The Science Behind

Weight #02

The Science Behind

Body Cardio

& Pulse Wave Velocity

Heart health and body composition
Wi-Fi scale

Withings®
Inspire health

The science behind the measurement

Pulse Wave Velocity is usually measured between the carotid and the femoral artery using a Sphygmometer and applanation tonometry. However, this device requires a well-trained operator and is only suitable in a medical setting. Withings has developed a new scale to measure Pulse Wave Velocity quickly and easily at home to ensure the general public has access to this important measurement.

Body Cardio measures the time difference between blood ejection by the heart in the aorta and the arrival of the blood flow in the feet. The time it takes for the pressure wave to travel along the arterial tree is called the Pulse Transit Time. It is used to compute Pulse Wave Velocity by Withings.

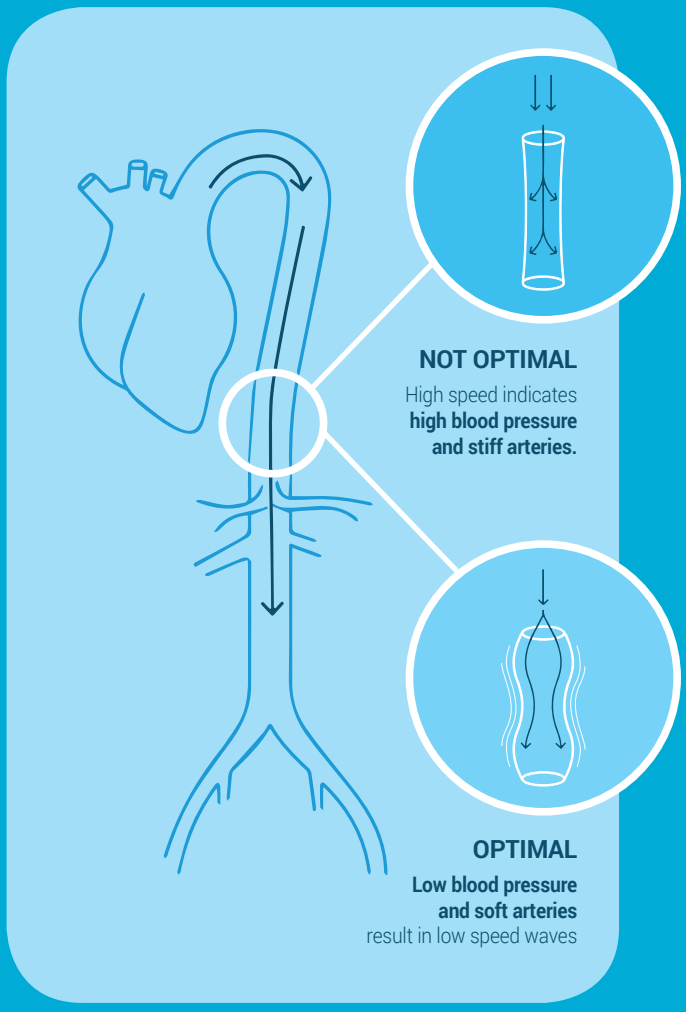

Figure 1. Impact of arterial wall properties and blood pressure on Pulse Wave Velocity.

Despite its medical value to assess cardiovascular health, the complexity associated with collecting Pulse Wave Velocity measurements means that it has, until now, been restricted to second-line medical examination. **Pulse Wave Velocity is now available to everyone for early detection and prevention of cardiovascular events.**

Why it matters

The impact of traditional cardiovascular indicators on health like blood pressure, diabetes, and cholesterol vary according to each person because they are influenced by factors such as age, personal history, and genetic predisposition. As a consequence, doctors need to analyze all these indicators to assess your cardiovascular health.

Pulse Wave Velocity takes many indicators into account - the impact of lifestyle, blood pressure, diabetes, and cholesterol - when assessing cardiovascular health. This is why Pulse Wave Velocity is the only stand-alone measurement that is able to give you the whole picture of your cardiovascular health and your potential risk of having or developing hypertension.

Dive into the science behind **the Pulse Wave Velocity**

Definition of the Pulse Wave Velocity & Arterial Stiffness

Pulse Wave Velocity is the propagation velocity of the pressure wave along the arterial tree. It is linked to the elasticity of the aorta arterial wall. The pressure wave along the arterial tree is due to the heartbeats, which induce blood volume changes in the vessels that expand and contract in response to these blood pressure changes.

Increased stiffness of the aorta will increase the propagation velocity of the pressure wave travelling in the aorta. The consequence of reduced distensibility is increased propagation velocity of the pressure pulse along the arterial tree. It follows the physical principle that, the speed of travel of a pressure wave along an elastic tube is directly related to the stiffness of the tube, this relationship being described as the Moens–Korteweg equation[1].

