RESEARCH PAPER

Comparison of the Polar H10 Device and Smartwatches for Measuring Heart Rate Variability in Healthy Individuals During Daily Activities: A Cross-Sectional Observational Study

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ABSTRACT

Background: The use of wearables for tracking physiological metrics like heart rate variability (HRV) is on the rise. However, despite the convenience of wrist-based smartwatches, their precision relative to traditional chest-strap monitors is still being evaluated.

Objective: The aim of this study was to assess the concordance between heart rate variability (HRV) measurements obtained from a smartwatch and those recorded using a Polar H10 sensor across varying levels of physical activity in healthy young adults.

Methods: A cross-sectional observational study was conducted to see how well smartwatches stack up against a gold-standard Polar H10 chest strap; we tested 78 healthy participants between 18 and 25 years old. They wore both devices simultaneously while completing a treadmill routine of brisk walking and running. By recording heart rate and HRV across all phases of the workout, we gathered a complete data set that we later processed using descriptive statistics in SPSS (v27.0).

Results: In this study we have compared the Polar H10 and smart watch devices, both of this devices shows a significant correlation, the significance value of smart watch is $p = 0.2314$, and the significance value of Polar H10 is $p = 0.0415$.

Conclusion: The Polar H10 are concluded more statistically significant as compared with smart watch with respect to heart rate variability when measuring it during intense activities.
Keywords: Heart rate variability, HRV, Polar H10, Smartwatch, Wearable devices, Cross-sectional study.
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INTRODUCTION

Heart rate variability (HRV) measures physiological phenomenon of variation in the time interval between heartbeats, non-invasive signalling of autonomic nervous system (ANS) function (4. Heart Rate Variability (HRV) non-invasive biomarker, as a key physiological indicator, for measuring cardiovascular health, stress and wellness).

Wearable technology has revolutionized physiological tracking by enabling the measurement of HRV controlled environments outside traditional settings [9]. Most wearable use light-based sensors photoplethysmography (PPG) to measure blood flow changes in the skin to track cardiovascular health, including heart rate and HRV [5][8]. The widespread adoption of PPG technology in consumer wearable is driven by its ability to provide comfortable, real-time health monitoring. The rapid growth of PPG-based tech is evidenced by a recent review, which identified more than 200 mobile applications designed for HRV monitoring [10].

Because of increasing popularity, the precision of PPG-derived HRV measurements is questionable, particularly when motion artifacts occur during active movement. Motion artifacts, sensor displacement, variable skin contact pressure, and limitations in optical signal detection can compromise data integrity during dynamic movements [5]. A recent study demonstrated that PPG-based devices exhibit higher measurement errors compared to chest straps during activities involving significant upper body movement, with mean absolute percentage errors reaching as high as 17.5% during sports such as badminton and soccer[7]. This susceptibility to motion-induced signal degradation raises important questions about the validity of smartwatch-derived HRV metrics in real-world, active conditions.

In contrast, chest strap monitors operating on ECG principles have established strong reputations for measurement precision. The Polar H10, in particular, has been extensively validated as a reliable reference device for HR and HRV assessment across rest and exercise conditions. Studies have shown that the Polar H10 demonstrates excellent agreement with gold-standard ECG, with mean absolute percentage errors for RMSSD as low as 2.16 % [6].

Because wearable's devices are now widely used in physical therapy and fitness, exercise science, and rehabilitation practice, rigorous, evidence-based evaluation of consumer products is necessary 3)(9). To minimize motion artifacts and improve signal quality, placing sensors on the forearm or upper arm is superior to the wrist, Even though the second option is convenient. Despite perfect placement, PPG-based devices still show lower precision during vigorous exercise or intense arm movement [8].

Although the cost-effectiveness and convenience of wearable devices make them appealing for regular monitoring, a critical evaluation is required regarding the limitations of their accuracy compared to their widespread availability [10]. Research shows that while chest-worn ECG monitors are accurate for heart patients, wrist-worn PPG trackers are less precise, with accuracy decreasing further in cases of heart failure and arrhythmia [8].

