Evaluation of different methods for determining the time delay of the arterial pulse wave: application to the pOpmètre ®

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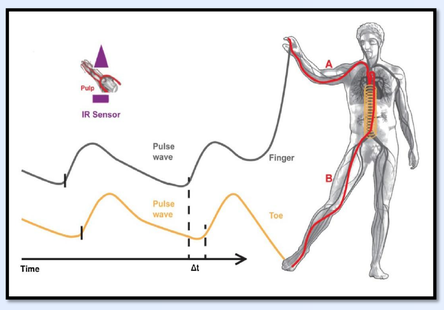
Introduction

Pulse Wave Velocity (PWV), an index of arterial stiffness, can be measured using different approaches by determining the time taken for the arterial pulse to propagate from one site to another. Here we used two different aspects to assess the PWV; the standard method Carotid-Femoral (CF) Sphygmocor (AtCor Medical – Australia) and the pOpmetre ® (Axelife SAS – France) which uses the Finger to Toe (FT) approach, The aim of this study was to evaluate the agreement between FT-PWV and CF-PWV and to assess the robustness of the foot wave detection method used by pOpmetre ®.

Materials and Methods

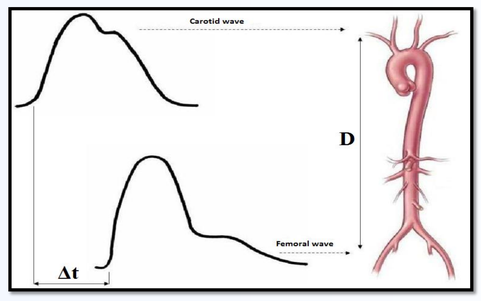
FT PWV - pOpmetre



$$ftPWV = \frac{k.height}{\Delta t}$$

The pOpmètre® has 2 photodiodes sensors, positioned on the finger and on the toe, next to the pulp artery. Pulse waves were recorded continuously for 20 sec, and the difference (Δt) between the toe pulse wave transit times (PWtt) and the finger PWtt was calculated. The travel distance was based on subject's height.

Applanation tonometry



$$PWV = \frac{D}{\Delta t}$$

SphygmoCor records pulse wave signals successively, synchronized with ECG R wave.

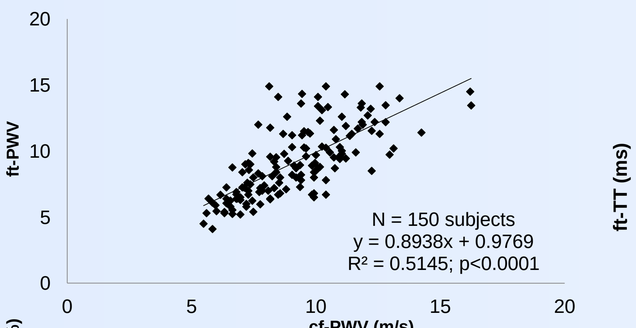
150 subjects mean aged 58(18) have been included in this study: 24 healthy subjects and 126 subjects with hypertension and/or with others CV risk factors. Each subject underwent applanation tonometry to calculate cf-PWV and pOpmètre to calculate ft-PWV. In-house software (MatLab; Mathworks) was used to calculate the propagation time from pOpmètre ® waveforms for 66 subjects using four methods, namely: maximum of second derivative (used by pOpmètre ®), intersecting tangents, 10% threshold and the cross correlation method.

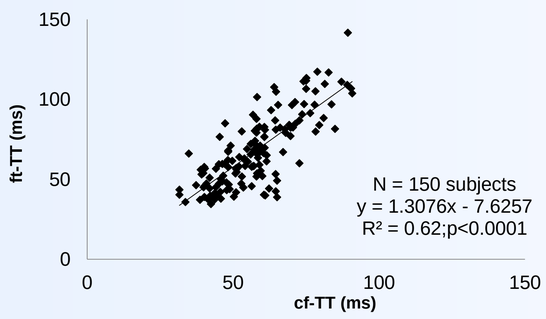
Study 1: Comparison of ft-PWV and ft-TT to SphygmoCor cf-PWV and cf-TT (n= 150 Subjects)

