Initial Validation of Withings Pulse Wave Velocity and Body Composition Scale

by
Aakriti Agrawal

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Approved by:

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Scott Collier, Ph. D., Thesis Director

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Ben Sibley, Ph. D., Second Reader

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Ted Zerucha, Ph.D., Interim Director, The Honors College

Abstract

Mobile devices, wearable technology, smartphone apps, and at home fitness tracking have becoming increasingly popular to monitor personal health. While cardiovascular diseases are the leading cause of mortality, these devices have become a part of people's daily lives as they continuously collect health data to help users prevent and manage chronic diseases. Research has shown that increased arterial stiffness is positively correlated to increased risk of cardiovascular disease. The gold standard for measuring arterial stiffness is pulse wave velocity and is usually measured by SphygmoCor. Withings Body-Cardio scale is a new method in measuring pulse wave velocity and is a scale that an individual can use every day. This study is a validation test comparing the Withings scale to the gold standard method using the SphygmoCor. Subjects in this study had their body composition calculated on the BodPod and had it compared to the measurements by the Withings scale. Standing blood pressure was taken manually and with SphygmoCor. Heart rate and pulse wave velocity were measured by the SphygmoCor had it compared to the measurements taken by the Withings scale. The results indicated that pulse wave velocity measurements taken by the two methods were not clinically different and that the Withings scale accurately calculates pulse wave velocity. This suggests individuals can use this scale daily to assess their cardiovascular health.

Introduction

Wearable devices and mobile phone health apps are becoming widely used among the public. According to the Intercontinental Marketing Services (IMS) Institute for Healthcare Informatics, there were around 110,000 mobile phone apps on Android and iPhone operating systems for health and fitness in 2015.[12] The sales for wearable technology are projected to grow in the United States to $30 billion by 2018. These devices include Fitbit, Apple's smartwatch, Jawbone, and Withings. Mobile devices have the capability to simultaneously collect data and have continuous access to personal health information which provides insights and a holistic view to individual health and fitness. As chronic disease is on the rise, these devices have integrated their existence into people's daily routines and have become a part of normal life. Thus, these devices can be used as a great tool to manage or prevent chronic diseases by empowering users and educating them to take control of their health.[1]

According to the World Health Organization, the leading causes of mortality in developed nations are cardiovascular diseases such as hypertension, coronary artery disease, stroke, and heart failure which are positively correlated to the stiffening of the central arterial system.[9] However, majority of risk factors for these diseases are preventable and treatable with healthy lifestyle behaviors. When the heart contracts, it results in a propagated wave that interacts with aortic impedance which creates a low velocity pressure wave as it progresses to the capillaries.[2,3] Elastic vasculature stiffening is associated with ageing, however, it is also related with cardiovascular and metabolic diseases where cellular mechanisms harden vessel walls. Decreased vascular compliance accentuates itself in a clinical setting as systolic hypertension where systolic blood pressure is greater than 140 mmHg and diastolic blood pressure is less than 90 mmHg.[2] The aorta is less able to accommodate the blood volume ejected by the left ventricle exposing the myocardium to higher systolic pressure which can lead to left ventricular hypertrophy.[3]

Mechanical properties of large arteries are important determinants of health. During the systolic part of blood flow, large elastic arteries absorb the energy which then reduces the cardiac work for the given cardiac output.[4] Pulse wave velocity is the gold standard in measuring arterial stiffness and is usually measured by a SphygmoCor.[5] It is considered the most precise way to non-invasively estimate arterial stiffness in humans. Measuring this is highly reproducible, accurate, and easily and automatically determined. It is used as an index of arterial distensibility: the ability of the artery to stretch. Faster speeds or a high pulse wave velocity indicate stiffer arteries which is associated with an increased risk in hypertension or cardiovascular disease. It is calculated from the distance the pulse travels between two recording sites and the time it takes for it to travel. The two recording sites commonly used are the carotid and femoral arteries.[4] Carotid-femoral pulse wave velocity evaluate aortic distensibility because the pressure waveforms are easily recorded on these sites, the distance between them is large enough for an accurate calculation of time interval, and it reflects arterial wall elasticity which is related to the aorta. Reduced arterial distensibility leads to an increase in systolic pressure which is associated with cardiovascular morbidity. In humans, age is the most important contributing factor to increased pulse rate velocity because of increased arterial stiffness from reduced elasticity and medial calcification where calcium deposits are found in the middle muscular layer of the arteries which leads to the hardening of arteries.[6] Stiffening of the arteries estimated by pulse wave velocity measurements helps early detection of vascular damage and individual cardiovascular risk.