METHODOLOGY

A cross-sectional observational study was conducted at MGM School of Physiotherapy, beginning with Scientific Advisory Committee approval. Researchers used simple random sampling to select 78 healthy individuals (aged 18–25) who regularly wear smartwatches. To guarantee safety and data reliability, participants with pre-existing cardiovascular or respiratory conditions were excluded. All participants completed a PAR-Q and provided written consent prior to taking part.

Participants used a smartwatch alongside a Polar H10 chest strap during a graded treadmill test. The 20-minute protocol included 5 minutes of seated rest, 5 minutes of brisk walking (4–5 km/h), 5 minutes of jogging (6–7 km/h), and 5 minutes of light running (8–9 km/h). Both tools recorded heart rate and HRV continuously, with HRV evaluated in milliseconds using time-domain metrics from RR intervals.

Data management was conducted in Microsoft Excel, followed by statistical evaluation in SPSS 27.0. Descriptive statistics specifically means and standard deviations, provided a data summary. Agreement between the smartwatch and the Polar H10 sensor was determined via correlation analysis, utilizing a significance threshold of $P < 0.05$ to ensure a valid and reliable comparison of heart rate measurements across varying exertion levels.

RESULTS

The study comprised 78 individuals divided into three brackets: 22 young adults (18–20 years), 42 (21–23 years), and 14 (24–25 years). During the trial, the Polar H10 accurately recorded heart rate variability (HRV) across all stages of the exercise.
Conversely, as the workout got tougher, the smartwatch started giving all-over-the-place HRV numbers. The researchers found only a weak but technically meaningful link between the two devices (\(r = 0.2314\), \(P = 0.0415\)). On the other hand, the Polar H10 chest strap stayed perfectly reliable and consistent from start to finish.
However, the smartwatches HRV measurements became increasingly inconsistent during intense exercise. Furthermore, when comparing the two devices, researchers found only a weak—though statistically meaningful—correlation between their results.

Tables 1–7 present the demographic and physiological characteristics of the study participants.

Table 1: Age Distribution

AGE (years)	No. of Participants (N)	Percentage (%)
18–20	22	28.20
21–23	42	53.84
24–25	14	17.94
Total	78	100
Mean ± SD		21.51 ± 2.01

Table 1: The participant group was highly concentrated in their early twenties, with an average age of 21.5 (\(\sigma = 2.01\)). The vast majority (53.84%) were 21–23 years old, followed by 18–20 year-olds at 28.20%, and 24–25 year-olds at 17.94%. Overall, the group was relatively uniform in age.

Table 2 Height Distribution

HEIGHT (m)	No. of Participants (N)	Percentage (%)
1.55–1.60	16	20.51
1.61–1.65	24	30.76
1.66–1.70	20	25.64
1.71–1.75	12	15.38
1.76–1.80	6	7.69
Total	**78**	**100**
Mean ± SD		**1.65 ± 0.07**

Table 2: Participants displayed a highly consistent height profile, averaging (1.65 pm 0.07) meters. A vast majority (exceeding 76%) fell within the 1.55m to 1.70m range, with the highest concentration (30.76%) in the 1.61m to 1.65m bracket. Group numbers declined as height increased, with 15.38% measuring 1.71m to 1.75m, and only 7.69% in the 1.76m to 1.80m category.

Table 3 Weight Distribution

WEIGHT (kg)	No. of Participants (N)	Percentage (%)
50–60	28	35.89
61–70	39	50.00
71–80	11	14.10
Total	78	100
Mean ± SD		62.71 ± 7.16

Table 3: Participant body weights were primarily concentrated in the 61–70 kg range, accounting for half of the cohort. The remainder of the group was split between the 50–60 kg (35.89%) and 71–80 kg (14.10%) categories. The mean weight of the participants was 62.71 kg (SD = 7.16), reflecting moderate variance.

Table 4 BMI Distribution

BMI Category	Range (kg/m²)	No. of Participants (N)	Percentage (%)
Underweight	<18.5	5	6.41
Normal	18.5–24.9	53	67.94
Overweight	25–29.9	20	25.64
Total		**78**	**100**
Mean ± SD			**23.03 ± 3.08**

Table 4: The vast majority of the group—67.94% fell within the healthy BMI range of 18.5 to 24.9. Meanwhile, 25.64% were classified as overweight, and a small minority (6.41%) were underweight. Overall, the group averaged a healthy 23.03 BMI. The low standard deviation of 3.08 highlights that most participants clustered closely around this healthy average.