Pulse Wave Velocity is used to measure the aortic stiffness and is considered to be the gold standard of arterial stiffness measurements[2]. Arterial stiffness describes the reduced capability of an artery to expand and contract in response to pressure changes. The consequence of this decreased capability is increased propagation velocity of the pressure pulse along the aorta.

Discover how Body Cardio
will help you to assess your cardiovascular health

1 **Pulse Wave Velocity** as independent indicator of your cardiovascular health

A recent expert consensus document on arterial stiffness[2] listed several longitudinal studies, demonstrating that a simple measure of Pulse Wave Velocity yielded prognostic values beyond and above traditional risk factors. The consensus report concluded that arterial stiffness measurements[2] are the only way to directly assess your cardiovascular health by measuring your arteries' health.

This is because Pulse Wave Velocity factors in the impact of blood pressure, atherosclerosis (plaques made up of fat on the arterial wall) and lifestyle when assessing the elasticity of the arterial wall.

2 **Pulse Wave Velocity** as an indicator of your potential risk for high blood pressure

Two different mechanisms induce an increase in Pulse Wave Velocity: High blood pressure by inducing a high load of the blood on the arterial wall[3][4] and arterial wall properties. A structural change of the arterial wall due to age, genetics, diabetes, atherosclerosis or sustained hypertension will increase the intrinsic stiffness of the arterial wall and impact its flexibility.

Because it is influenced by both properties of the arterial wall and blood pressure, a short term increase in Pulse Wave Velocity can give you an indication of your blood pressure variations.

3 What is a healthy **Pulse Wave Velocity?**

Pulse Wave Velocity values are used to calculate the age of your arteries. Each Pulse Wave Velocity value above the 75th percentile is a sign of an accelerated aging and each value above the 90th indicates damage in the arterial wall or elevated blood pressure. Pulse Wave Velocity increases with age by approximately 0.1m/s per year[5].

In the mobile application, your Pulse Wave Velocity is compared to the average Pulse Wave Velocity of people in your same age group.

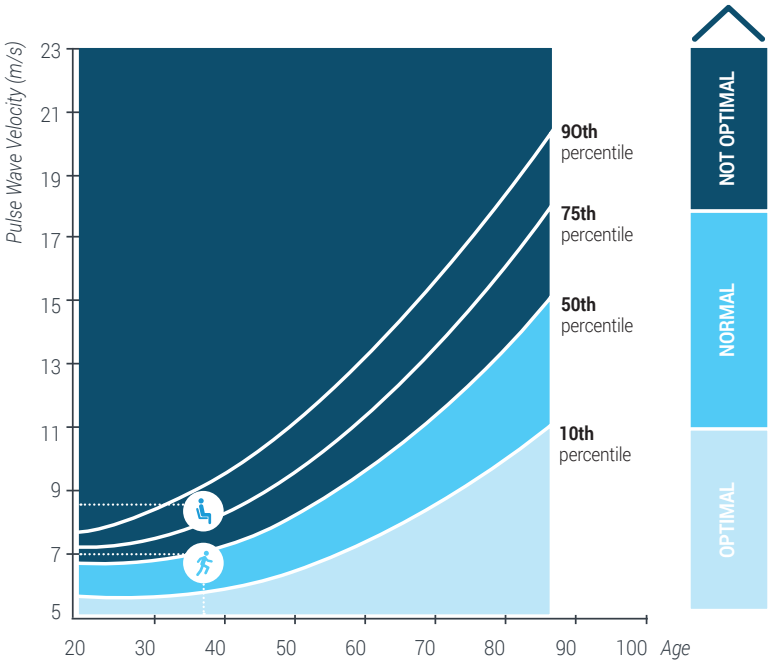

Figure 2. Relation between age, pulse wave velocity and cardiovascular risk.

Use of ballistocardiography and impedance plethysmography to measure Pulse Wave Velocity

When the heart beats it ejects blood in the aorta and exerts a force that leads to weight variations on the scale. In the case of Body Cardio, ballistocardiography has been shown to be synchronized with the opening of the aortic valve and consecutive blood ejection. Impedance plethysmography in a single foot shows the arrival time of the pulse wave in the foot.

So the Pulse Transit Time measured on the scale is the interval between the onset of the systolic pressure wave at the base of the aorta and its arrival at the foot. With an appropriate calibration on a first cohort of individuals, the Pulse Wave Velocity derived from the Pulse Transit Time measured by Body Cardio and the height of the patient can be compared to the one measured with a Sphygmometer[6].

