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NOTES FOR FITNESS AND HEALTH PROFESSIONALS
A Fact Sheet for Performing Pulse Wave Velocity Analysis

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Abstract

The purpose of this fact sheet is to summarize the theoretical concept of pulse wave velocity as well describe the technical steps required to manually measure this popular and important marker of vascular stiffness. **Health & Fitness Journal of Canada 2010;3(2):25-27.**

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Introduction

Vascular stiffness is highly related to cardiovascular disease risk (Laurent et al. 2006). Pulse wave velocity (PWV) has recently been established as the gold standard for estimating vascular stiffness (van Popele et al. 2001). This marker has widespread application as a primary outcome measure of intervention studies as well as monitoring overall cardiovascular risk in patients and clients (Laurent et al. 2006, van Popele et al. 2001).

Methodology

Pulse wave velocity simply measures to speed of pulse transmission through the body. It is denoted by the equation:

$$PWV = D/T.$$

where D = the distance (cm) between the two points on the body where the pulse is collected (Denoted by "A" in Figure 1).

Points are most commonly sites where a pulse can be collected however it is also:
T= the time (seconds) that it takes for the pulse to travel from the proximal to the distal location (Denoted by either "B" or "C" in Figure 1**).
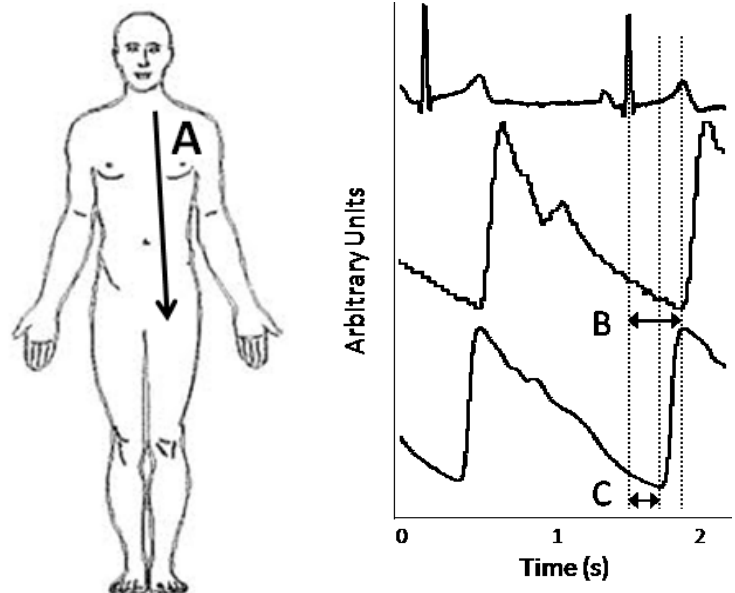

Figure 1. "A" denotes an example distance (cm). "B" denotes the time delay between r-wave of electrocardiogram and time at minimum of arbitrary arterial pulse. "C" denotes the time delay between time at minimum for two arbitrary arterial pulses.

** Points are most commonly two sites where a pulse can be collected however it is possible to use the r-wave of an electrocardiogram (ECG) as the proximal point. It is considered the time points where the pulse is first transmitted out of the heart.

Normal values of PWV can range from 200-700 cm/s depending on the segment of interest. Typically, more peripheral segments such as the leg or arm have higher pulse velocity as compared to central segments.

New equipment is constantly being released which either automatically or manually measures PWV in laboratory and even remote settings.

- Required equipment for manual PWV measurement include: monitoring software and hardware (typically a PowerLab® with LabChart®) with two input signals. These can range from an ECG, infrared plethysmograph probe, arterial tonometer, Caretaker®, Finapres® or Portapres®.

- Automatic models include: SphygmaCor® and AtCor®

Automatic PWV machines require that the operator enter the measured distance "A" and the machine simply calculates the time delay between pulse transmission and arrival from one probe to the next (or between the r-wave and the pulse arrival at the single probe).

Manual equipment is no more affordable, however, users can collect an almost limitless number of additional input variables. Over the past few years, I have standardized a procedure for manual measurement of PWV using PowerLab® with LabChart® and two infrared pleythysmograph probes (PP) which can accomplish the same measurements as the automatic units using a few simple steps.

1. Set up the PowerLab with three live collecting channels (ECG, PP-C, PP-F).
2. Place PP-C on the carotid pulse and PP-F on the femoral pulse (both can be landmarked using established criteria)
3. A minimum of ten consecutive beats is required for a reliable and valid estimate (30 or more is ideal).
4. Click STOP once completed to end sampling phase
5. Find appropriate threshold for ECG (detailed below)

   a) *COMMANDS>FIND>select ECG CHANNEL>FIND DATA>LOCAL MAXIMA>SELECT ALL CHANNELS>THRESHOLD – Try 12% (this will be a trial and error until a threshold is found that only stops on r-wave and skips over all t-waves). Alternatively, do not use threshold, instead use DATA ABOVE. Using the y-axis of the ECG as your guide, select an absolute value that is above the maximum height of the t-wave but below the r-wave.*
   b) *Set up Data-Pad (this is the spreadsheet that will record raw data from the waveforms collected live).*

6. WINDOWS>DATA PAD>Click on Column A>SELECTION AND ACTIVE POINT>TIME AT MINIMUM. Finally, select PP-C channel and click OK. This has programmed Column A to record the time at which the minimum of PP-C occurs.
a) Repeat these steps for "Column B" but select PP-F channel.
7. Creating Macro (this is a mini-program which will tell the software how long and at what interval data will be recorded to the data pad)
a) *MACRO>START RECORDING, COMMANDS>FIND>CHANNEL: Choose ECG channel at the start of where pulse*

contours were collected during step 3. Fill in either "local maxima threshold" or "data above" depending on what recognition technique was used in step 5a. >uncheck SELECT ALL CHANNELS>OK.

b) *Click COMMANDS>FIND>SELECT TO PREVIOUS POINT>click SELECT ALL CHANNELS>OK. Click COMMANDS>ADD TO DATA PAD. Click MACRO>MACRO COMMANDS>BEGIN REPEAT>TYPE 10-30 (depending on how many quality consecutive beats have been collected). Click COMMANDS>FIND NEXT. Click COMMANDS>ADD TO DATA PAD. Click MACRO>MACRO COMMANDS>END REPEAT. Click MACRO>STOP RECORDING. Only fill in Menu Item Type as "PWV".*

8. Click CHANNEL SETTINGS>highlight ALWAYS SECONDS

9. Running the macro (which is now stored in the toolbar) is performed by clicking MACRO>PWV. First, make sure that cursor has been clicked on raw data at beginning of data where values are desired.

10. Save file (export if using LabChart) as Microsoft Excel spreadsheet.

11. Using Excel, calculate time delay between distal and proximal pulse (subtract smaller time from larger)

12. Calculate average for 10-30 beats.

13. Divide distance recorded between two sites (cm) by time (s)

This is the PWV for a given participant.

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Qualifications

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