Movement, sweat, and wristband fit as sources of heart rate inaccuracy in wearable devices

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Wearable devices for health monitoring have the potential of transforming healthcare. Most smartwatches assess physical activity, stress and cardiac disease through photoplethysmographic heart rate (HR) monitoring. We aimed to quantify the effect of movement, wristband tightness and sweat on wearable HR inaccuracy.

In 17 healthy individuals, HR was recorded using two smartwatches, Garmin Vivoactive 4 (GV) and Fitbit Sense (FS), concurrently with ECG at rest and during controlled arm movement, that mimic moderate and vigorous exercise without increasing HR. Recordings lasted 30 sec and were repeated after reducing the wristband tightness by one and two notches, and using saline solution to reproduce the effect of increasing sweating (one and two drops). Inaccuracies were measured as the mean absolute percentage error, MAPE, with ECG as reference. Wilcoxon signed-rank test (uncorrected) was used to assess the impact of each condition with respect to optimal conditions (no movement or sweat and perfect wristband fitting).

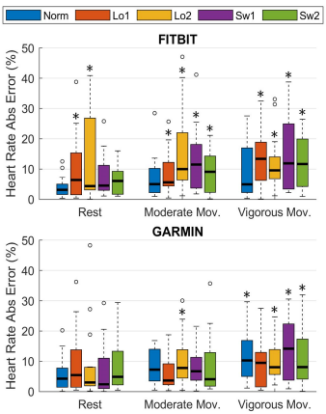

*Figure 1: MAE for HR. Lo=Wristband loosened; Sw=Sweat; * p<0.05*

As shown in Figure 1, in optimal conditions MAPE = 4.3% (1.4%, 7.7%) [median, interquartile-range] and 3.1% (1.6%, 5.0%) (p=0.58), for GV and FS, respectively. With optimal fitting and no sweat, moderate movement did not increase MAPE, while vigorous movement increased MAPE for GV (p=0.013) but not for FS (p=0.07). Reducing the tightness of the wristband by 1 notch increased MAPE for FS during rest (p=0.021) and moderate (p=0.004) and vigorous (p=0.002) movement, but not for GS, for which losing the tightness by 2 notches increased MAPE during moderate (p=0.015) and vigorous (p=0.008) movement. Sweat (1 drop) increased MAPE during moderate movement using FS (p=0.002), and during vigorous movement for both devices (p=0.011 and p=0.013). Median MAPE did not exceed 14.1% in any configuration.

In conclusion, wristband tightness and sweating can increase HR inaccuracy even during rest and moderate movement, but this remained limited to <15%.