Toe Systolic Pressure (TSP) Ankle-Brachial Index (ABI)

Data

Digital Volume Plethysmography (DVP) Waveforms

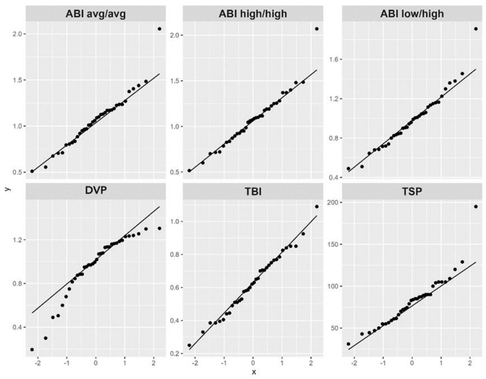


0.27 (Severe*) 0.33 (Moderate*)



1.14 (Normal*) 1.23 (Normal*)

Q-Q Plots of ABI, DVP, TBI, TSP Metrics



Non-Inferiority Analysis

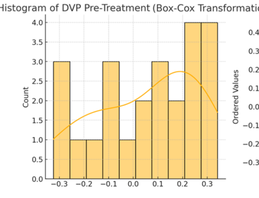
Non-Inferiority Analysis, using NIM = -0.1, -0.2, and -0.3, alpha = 0.025

Paired Legs

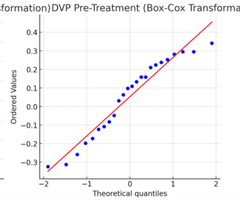
Hypotheses	Comparison	Test	Effect Size [95% CI]	p-value [NIM = -0.1]	p-value [NIM = -0.2]	p-value [NIM = -0.3]
H0: μDVP - μABI/TBI ≤ NIM	DVP – ABI Low/High	TOST (Mann-Whitney)	0.03 [-0.10, 0.15]	0.0246	<0.001	<0.0001
H1: μDVP - μABI/TBI > NIM	DVP – ABI High/High		-0.07 [-0.20, 0.06]	0.3	0.027	< 0.001
	DVP – ABI Avg/Avg		-0.05 [-0.18, 0.06]	0.22	0.016	< 0.001
	DVP – TBI		0.38 [0.27, 0.48]	< 0.0001	< 0.0001	<0.0001
H_0: $\mu_{ABI} - \mu_{TBI} \leq$ NIM	ABI Low/High – TBI	TOST (Two-Sample T-Test)	0.36 [0.25, 0.47]	< 0.0001	< 0.0001	< 0.0001
H_1: $\mu_{ABI} - \mu_{TBI} >$ NIM	ABI High/High – TBI		0.48 [0.33, 0.56]	< 0.0001	< 0.0001	< 0.0001
	ABI Avg/Avg – TBI		0.44 [0.32, 0.55]	< 0.0001	< 0.0001	< 0.0001

Note: p < 0.025 and 95% CI excluding the NIM indicates non-inferiority. Highlighted comparisons indicate non-inferiority has been met. Non-inferiority margin (NIM) deals with effectiveness. NIM helps answer whether the intervention can help patients.

Histogram of DVP Pre-Treatment (Box-Cox Transformation)



DVP Pre-Treatment (Box-Cox Transformation)



Results

A total of **72 limbs** were analyzed from patients (mean age **73 years**, **53% male, 47% female**).

- **DVP was the fastest test** (**3.79 min**) compared to **ABI** (**8.96 min**) and **TSP** (**6.00 min**).
- **DVP was non-inferior to ABI** (**mean difference: -0.021, p < 0.05, TOST, NIM = -0.3**).
- **DVP showed strong reliability**, with **minimal operator variability** and consistent performance across patient demographics.
- **Statistical analyses** confirmed **strong correlations** among ABI measures (**r > 0.95**) and **TSP-TBI correlation > 0.80**.
- **DVP required less equipment**, avoiding painful cuffs, operator variability, and ABI limitations in **mild & severe PAD cases**.

These findings support **DVP as a faster, reliable, and non-inferior alternative to ABI** for PAD screening.

Discussion

DVP offers a practical, reliable, and time-efficient solution for PAD detection in mobile wound care settings. Unlike ABI and TSP, DVP minimizes patient discomfort and operational challenges, facilitating rapid point-of-care decisions. Its ease of use allows clinicians to promptly evaluate limb perfusion, initiate appropriate treatments such as advanced treatment modalities, debridement, and make timely referrals for vascular evaluation. Further research is planned to evaluate DVP's broader application across diverse chronic wound types and its long-term impact on patient outcomes.

This study underscores the potential of DVP as a transformative tool in mobile wound care, enabling improved accessibility to vascular diagnostics and reducing complications associated with delayed PAD detection.