Figure 1: BMI distribution of participants

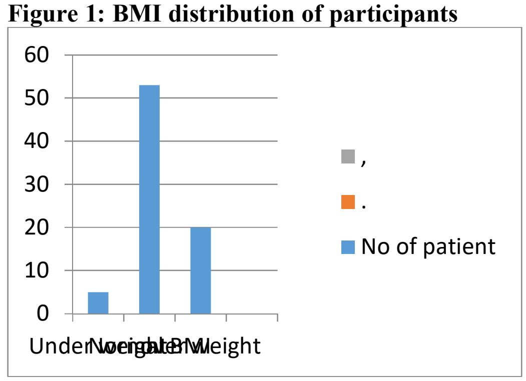

Table 5: Gender Distribution

Gender	No. of Participants (N)	Percentage (%)
Males	17	21.79

Females	61	78.21

Table 5: The group was mostly made up of women—about (78%) or (61) people while only (22%) or (17) were men. It's important to keep this in mind when reading the results, since it means the findings might not apply perfectly to a wider, more balanced group

Table 6: Heart Rate Measurements by Device

Device	Pre-Exercise HR (bpm)	Post-Exercise HR (bpm)
Polar H10	98–100	98–111
Smartwatch	92–98	88–108

Table 6: A comparative analysis of heart rate measurements between the Polar H10 device and a smartwatch was conducted before and after an exercise session. The Polar H10 maintained a baseline of 98–100 bpm pre-exercise, escalating to a range of 98–111 bpm post-exercise. Conversely, the smartwatch registered a resting heart rate of 92–98 bpm, and slightly dropped to 88–108 bpm upon completion of the workout.

Figure 2 Comparison of heart rate between devices

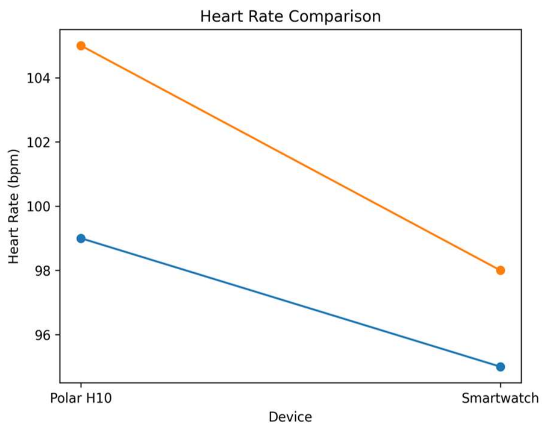

Table 7A: Time-Domain Heart Rate Variability (HRV, ms) Comparison Between Devices

Activity Phase	Polar H10 HRV (ms)	Smartwatch HRV (ms)	Mean Difference (ms)
Rest (Baseline)	68–75	65–72	3–5
Brisk Walking	55–65	48–60	5–8
Jogging	40–55	30–50	8–12
Light Running	25–40	15–35	10–15

Figure 3 Comparison of heart rate between devices

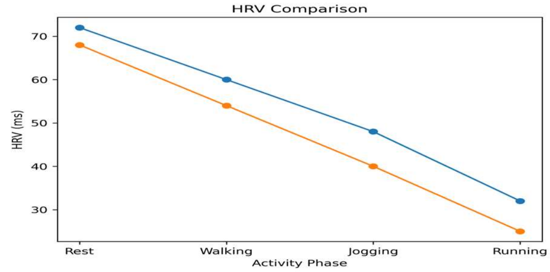

Table 7B: RR Interval (seconds) Comparison Between Devices

Activity Phase	Polar H10 RR Interval (sec)	Smartwatch RR Interval (sec)	Difference (sec)
Rest	0.80–0.90	0.78–0.88	0.02–0.04
Brisk Walking	0.70–0.80	0.65–0.75	0.04–0.06
Jogging	0.60–0.70	0.52–0.65	0.05–0.08
Light Running	0.50–0.60	0.42–0.55	0.06–0.10

