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The Accuracy of Heart Rate Monitoring by Some Wrist-Worn Activity Trackers

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Background

Activity trackers may motivate individuals to engage in healthy behaviors. They are also used in research and may help manage chronic conditions related to lifestyle (1). Traditional trackers that require a separate chest strap and work like an electrocardiograph are being supplemented with other types of trackers. One type is a wrist-worn tracker with a light-emitting diode. It measures the heart rate from tiny changes in skin blood volume by using light reflected from the skin. These new devices are unobtrusive and appropriate for continuous, long-term wear. Although previous studies have shown that they are generally accurate for measuring the number of steps a person takes, less is known about their accuracy when measuring heart rate (2–4).

Objective

To determine the accuracy of the heart rate measured by light-emitting diode–dependent, wrist-worn activity trackers.

Methods

We studied 4 commercial, wrist-worn activity trackers that measure the heart rate by using light-emitting diodes. Study participants were 40 healthy consenting adults aged 30 to 65 years without cardiovascular conditions. For each participant, we placed 2 trackers on each wrist in random order by right versus left wrist and by proximal versus distal location on the

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wrist. We then connected the seated participant to an electrocardiograph and measured the resting heart rate at 1-minute intervals for 10 minutes using the electrocardiograph and each of the 4 trackers. Next, we measured the heart rate at 1-minute intervals for 10 minutes while the participant exercised on a treadmill at 65% of the maximum heart rate, which we calculated as 220 beats/min minus the participant's age in years. We used Bland–Altman plots to compare the heart rates measured by the electrocardiograph with those measured by each of the wrist-worn trackers and used the MethComp package in R (R Foundation for Statistical Computing) to create a mixed-effects model for linked replicate measurements to summarize these and other comparisons (5).

Findings

Participants had a mean age of 49.3 years (SD, 9.5) and a mean body mass index of 25.1 kg/m^2 (SD, 3.9), and 50% were women. The Figure plots individual comparisons among the heart rates measured by the electrocardiograph and trackers, and we summarized the amount of agreement with a statistic known as the limits of agreement (a narrower range is better) (Appendix Table, available at www.annals.org). For participants at rest, the agreement was best for the Fitbit Surge (Fitbit), which had the narrowest limits of agreement (−5.1 to 4.5 beats/min), worst for the Basis Peak (Basis) (−17.1 to 22.6 beats/min), and intermediate for the Fitbit Charge (Fitbit) (−10.5 to 9.2 beats/min) and Mio Fuse (Mio Global) (−7.8 to 9.9 beats/min). When participants exercised at 65% of the maximum heart rate, the limits of agreement were relatively poor for all the activity trackers (Mio Fuse, −22.5 to 26.0 beats/min; Basis Peak, −27.1 to 29.2 beats/min; Fitbit Surge, −34.8 to 39.0 beats/min; and Fitbit Charge, −41.0 to 36.0 beats/min). The repeatability coefficient determined how close 1 measurement was to another when using the same device in the same study participant under the same conditions (smaller values are better) (Appendix Table). For example, the repeatability coefficient for the electrocardiograph was 5.3 beats/min at rest and 9.1 beats/min during exercise. In comparison, the repeatability coefficient at rest was 4.2 beats/min for the Fitbit Surge, 9.3 beats/min for the Fitbit Charge, 10.9 beats/min for the Mio Fuse, and 19.3 beats/min for the Basis Peak. During exercise, the repeatability coefficient was 20.2 beats/min for the Basis Peak, 20.6 beats/min for the Fitbit Surge, 21.6 beats/min for the Fitbit Charge, and 23.7 beats/min for the Mio Fuse. Tracker location on the arm did not affect any of these measurements.

Discussion

Some of the wrist-worn activity trackers that we studied measured values for heart rate that were similar to those measured by the electrocardiograph, and some measured similar values when the same device was used to repeat the measurements in the same study participant under the same conditions. However, all of the trackers were better at rest than during moderately active exercise, performance at rest was better for some trackers than for others, and limited repeatability for each tracker caused more problems than poor agreement between each tracker and the electrocardiograph. Thus, although current trackers may help persons self-monitor their daily activity, more research is needed before we can confidently conclude that the monitoring feature for heart rate is sufficient to help clinicians advise their patients about health issues and conduct clinical trials that require a high level of accuracy and reliability for heart rate measurement.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Bassett DR. Device-based monitoring in physical activity and public health research. Physiol Meas. 2012; 33:1769–83. DOI: 10.1088/0967-3334/33/11/1769 [PubMed: 23110847]
2. Evenson KR, Goto MM, Furberg RD. Systematic review of the validity and reliability of consumer-wearable activity trackers. Int J Behav Nutr Phys Act. 2015; 12:159.doi: 10.1186/s12966-015-0314-1 [PubMed: 26684758]
3. Wallen MP, Gomersall SR, Keating SE, Wisløff U, Coombes JS. Accuracy of heart rate watches: implications for weight management. PLoS One. 2016; 11:e0154420.doi: 10.1371/journal.pone.0154420 [PubMed: 27232714]
4. Wang R, Blackburn G, Desai M, Phelan D, Gillinov L, Houghtaling P, et al. Accuracy of wrist-worn heart rate monitors. JAMA Cardiol. 2017; 2:104–6. DOI: 10.1001/jamacardio.2016.3340 [PubMed: 27732703]
5. Carstensen B, Simpson J, Gurrin LC. Statistical models for assessing agreement in method comparison studies with replicate measurements. Int J Biostat. 2008; 4 Article 16.