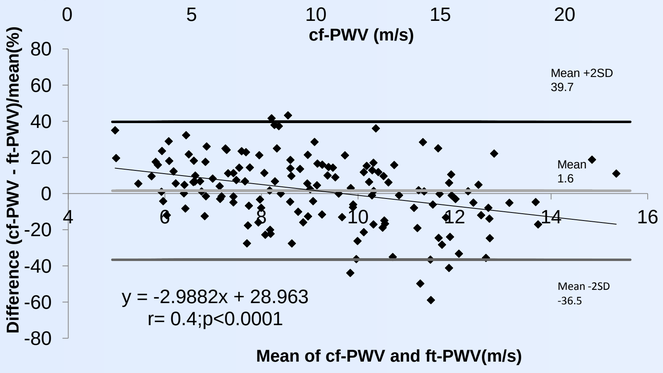
Study 2: Evaluation of different foot wave detection methods for determining the time delay of the arterial pulse wave (n = 66 subjects)

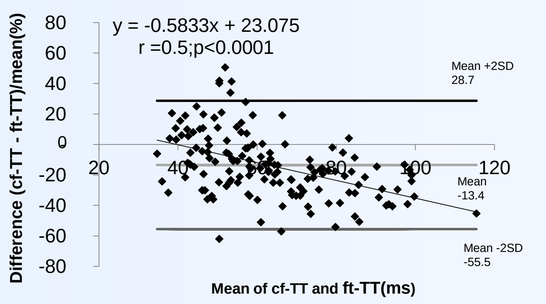
Results

1. Comparison of ft-PWV and cf-PWV









1. Correlation and Bland&Altman plot of PWV and transit time measured by two approaches: Carotid-femoral and Finger-toe
2. Correlations of ft-PWV and ft-TT with different foot wave detection methods

	Study 1 (n = 150; 87 men)	Study 2 (n = 66; 37 men)
Age (years)	58±17 [22-87]	59±13 [23-74]
Height (cm)	169±10 [147-198]	170±10 [148-195]
Weight (kg)	73±13 [44-116]	75±13 [51-106]
BMI (kg/m²)	25±4.8 [16-36]	26±4.1 [18-36]
cf-PWV(m/s)	9.16±2.1 [5.48-16.24]	8.89±1.7 [5.68-13.12]
cf-TT (ms)	57±13 [32-91]	59±12 [37-89]
ft-PWV (m/s)	9.17±2.6 [3.58-14.9]	8.70±2.5 [4.1-14.9]
ft-TT (ms)	67±22 [34-141]	71±21 [32-141]

Data are mean ± standard deviation [range], BMI: body mass index; cf-PWV: carotid-femoral pulse wave velocity;cf-TT: carotid-to-femoral transit time;ft-PWV: finger-toe pulse wave velocity; ft-TT: finger-to-toe transit time

2. Evaluation of different foot wave detection methods

FT - PWV (m/s)		
Method	**r^2**	**RMSE**
Maximum derivative	0.51	1.2
Intersecting tangents	0.37	1.76
10 % upstroke	0.35	1.84
Cross-Correlation	0.22	2.45

FT-PWV correlations with different algorithms

FT - TT (ms)		
Method	**r^2**	**RMSE**
Maximum derivative	0.61	12
Intersecting tangents	0.5	15
10 % upstroke	0.48	16
Cross-Correlation	0.37	18

FT-TT correlations with different algorithms

Discussion and Conclusion

This study showed that pOpmetre ® measurements well correlated with the gold standard method and the wave foot detection algorithm used by pOpmetre ® gave the best correlation comparing to other algorithms. The FT-PWV technique has correct agreement with the reference technique, however further studies are needed to validate FT-PWV method in larger populations. In conclusion, the results of the present study indicate that pOpmetre ® may be a promising device to assess arterial stiffness. Compared to CF-PWV, FT-PWV is faster, simpler to perform and importantly, more acceptable to patients.