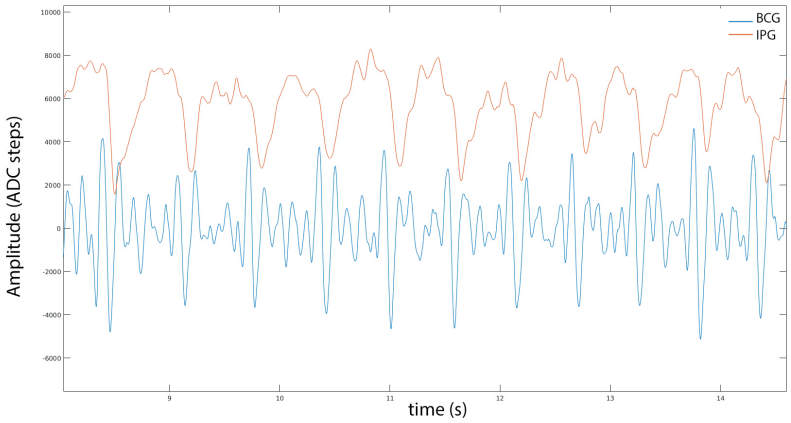

Figure 3. Ballistocardiography (BCG) and Impedance Plethysmography (IPG) signals on Body Cardio.

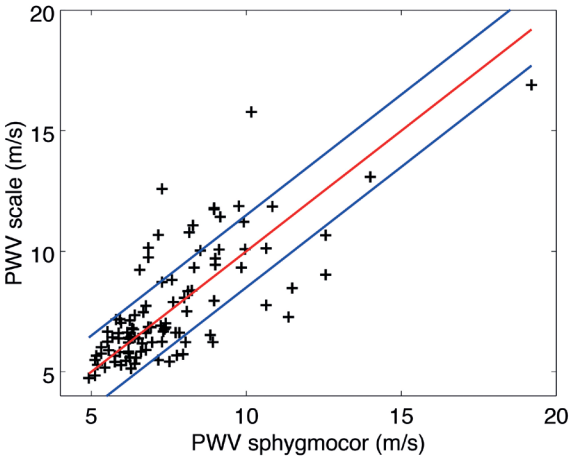

Figure 4. Estimated Body Cardio Body PWV against the reference values obtained with the Sphygmocor (correlation coefficient is r = 0.7). Velocities on the red line are equal. Crosses within the blue lines are ≤ 1.5 m/s away from the reference value.

Scientific validation of Body Cardio

To assess the validity of the measurement of Body Cardio, Withings has performed a study, which compared the measurement of the Aortic Pulse Wave Velocity by Body Cardio to a Sphygmometer, following the recommended guidelines[1]. The Sphygmometer uses applanation tonometry, to measure the Pulse Wave Velocity in the aorta between the carotid and femoral arteries.

This technic, called carotid–femoral pulse wave velocity is a useful measure of central arterial, mainly aortic, stiffness and, by consensus, is generally accepted as the simplest, noninvasive, robust, and reproducible method to determine arterial stiffness[7].

The study was conducted on a group of 111 individuals. The study was conducted in a clinical context by a medical team specialized in arterial stiffness (Pr. Pierre Boutouyrie, AP-HP, Hopital Europeen Georges Pompidou, Paris, France). Two parameters were considered, the Pulse Transit Time and the Pulse Wave Velocity.

The results (figure 4) of this preliminary study show a good correlation between the Pulse Wave Velocity measurements using the Body Cardio and the measurements using the Sphygmometer.

How can you improve **Pulse Wave Velocity?**

- Increase physical exercise
- Decrease salt intake[8]
- Decrease alcohol consumption
- Lose weight[9]
- Decrease stress and anxiety
- Increase some kinds of foods: Mediterranean diet, dark chocolate, green tea…

How to get a **reliable measurement?**

Changes in blood pressure are related to various factors: time of day, stress level, physical activity, diet, alcohol, coffee, and smoking. These factors will cause significant changes in Pulse Wave Velocity, so it is not unusual for one person's Pulse Wave Velocity to vary in a single day. The best way to use your Body Cardio is to follow your Pulse Wave Velocity trend over time. Follow these tips to improve the reliability of your measurements:

- Quiet room with stable temperature (the best is 22-23°C (71.6-73.4°F)[10]
- Same hour every day
- At least 3 hours after a meal, drinking coffee or smoking a cigarette
- Without moving and speaking
- With your feet at the center of the scale.
- Put your hands on the wall in front of you to ensure proper stability if you encounter several failures in your measurements.

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