Agreement of Heart Rate Measurements Among Wrist Wearable Devices Across Exercise Modalities: A Case Study

Lee, J.[1], Park, J.[1], Son, S.[1] , Lee, J.Y.[1], Lee, H.[1], Yun, S.[1], Jung, A.[2], Kim, G.[2], Kim, H.[2], Lee, D.T.[1*]

[1] Kookmin University, Seoul, Republic of Korea, [2] Samsung Electronics

* E-mail : dtlee@kookmin.ac.kr

ABSTRACT

Background & Purpose: This study was conducted as part of a usability evaluation to support the development and optimization of exercise algorithms in Samsung Health. The purpose of this study was to examine the agreement of heart rate measurements between the Samsung Galaxy Watch and other commercial wearable devices across a range of exercise conditions, using the Galaxy Watch as the reference device, with comparisons performed according to exercise modality.

Methods: Five healthy adult participants were recruited for this study. All participants wore a Samsung Galaxy Watch and additionally wore one or two wrist-worn wearable devices selected from six brands (Apple, Coros, Garmin, Suunto, Pixel, and Whoop) on both wrists simultaneously. Participants completed three exercise protocols on separate days, with exercise intensity standardized based on Galaxy Watch measurements: 1) Level walking: walking on flat terrain at an average speed of 5.45 km/h for 1.96 km in 21 min, 2) Resistance exercise: 3 sets of squat, push-up, burpee, and mountain climber with each performed for 1 min per set, 3) Flexibility exercise: 25 mat Pilates and full-body stretching, including elbow plank, roll back, and toe taps for 29 min. All devices were synchronized to start and stop recording simultaneously. After each session, raw heart rate data were extracted and synchronized at 15-second intervals for time-series analysis of real-time fluctuations.

Results: Analysis of heart rate differences between the Galaxy Watch and other wearable devices revealed exercise-dependent variability. During flexibility exercise, the Galaxy Watch tended to report higher values than other devices, with discrepancies exceeding 20 bpm in some segments. During walking, bias ranged from −15.7 to 14.9 bpm and varied across devices, indicating substantial algorithm-related variability. During resistance exercise, most comparator devices recorded higher heart rates than the Galaxy Watch, reflecting predominant underestimation. Large discrepancies of up to 40 bpm were observed during high-intensity upper-body movements. Measurement stability gradually improved over time during flexibility and walking exercises.

Conclusion: The findings of this study indicate that agreement in wrist-worn heart rate measurements varies substantially according to exercise modality and movement characteristics. Although walking is considered a cyclic activity with relatively low measurement error, considerable inter-device variability was observed, suggesting that differences in proprietary calibration algorithms may serve as a primary determinant of measurement accuracy. Furthermore, during resistance exercises involving substantial upper-body movement, comparator devices tended to overestimate heart rate relative to the Galaxy Watch, highlighting the need for caution when interpreting heart rate data interchangeably across wearable devices.

PURPOSE

- The purpose of this study was to compare heart rate (HR) agreement between the Samsung Galaxy Watch and other commercial wearable devices during level walking, resistance exercise, and flexibility exercise.

METHODS

1. Participants

- Five healthy adults participated in this study.
- Participant characteristics are summarized in Table 1.

2. Devices

- All participants wore a Samsung Galaxy Watch as the reference device, along with one or two comparator wrist-worn wearable devices (Table 1).
- Devices were worn simultaneously across both wrists during each exercise protocol.

Table 1. Participant Characteristics and Device Allocation

Participant	Sex	Age group	Comparator devices
1	Female	40s	Apple Watch 11
2	Female	20s	Whoop 5.0 (Life membership)
3	Male	20s	Suunto Race S
4	Female	20s	Coros Pace Pro/ Garmin Forerunner 970
5	Male	20s	Pixel Watch 4

3. Exercise Protocols

- Each participant completed three exercise protocols on separate days.