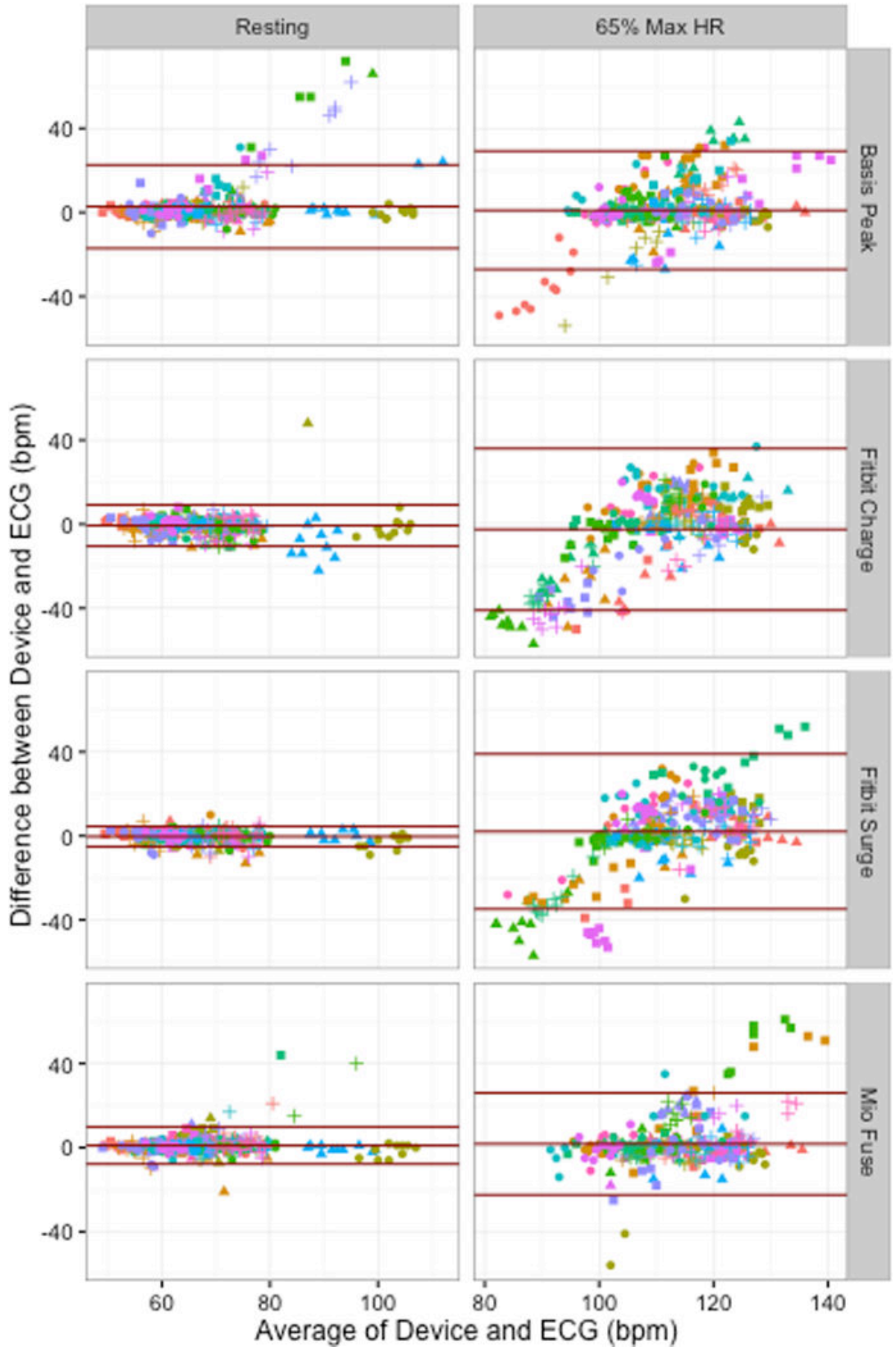

Figure.

Comparison of heart rates measured by electrocardiograph with those measured by each tracker, at rest and with moderately intense activity. Each point represents the heart rate measured at the same time by electrocardiograph and a tracker. The *x*-axis describes the mean of the 2 values in beats per minute, and the *y*-axis describes the difference between the 2 values in beats per minute. Points identified by a unique combination of color and symbol are measurements in a single study participant. On the *y*-axis, points above 0 indicate that the tracker value was higher than that measured by the electrocardiograph and those below 0 indicate that the tracker value was lower. The black horizontal line indicates the average difference between the heart rate measured by the tracker and the electrocardiograph, which is known as the bias. (On this small scale, many of the black lines are so close to the value of 0 on the *y*-axis that appreciating the direction and size of the bias is difficult. See the Appendix Table [available at www.annals.org] for bias values.) The red horizontal lines indicate the limits of agreement and include approximately 95% of the differences.