A new method of calculating pulse wave velocity is via Withings' Body-Cardio Scale which connects to the Health Mate app on a smart phone device.[10] Unlike the SphygmoCor which requires a trained operator and is used in a medical setting, the Body-Cardio Scale can be used at home. It provides accessibility to the measurement of pulse wave velocity to the general population. The way that the scale does this is by measuring the time it takes for the blood that is ejected by the aorta to reach the feet. Because many factors can affect the variation of blood pressure and pulse wave velocity measurements such as time of day, stress level, diet, physical activity level, and coffee consumption, an individual will be able to estimate pulse wave velocity daily with the scale to get a more holistic picture of cardiovascular health.

Methods

Participants Five young adults participated in this study. Four subjects were male and one subject was female.

Study Design Subjects reported to the Vascular Biology and Autonomic Studies lab in Charleston Forge for one visit that lasted approximately 60 minutes. The subjects were tested early in the morning, were fasted for at least 8 hours, and refrained from alcohol, caffeine and tobacco 24 hours prior to the visit. The study was approved by the University Institutional Review Board. Subjects gave written informed consent and went through a medical history form before participation.

Height and weight of the subjects were measured and blood pressure was then measured standing up. Body fat percentage was measured next using the BodPod plethysmograph. The subject sat in the chamber while the BodPod estimated fat mass and muscle mass by air movement.

The subject was registered on to the Withings Scale by using the Health Mate App to enter biometric data on an Apple iOS device. Once the biometric data was entered in, the subject moistened his or her feet before stepping on to the Withings Scale. Then, the subject stood on the scale until it recognized him or her and could calculate heart rate. The subject stood on the scale five times or until a pulse wave velocity measurement was detected.

A standing blood pressure was then calculated with the SphygmoCor. After that, a cuff was placed on top of the thigh to constrict the femoral artery. Measurements were taken from the carotid artery to the sternal notch, from the sternal notch to the cuff, and the femoral artery to the cuff. A pen-like device was placed on the subject's carotid artery and the SphygmoCor measured pulse wave velocity and heart rate. Directly after, the subject dampened his or her feet with a wet paper towel and stood on the Withings scale until a pulse wave velocity measurement was taken. Heart rate, fat mass, and fat free mass were also calculated by the Withings scale. A total of three trials were conducted.

Results

Statistical analyses were run for all samples through SPSS. Repeated measures anova was performed. Since several measures did not reach significance t-tests were employed and the results were plotted as box and whiskers to create visual representations of the data.

