

# Calibration methods between pulse wave velocity and blood pressure with PPG morphology

**Citation for published version (APA):**

Radha, M., & Aarts, R. M. (2017). *Calibration methods between pulse wave velocity and blood pressure with PPG morphology*. Poster session presented at 6th Dutch Bio-Medical Engineering Conference 26 & 27 January 2017, Egmond aan Zee, The Netherlands, Egmond aan Zee, Netherlands.

**Document status and date:**

Published: 26/01/2017

**Document Version:**

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

**Please check the document version of this publication:**

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

**General rights**

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

[www.tue.nl/taverne](http://www.tue.nl/taverne)

**Take down policy**

If you believe that this document breaches copyright please contact us at:

[openaccess@tue.nl](mailto:openaccess@tue.nl)

providing details and we will investigate your claim.

# Calibration methods between Pulse Wave Velocity and Blood Pressure with PPG morphology

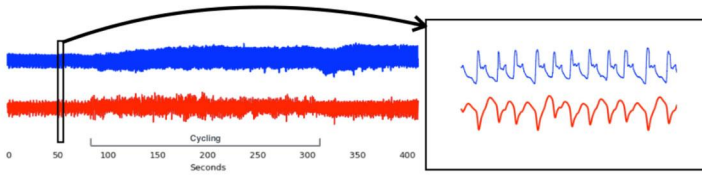
## Background

**Pulse arrival time** is an indirect measure of pulse wave velocity (PWV). Pulse wave velocity is correlated with systolic blood pressure (SBP) and has been proposed as a surrogate method to track systolic blood pressure. The relationship is given by the Moens-Korteweg equation (on the right).

$$PWV = \sqrt{\frac{E_0 e^{\gamma BP} \cdot h}{2\rho \cdot r}} \quad BP = \frac{1}{\gamma} \ln(PWV) - \frac{\ln(E_0 h)}{2\rho r \gamma}$$

$E_0, h, \rho, r$  and  $\gamma$  can be assumed to stay relatively constant within a subject. Thus, a linear calibration to estimate the parameters  $A$  and  $B$  in the linear relationship  $SBP = A \cdot \ln(PWV) + B$  would allow PWV-based SBP tracking.

While  $B$  can be predicted with a single calibration measurement,  $A$  requires a set of simultaneous SBP and PWV measurements to enable accurate calibration.



## Proposal

The parameter  $\gamma$  is an expression of the responsiveness of PWV to changes in SBP, which is related to the ability of the blood vessel to increase in size (i.e. elasticity) in response to increasing pressure.

Measuring arterial elasticity directly is not possible, but the Age Index (AGI) has been proposed as a morphological characteristic of the blood pulse waveform (measured with photoplethysmography, PPG) that expresses the arterial elasticity. AGI is derived from the acceleration PPG (on the right) as:  $AGI = (b-c-d-e)/a$

We propose that if the subject experiences a stressor that induces changes in blood pressure (e.g. physical exercise), the change in AGI will be proportional to the parameter  $\gamma$ .

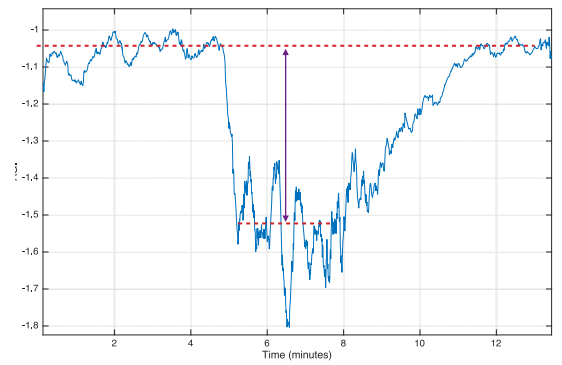
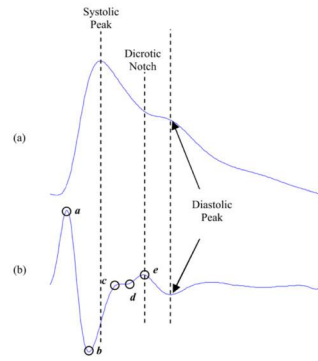
## Method

**Data collection:** 16 subjects performed cycling experiments (5 minutes cycling, 5 minutes rest, repeated 3 times). For each heart beat, the following measures were computed:  
 - **PWV** from ECG to finger PPG,  
 - **SBP** with a CNAP device (vascular unloading technique)  
 - **AGI** from the second derivate of the finger PPG.

**Ground truth for A:** After data cleaning, traditional linear calibration was performed by fitting PWV to SBP through  $SBP = A \cdot PWV + B$ . All heart beats of a participant were used as samples in this model.

**Predicting A with AGI:** The change in AGI during cycling was computed as the standard deviation of AGI over the entire cycling/rest period. The parameters  $A$  were predicted using  $\text{std}(AGI)$  through linear regression per subject. A correlation of 0.84 is found between  $A$  and  $\text{std}(AGI)$ .

**Performance evaluation:** To test the performance,  $\text{std}(AGI)$  was used to predict  $A$  ( $A_{pred}$ ). Then, a single baseline calibration point was taken where  $SBP_{base}$  and  $PWV_{base}$  was obtained for each subject.  $B$  was then calculated as:  $B = SBP_{base} - A_{pred} \cdot \ln(PWV_{base})$



## AGI-based calibration