Level walking	Resistance exercise	Flexibility exercise
· Walking on flat terrain · 21 min · 1.96 km at 5.45 km/h	· Bodyweight resistance exercise · 30 min · Squat, push-up, burpee, mountain climber	· Mat-based flexibility exercise · 29 min · 25 Pilates-based movements

4. Data Acquisition and Analysis

- Recording was started and stopped simultaneously across all devices.
- Raw HR data were collected at 15-s intervals and averaged into 5-min intervals for each exercise modality.
- HR differences were calculated as Galaxy Watch HR minus comparator device HR for descriptive comparison.

CONCLUSION

- HR agreement varied by exercise modality and comparator device.
- Galaxy Watch HR was slightly higher during walking and flexibility exercise, but lower during resistance exercise.
- Upper-body movement during resistance exercise may affect wrist-based HR measurement.
- Caution is needed when interpreting wearable-derived HR data across devices and exercise modalities.

RESULTS

- Positive values indicate higher HR values from the Galaxy Watch (Figure 2-4).

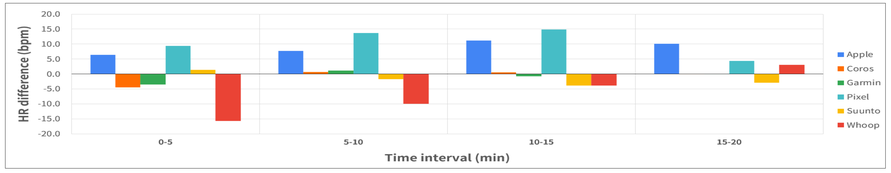


Figure 2. Five-Minute HR Differences During Level Walking

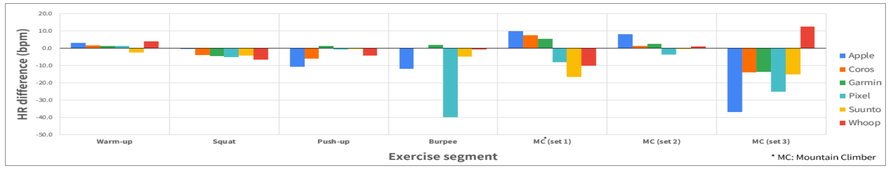


Figure 3. Segment-Specific HR Differences During Resistance Exercise

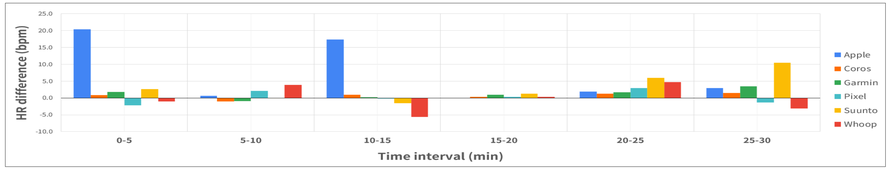


Figure 4. Five-Minute HR Differences During Flexibility Exercise

- Five-minute average HR differences varied by exercise modality and device (Table 2).
- The Galaxy Watch showed slightly higher HR values during walking (+1.6 bpm) and flexibility exercise (+2.1 bpm).
- The Galaxy Watch showed lower HR values during resistance exercise (−4.4 bpm).
- Larger negative differences were observed during resistance exercise, especially during burpee and mountain climber segments.

Table 2. Mean HR Difference by Device and Exercise Modality (bpm)

Exercise modality	Apple	Coros	Garmin	Pixel	Suunto	Whoop	Avg.
Level walking	8.9	-0.8	-0.8	10.6	1.8	6.6	**1.6**
Resistance exercise	-5.6	-1.9	-0.7	-11.5	-6.3	-0.6	**-4.4**
Flexibility exercise	7.2	0.7	1.2	0.3	3.1	-0.1	**2.1**

ACKNOWLEDGEMENT

- This study was supported by Samsung Electronics (KMU-S2025-0106).