Figure 4: Comparison of RR intervals between devices

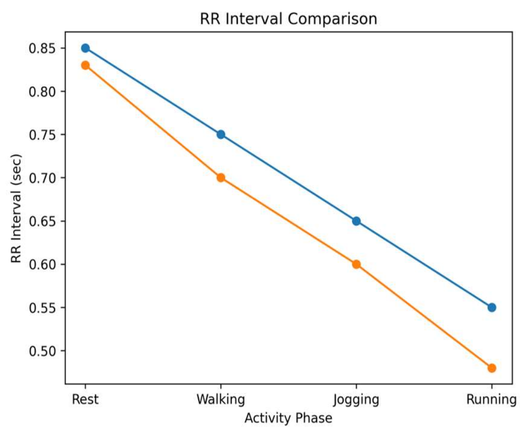

Table 7A and Table 7B: During rest, the Polar H10 and smartwatch show similar heart rate variability (HRV), differing by only 3–5 ms. However, as activity increases, the gap widens. The smartwatch records consistently lower HRV than the Polar H10, with the difference expanding from 5–8 ms during brisk walking to 10–15 ms while running.

Just like with RR intervals, heart rate variability (HRV) decreases as workout intensity goes up, and the gap between device readings widens at higher workloads. While smartwatches measure HRV decently at rest, their accuracy falls during active movement, largely due to physical disruption and the limits of optical sensors

These demographic and physiological details provide a useful snapshot of the study group. Because the participants were mostly women in their early twenties, the findings best apply to a similar demographic. Weight data also clarifies the physical profile of the group, which is a key for interpreting the study's focus, while reporting averages and variations makes the data much easier to grasp.

DISCUSSION

In this study, the primary objective of this investigation was to assess the concurrent validity of heart rate variability (HRV) metrics recorded by consumer-grade smartwatches by comparing them against the clinical-grade precision of a Polar H10 chest strap across a spectrum of exercise intensities. The findings reveal a clear discrepancy: as the physical exertion of the participants increased, the accuracy and concordance between the two tracking methods significantly degraded. As detailed in the statistical breakdowns of Tables 7A and 7B, this measurement gap was not static. Rather, the variance in HRV readings widened progressively, starting with a close alignment during baseline resting periods and worsening noticeably as subjects transitioned into light jogging and running.

The weak correlation (\(r = 0.2314\)) shows these two devices just don't agree, especially when you push the intensity. Why? It comes down to basic physics and tech. Wrist trackers rely on light and get easily confused by arm movement and sweat when you work out hard. But the Polar H10 straps to your chest and reads electrical heart signals directly, giving it a massive edge in reliability over the Apple Watch.

These findings match previous research, which indicates that optical sensors on wrist-worn devices often either underestimate or overestimate heart rate and HRV during moderate to vigorous exercise. Similar observations have been made in other validation studies, where PPG-based wearable lost accuracy in measuring HRV once things got moderately intense. A number of studies have pointed out that motion-induced noise and signal distortion really throw off the accuracy of photoplethysmography-based devices, especially when there's a lot of movement or sweating going on. Meanwhile, chest strap monitors like the Polar H10 have repeatedly proven themselves to be more valid and reliable when it comes to capturing cardiac signals, whether at rest or during exercise. That's an important point to keep in mind when interpreting HRV data in research or clinical settings.

Although smartwatches provide an effortless way to monitor daily heart health, caution is required when depending on them for highly precise HRV analysis. Future research should prioritize enhancing optical sensor algorithms and motion artifact reduction so that wrist-worn devices can reliably track data during dynamic movements. Additionally, integrating multiple sensors or utilizing hybrid systems may help strike a better balance between ease of use and clinical measurement accuracy.

Basically, because the Polar H10 tracks your heartbeat directly from electrical signals, it doesn't get messed up by movement the way smartwatch optical (PPG) sensors do when your workout gets tough. Although wearable devices are sufficient for monitoring daily wellness, they fall short of the rigorous accuracy and reliability standards demanded by clinical and scientific research environments.