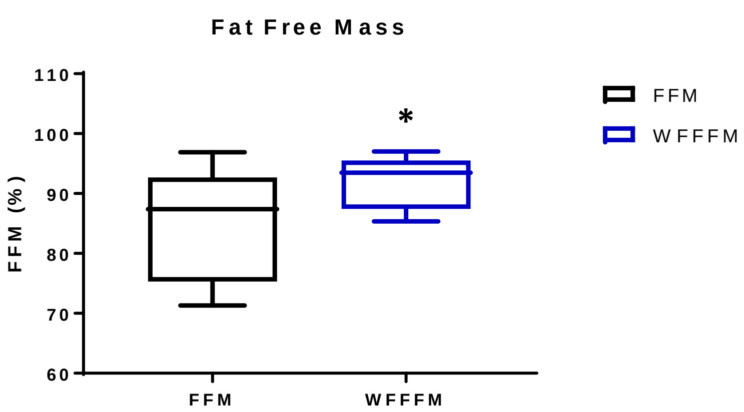

Figure 1. Fat free mass percentage calculated with BodPod vs Withings scale

BodPod fat free mass had a mean of 84.68 ± 9.74% and Withings fat free mass had a mean of 91.88 ± 4.52%. There was a significant difference between fat free mass measured with gold standard versus Withings scale where the Withings significantly overestimated fat free mass (*p = 0.037)

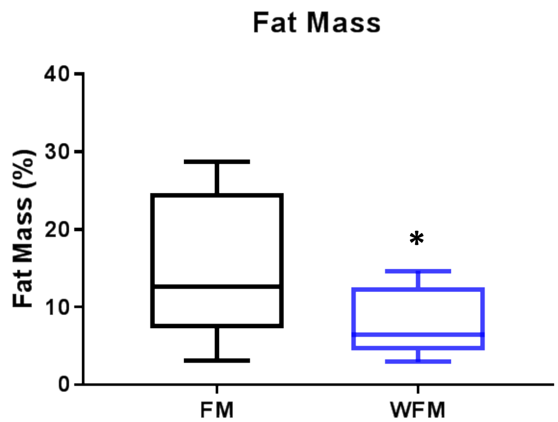

Figure 2. Fat mass percentage calculated with BodPod vs Withings scale

BodPod fat mass had a mean of 15.32 ± 9.74% and Withings fat mass had a mean of 8.11 ± 4.53%. There was a significant difference between fat mass measured with gold standard versus Withings scale where the Withings significantly underestimated fat mass (*p = 0.037)

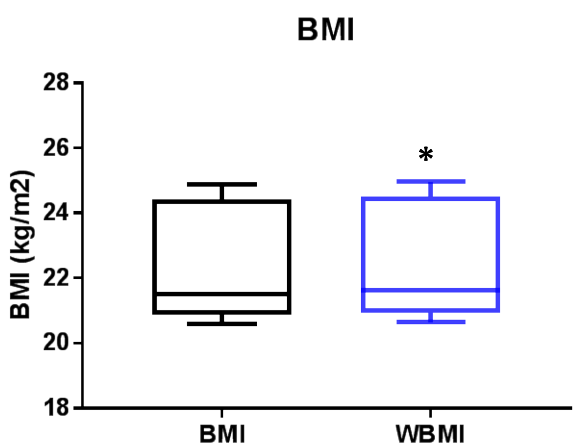

Figure 3. Body Mass Index calculated with BodPod vs Withings Scale

The mean for BMI calculated with BodPod was 22.41 ± 1.89% and from Withings it was 22.5 ± 1.9%. There was a significant difference between BMI measured with gold standard versus Withings scale where the Withings slightly overestimated BMI (p = 0.004)

