Heart Rate and Energy Expenditure Validity for the Fitbit Charge HR 2 and Apple Watch

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STUDY INTRODUCTION AND PURPOSE

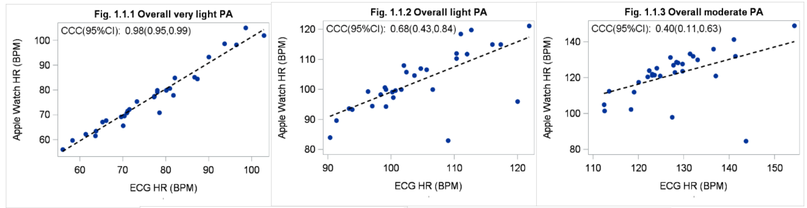
- Wearable devices, such as the Fitbit Charge and Apple Watch, are convenient means of monitoring exercise heart rate and energy expenditure.
- Consumers may rely on wearable devices to adhere to exercise prescriptions, and measure energy balance.
- The accuracy of these devices, however, has come under scrutiny in recent years.
- The **purpose**, therefore, was to validate the heart rate and energy expenditure measurements in two popular consumer devices, the Fitbit Charge HR 2 (Fitbit) and the Apple Watch Series 1 (Apple Watch).

METHODS

- Thirty young adults (15 males and 15 females, age=23.5 ± 3.0 years) completed a health screening, and participants underwent assessment for weight, height, and blood pressure.
- The procedures were reviewed and approved by the Colorado State University Institutional Review Board before the start of the study.
- Participants were fitted for a mask for the metabolic cart, and prepped with a 12-lead electrocardiogram (ECG), the equipment for criterion heart rate measure.
- The Apple Watch device was placed on the participants' right wrists and the Fitbit Charge was places on the left wrists.
- Participants began the Bruce Protocol maximal exercise test on a treadmill while investigators took heart rate readings from the ECG and each device per minute.
- At the conclusion of the exercise test, total energy expenditure (Kcals) was recorded from all of the wearable devices and calculated from data from the metabolic cart, the equipment for criterion energy expenditure measure.
- Means and standard deviations were calculated for heart rates and energy expenditure. Paired t-test analyses were performed and Cohen's d effect sizes were calculated.
- Regression scatterplots and concordance correlation coefficient (r_c) were used to depict the strength of the relationship of Apple Watch and measurements and criterion measurements

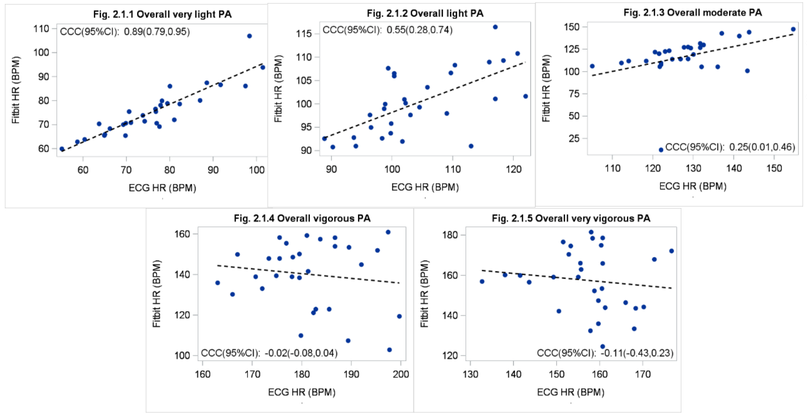
RESULTS

Heart Rate Data



Figures 1.1.1 – 1.1.5 Apple Watch vs. ECG heart rate Regression Plots

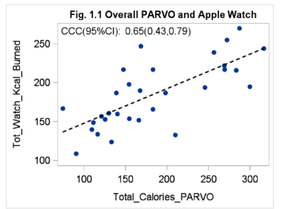
CCC: Concordance Correlation Coefficient; CI: confidence interval; HR: heart rate; BPM: beats per minute



Figures 2.1.1 – 2.3.5. Fitbit vs. ECG heart rate Regression Plots

CCC: Concordance Correlation Coefficient; CI: confidence interval; HR: heart rate; BPM: beats per minute

Energy Expenditure Data



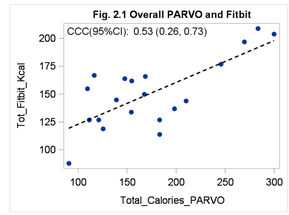


Figure 1.1 Apple Watch vs. ECG EE Regression Plot

Figure 2.1 Fitbit vs. ECG EE Regression Plot

CONCLUSIONS

- When measuring **heart rate**, the **Fitbit** had a relative error rate of **3.9%-13.5% compared to the ECG,** across **all exercise intensities.**
- The **Apple Watch** had a relative error rate of **2.4%-5.1%** when comparing heart rate measurements to the ECG, across **all exercise intensities.**
- **Both devices** had lower error rates when measuring heart rate at very low exercise intensities.
- When calculating **energy expenditure,** the **Fitbit overall error rate** was **24.17%.** For **females**, it was **16.72%,** and for **males**, it was **24.17%.**
- The **Apple Watch energy expenditure** calculations had an **overall error rate** of **24.25%,** an error rate of **29.93% for females,** and **18.58% for males.**
- The **Apple Watch** revealed **overestimated EE for females** but **underestimated EE for males**. **The Fitbit underestimated EE for both males and females.**
- Researchers, practitioners, and personal users of wearable devices should consider these data when designing programs or training plans that use heart rate or energy expenditure targets as measured by these devices.

FUTURE DIRECTIONS

- Further research is required to determine the validity of heart rate measurements and energy expenditure calculations from wearable devices in the free living environment.
- Future studies should also include a variety of exercise modalities as the current study only utilized a treadmill running maximal exercise test.

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