CONCLUSION

Smartwatches are excellent for daily use when you simply want to easily monitor your heart rate. However, their accuracy tends to decline while monitoring heart rate variability (HRV), particularly when you start moving more vigorously. At those times, they simply don't align as well with the Polar H10. In contrast, the Polar H10 consistently provides more accurate and reliable HRV data whether you're working in a controlled laboratory or outdoors. Choosing the appropriate tool for the task is ultimately what this boils down to. A cautious decision must be taken with measurement fidelity at the forefront if precise HRV measurement is essential, for example, for research or therapeutic activity.

REFERENCES

1. Steere K. Evidence-based clinical utility of heart rate variability across populations, including long COVID. Cardiopulmonary Physical Therapy Journal. 2025;36(1):58-69.
2. Wang BX, Brennand E, Le Page P, Mitchell ARJ. Heart rate variability in cardiovascular disease diagnosis, prognosis and management. Frontiers in Cardiovascular Medicine. 2025;12:1680783.
3. Hossain MB, et al. Applications of heart rate variability metrics in wearable sensor technologies: a comprehensive review. Electronics. 2026;15(8):1707.
4. Schaffarczyk M, Rogers B, Reer R, Gronwald T. Validity of the Polar H10 sensor for heart rate variability analysis during resting state and incremental exercise in recreational men and women. Sensors. 2022;22(17):6536.
5. Ceugniez M, Devanne H, Hermand E. Reliability and accuracy of the Fitbit Charge 4 photoplethysmography heart rate sensor in ecological conditions: validation

study. JMIR Mhealth Uhealth. 2025;13:e54871.

6. Johansson H, Adderley E, Clarke S, et al. An observational study of the reliability and concurrent validity of heart rate variability devices in athletes. Frontiers in Physiology. 2025;16:1707318.
7. Zheng X, Hu S, Dwyer V, Barrett L, Derakhshani M. Joint attention mechanism learning to facilitate opto-physiological monitoring during physical activity. Biomedical Signal Processing and Control. 2025.
8. Rogers B, Schaffarczyk M, Gronwald T. Estimation of respiratory frequency in women and men by Kubios HRV software using the Polar H10 or Movesense medical ECG sensor during an exercise ramp. Sensors. 2022;22(19):7156.
9. Walecka I, Gąsior JS, Wieniawski P, Werner B. Elite HRV smartphone application using Polar H10 is valid for short-term heart rate variability analysis in pediatric cardiac patients. Kardiologia Polska. 2024;82(12):1275-1277.
10. Li K, Cardoso C, Moctezuma-Ramirez A, Elgalad A, Perin E. Heart rate variability measurement through a smart wearable device: another breakthrough for personal health monitoring? International Journal of Environmental Research and Public Health. 2023;20(24):7146.
11. Montalvo S, Martinez A, Arias S, et al. Commercial smart watches and heart rate monitors: a concurrent validity analysis. Journal of Strength and Conditioning Research. 2023;37(9).
12. Immanuel S, Teferra MN, Baumert M, Bidargaddi N. Heart rate variability for evaluating psychological stress changes in healthy adults: a scoping review. Neuropsychobiology. 2023;82(4):187-202.
13. Hajj-Boutros G, Landry-Duval MA, Comtois AS, Gouspillou G, Karelis AD. Wrist-worn devices for the measurement of heart rate and energy expenditure: a validation study for the Apple Watch 6, Polar Vantage V and Fitbit Sense. European Journal of Sport Science. 2023;23(2):165-177.
14. Chalmers T, Hickey BA, Newton P, et al. Stress watch: the use of heart rate and heart rate variability to detect stress: a pilot study using smart watch wearables. Sensors. 2021;22(1):151.
15. Chattopadhyay S, Das R. Comparing heart rate variability with polar H10 sensor and pulse rate variability with LYFAS: a novel study. Journal of Biomedical Engineering and Technology. 2021;9(1):1-9.
16. Chung V, Chopin L, Karadayi J, Grèzes J. Validity of the Polar H10 for continuous measures of heart rate and heart rate synchrony analysis. Sensors. 2026;26(3):855.
17. Bonafini F, et al. Anatomical placement and accuracy of wearable heart rate monitors. Sensors. 2025.
18. Miller DJ, et al. A validation study of six consumer wearables for heart rate and heart rate variability measurement. Sensors. 2022;22(19)