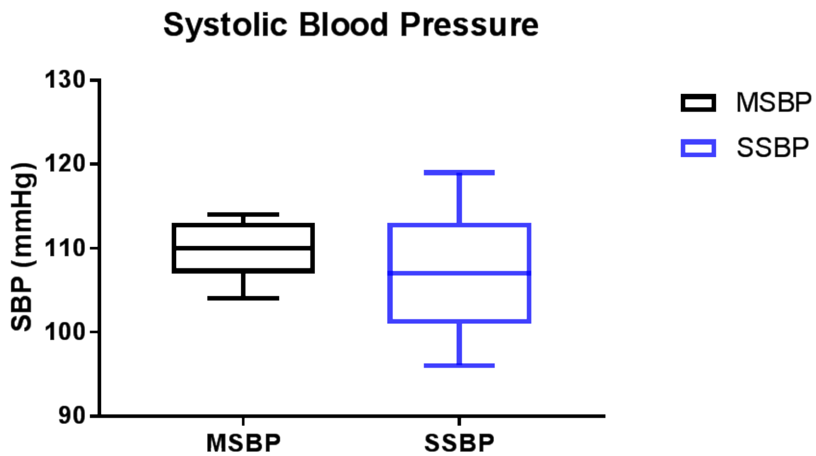

Figure 4. Systolic blood pressure taken standing manually vs SphygmoCor

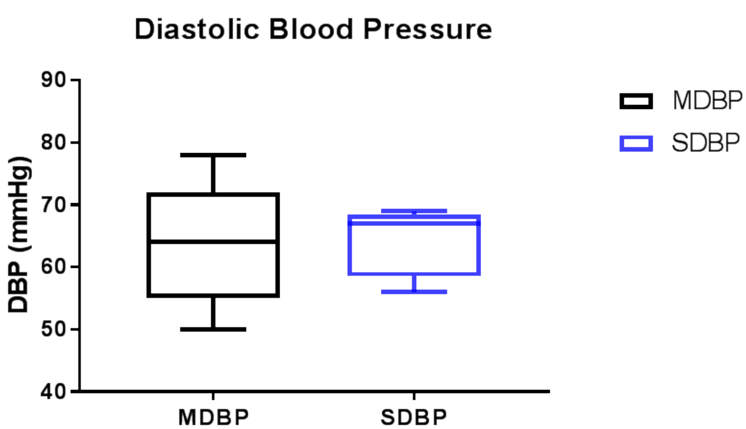

Figure 5. Diastolic blood pressure taken standing manually vs SphygmoCor

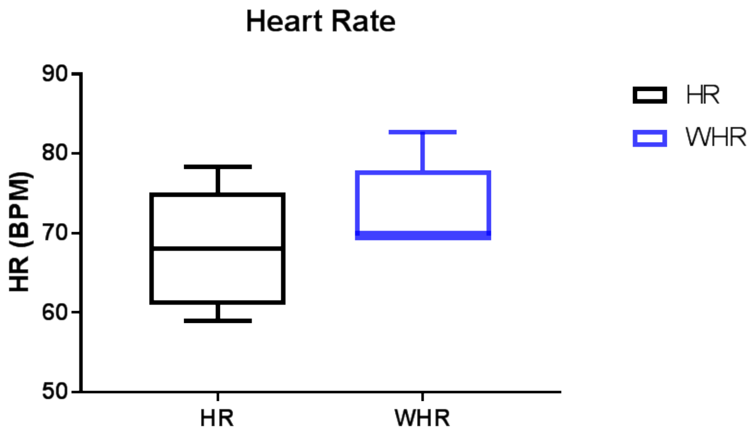

Figure 6. Heart rate calculated with SphygmoCor vs Withings scale

SphygmoCor heart rate mean was 68.07 ± 7.56 beats per minute and Withings heart rate mean was 72.73 ± 5.79 beats per minute. There was no significant difference between heart rate measured with gold standard versus Withings scale ($p = 0.096$).

