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Activity Tracking's Newest Companion - Pulse Wave Velocity

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Chances are you or someone you know is wearing a device to monitor their physical activity. Sales of consumer physical activity monitor "watches" have skyrocketed from 15 million in 2014 to 65 million in 2017 (DigiWorld https://www.statista.com/statistics/461548/wearable-tech-sales-worldwide-by-category/ Accessed May 14, 2018). This explosion in physical activity monitoring is attracting investigators intrigued by their research potential.[1] Many consumer devices have the ability to transfer data on a scale that facilitates longitudinal studies. Once the validity of these consumer monitors was established for tracking steps, researchers began to use them in combination with devices to monitor other physiological functions. Brouard et al.[2] analyzed data from 19,000 adults who owned both a Withings' Pulse activity tracker and the company's FDA-cleared wireless blood pressure (BP) cuff. The authors found increases of 1,000 steps per day for one month led to decreases in systolic BP in both sexes (Δ: Men, −0.13 mmHg; Women, −0.21 mmHg). Using the same devices in over 9,000 individuals across 37 countries with an analysis stratified by body weight (BW), Menai et al.[3] found that increasing steps by more than 3,000 per day decreased both systolic (−1.6 mmHg) and diastolic (−1.3 mmHg) BP in overweight but not in normal weight individuals.

In this issue, Modena et al.[4] are the first to report findings from a study in a naturalistic setting that combines an activity tracker with a "smart" BW scale that also measures pulse wave velocity (PWV). Using ballistocardiography and impedance plethysmography, Withings was the first to develop a consumer device that measures PWV via a BW scale. Moreover, a recent report demonstrated 'acceptable' comparability of these PWV measurements with values for carotid-femoral PWV assessed by applanation tonometry.[5] The Modena study was conducted over 4-months in 246 adults who already owned all three Withings devices: a physical activity monitor watch, a BP cuff, and a "smart" scale. All three devices were connected to a custom designed smartphone app.

As would have been predicted, PWV most strongly correlated with mean arterial pressure (R^2 = 0.13) and age (R^2 = 0.20) and was predicted by a combination of mean arterial

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pressure, age, BW, and heart rate (R^2 = 0.36) with only a weak association between steps per day and PWV (R^2 = 0.02). So, have we learned anything new about PWV? The answer is No. We already knew that PWV is inversely associated with physical activity and positively associated with BP, BW and age and apparently correlated with HR[6]. The question, however, is not *'Have we learned anything new?'* but rather, '*Can we learn anything new?'* This study suggests, Yes, we can. Not only have Modena et al.[4] demonstrated the ability to integrate three interconnected mobile health (mHealth) technologies over several months, but they also have provided evidence the integrated data are valid, thereby opening the door to assessing interrelationships of cardiovascular disease risk factors including sedentary lifestyle, dysregulated sleep, and elevated BP, heart rate, BW, body mass index and PWV.

One key advantage of these consumer devices is their relative ease of use for cost- and resource-efficient longitudinal data collection in an ecologically valid setting. This enabled Kim et al.[7] to analyze BP variability in over 55,000 individuals from 185 countries over 14 months, revealing that BP variability was associated with age, higher in women, and influenced by the time of day, day of the week, and geographical location. It remains unknown whether integrating PWV measurement would add value to a similar analysis of multiple cardiovascular risk factors.

Arterial stiffness, assessed by aortic PWV, is a strong predictor of cardiovascular disease and death.[8] Thus, the ability to measure PWV at home opens the door to answering a myriad of questions concerning this risk factor. Large population studies of PWV could provide reference values to inform our understanding of arterial stiffness, guide individualized interventions and disentangle lifestyle and other factors that contribute to the heterogeneity in BP and PWV interrelationships. Moreover, this technology would facilitate future research into new therapeutic strategies that might target PWV selectively.[8]

As with any approach, there are limitations that must be considered. The authors had no trouble recruiting participants in this proof of concept study; however, their population was highly skewed because only people who already owned all three devices, and who were also using the BP cuff at least once per week, for most weeks, and over three months prior to enrollment, were recruited. Would recruitment, retention, and study adherence be as effective in a population of greater research interest and representative of patients who might derive the greatest benefit from mHealth-guided risk factor assessment, diagnosis, lifestyle and other individualized interventions? Our ongoing study using similar Withings devices in an urban Black population with systolic BP between 130–160 mmHg suggests not.[9] Of the 38 participants who have thus far completed the study, participation (defined as any data that month) and full adherence (nine BP cuff and nine scale measurements; 27 days of watch data) was at least 90% in the first month but declined substantially over six months for all three devices. Adherence (including failure to get a reading because of technical problems) was greatest for daytime use of the activity monitor and least for PWV measurement.

While the consumer mHealth technology used in the Modena study holds much promise as a measurement tool, major challenges remain. Measuring PWV via the smart scale can be finicky at times requiring multiple attempts before a reading is generated. Validity and reliability of BP measurements remain a concern for all automated oscillometric devices, including the Withings BP-800, requiring comparison with auscultated measurements in individual participants or patients. While total sleep time determined by the Withings Activité watch was validated by polysomnography, this device, similar to other consumer monitors, does not accurately assess sleep efficiency or sleep architecture, each of which predict health outcomes better than total sleep duration.[10] Additional challenges include changes in technology ownership, impacting device support and availability. Case in point, Withings was sold to Nokia in June 2016 and in January 2018, Nokia removed the PWV feature from the Withings scale through a mandatory software update. Hopefully, the recent buyback of the Nokia digital health business by a Withings co-founder (https://www.cnet.com/news/nokia-to-sell-withings-health-division-back-to-original-founder/ Accessed May 14, 2018) will lead to the reintroduction of the PWV feature on the smart scale and promote research on PWV in populations of interest.

Incorporating consumer monitors into behavior change research is a growing area of investigation. These devices coupled with notification systems that target the individual or social support group through mobile apps are being studied to determine what combinations of strategies are most effective in creating behavior change, including motivating individuals to seek healthy lifestyles, promoting adherence to individualized prescription plans and encouraging them to discuss their health with their physician. Investigators also need to focus on strategies to maintain participant engagement given that novelty of device use can fade with time, and negatively impact study adherence.[11]

Another area of mHealth technology ripe for investigation is in health services; how could mHealth technology use influence healthcare costs and utilization? Will insurance claims be influenced by monitoring interventions and health self-management? Additional mHealth technologies (e.g., continuous glucose monitoring, measurement of hemoglobin, oxygen saturation, body temperature, cardiac rhythm or heart rate variability by electrocardiography or photoplethysmography) will further inform human health and impact models of clinical care. Moreover, improvements in technology that lead to reliable estimates of energy expenditure, and detect the type of physical activity (e.g., running vs. biking) will enable individualized prescriptions of physical activity regimens at a granular level. In conclusion, much more research is needed to achieve the full potential of wearable monitors as health interventions and opportunities for clinical research. Modena et al.[4] provide the encouragement to “just do it.”

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