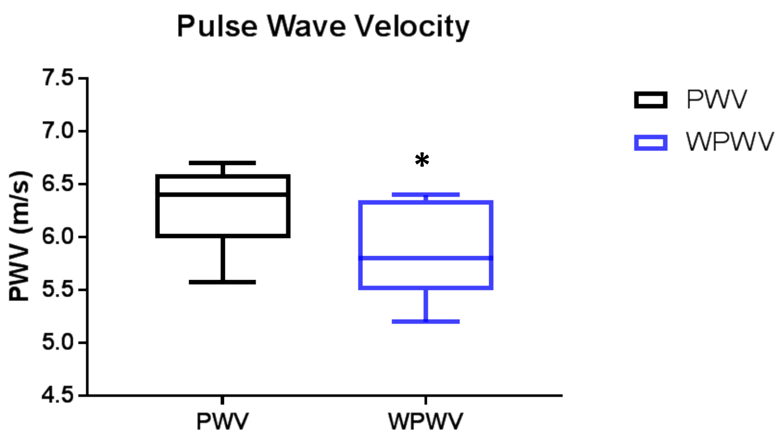

Figure 7. Pulse wave velocity calculated with SphygmoCor vs Withings scale

SphygmoCor pulse wave velocity mean was 6.31 ± 0.43 m/s and Withings pulse wave velocity mean was 5.9 ± 0.48 m/s. There was a significant difference between pulse wave velocity measured with gold standard versus Withings scale where the Withings slightly underestimated pulse wave velocity ($p = 0.011$)

Discussion

The present study was a validity test comparing pulse wave velocity measurements with the Withings Body-Cardio scale to the SphygmoCor gold standard. The results suggest that there is significant different between body composition comparing the Withings scale to the BodPod gold standard. With a 7% fat mass and fat free mass difference between the means, the Withings scale is not reliable in measuring body composition as it significantly overestimates fat free mass and significantly underestimates fat mass. Withings uses Bioelectrical Impedance Analysis (BIA) to estimate body composition. The scale sends a small current to measure impedance that is used to calculate an estimate of total body of water which estimates body composition.[11] However, a person's hydration levels can affect BIA's accuracy. BMI measurements between BodPod and the Withings scale had a significant difference where Withings slightly overestimated BMI. The height of the subject was measured by the stadiometer, however, the difference in BMI came from the different weight measurements calculated by BodPod and Withings. The results also show that there is no significant difference between heart rate calculated by the SphygmoCor gold standard and the Withings scale. This is important because an increase in heart rate is correlated with an increase in pulse wave velocity. Systolic and diastolic blood pressure was measured once manually standing up and three times by the SphygmoCor from the three trials and an average taken from the three trials. Research has shown that an increase in blood pressure has an increase in pulse wave velocity. The results for the subjects showed they had normotensive blood pressure which related to the pulse wave velocity results as those were in the normal range of 5.3 m/s – 7.1 m/s for ages less than 30 years. Pulse wave velocity measurements between the SphygmoCor gold standard and Withings scale had a significant difference with Withings slightly underestimating it. However, there is no clinical difference between the gold standard and the scale. This suggests that the Withings scale is reliable to accurately measure pulse wave velocity.

Arterial stiffness is the vessels' first modification that leads to cardiovascular disease therefore consistently measuring pulse wave velocity can help with early detection of cardiovascular disease and to help maintain a healthy lifestyle. This study indicates that the Withings Body-Cardio scale can be used by individuals daily to measure pulse wave velocity. Individuals can use the scale at home without a trained professional and can get a pulse wave velocity measurement over time to best assess cardiovascular health. At home measurements are ideal because it reduces the white coat effect: blood pressure increases when obtained by a medical professional of authoritative standing. Research has shown that the effect specifically increases systolic blood pressure and is a common phenomenon conditioned by anticipation of having blood pressure taken with the fear that the results may indicate an illness.[8]

There are few limitations in this study. One was the amount of time it took to get a pulse wave velocity measurement with the SphygmoCor. Because it took a long time detecting a pulse in the carotid artery, the tonometer depressed the artery. Thus, it became more difficult to get accurate pulse wave velocity measurement in the subsequent trials. The Withings scale also did not detect heart rate and pulse wave velocity consistently. There were only five subjects so the sample size was small which questions the stability of the statistics. In future studies, a bigger age range should be introduced to provide more variability in the results instead of in the normal range with healthy young adults.

In conclusion, the Withings Body-Cardio scale is a valid way of measuring pulse wave velocity in healthy young adults and can be used instead of the SphygmoCor. It is affordable and can provide an overall assessment of cardiovascular health.

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