

Heart Rate and HRV on Wearables: What to Trust

By Rooted Motion Physical Therapy

Move Better. Live Rooted.

A consumer rating of twelve popular watches, rings and straps for heart rate and heart rate variability — scored from forty published studies, most of them tests against a hospital ECG, with the makers' own specifications alongside.

How a Wearable Reads Your Heart

A chest strap reads the heart the way a hospital does, picking up the electrical signal of each beat through the skin (an ECG). A watch or ring shines green or infrared light into the skin and watches it change as blood pulses through (called PPG). Light works well when you are still and blood is flowing; it struggles when the wrist moves, the sensor sits loose, circulation is low, or the heart rate is changing quickly.

Heart rate is beats per minute. Heart rate variability, or HRV, is the tiny changes in the gap between one beat and the next, measured in thousandths of a second. A watch has to catch every single beat to get HRV right; missing one beat in a hundred barely changes heart rate but can wreck HRV. That is why a device can be excellent at one and poor at the other [12,38,39]. Most rings and bands report the RMSSD version of HRV from your sleep; Apple reports a different one (SDNN) from short daytime samples. The two are not interchangeable, so never compare your number to a friend's on another brand [38].

How We Scored

We searched the published research for tests of each device against a medical ECG or a validated chest strap, added the pooled reviews and HRV method papers that set the rules, kept 40, and scored three things from 1 (poor) to 5 (matches the ECG): heart rate at rest or asleep, heart rate during exercise, and HRV. Each score carries a label for how much testing exists, because a 5 from one small study is not the same as a 5 from ten. A dash means no published test; it counts as zero, and the device lands in the bottom tier — not because it is bad, but because nobody has checked. Where a study was written by the maker's own staff we say so, and the models tested are usually a generation or two behind what is on sale. A new sensor is not automatically a validated one.

The Ratings

Device	Resting / sleep HR	Exercise HR	HRV	Total / 15	How much testing
Polar H10 (chest strap)	5	5	5	15	Strong
Apple Watch	5	4	3	12	Strong
Oura Ring	5	2	5	12	Strong (night only)
WHOOP	4	3	4	11	Strong
Polar Verity Sense (arm band)	5	5	—	10	Moderate
Garmin	4	3	2	9	Moderate
Fitbit	4	3	—	7	Strong for HR, none for HRV
Samsung Galaxy Watch	3	4	—	7	Limited
Google Pixel Watch	4	3	—	7	Limited (one study)
Amazfit	3	3	—	6	Limited (older models)
Coros	—	—	—	0	None found

Device	Resting / sleep HR	Exercise HR	HRV	Total / 15	How much testing
Ultrahuman Ring	—	—	—	0	None found

The tier list

Tier	Devices	What it means
1 — Best available	Polar H10	Matches a hospital ECG for heart rate and HRV, at rest and during hard exercise
2 — Very good	Apple Watch · Oura Ring · WHOOP · Polar Verity Sense	Trustworthy for what each is built for; each has one clear blind spot, named below
3 — Good, with caveats	Garmin · Fitbit · Samsung · Pixel Watch · Amazfit	Fine for everyday heart rate and trends; HRV either untested or tested once and found wanting
4 — Not enough evidence	Coros · Ultrahuman Ring	No independent test against an ECG that we could find. They may be fine; nobody has checked

Most recommended

For HRV, or for a standing heart-rate test at home, the Polar H10 chest strap with a free phone app is the only consumer device that behaves like a hospital ECG for heart rate and standard HRV in every study that has tested it — one complex HRV measure drifts at high intensity [27,28,29,30]. If you want HRV without thinking about it, the Oura Ring is the most accurate overnight device tested, as long as you use its night number only [15,23]. For an everyday watch, the Apple Watch has the strongest heart-rate record of any wrist device [1,2,8,9] — treat its HRV as a rough guide. For workouts without a strap, the Polar Verity Sense arm band is the best optical sensor tested [26,31].

Specifications at a Glance

Sampling rate is how many times a second the sensor looks; a faster look catches the exact moment of each beat, which HRV depends on. Only four makers publish it — Polar (built for developers), Samsung (in its developer kit), Oura for one generation, and WHOOP for its newest band. The rest publish how often they record a heart rate, or nothing. Everything here is from the makers' own pages or developer documents; prices are the makers' US prices in September 2026 and change often.

Device	Sensor	Sensor sampling rate (published)	How often heart rate is recorded
Polar H10	ECG chest strap	130 per second, ECG stream (developer docs)	Every second, with each beat interval in milliseconds
Polar Verity Sense	Optical arm band	28 to 176 per second, selectable (developer docs)	Every second over Bluetooth
Samsung Galaxy Watch	Optical + ECG (BioActive)	25 per second continuous, 100 on demand; ECG 500 per second (developer docs)	Every second to developers; app interval not published
Oura Ring	Optical, finger	250 per second — published for Gen 3 only	"24/7"; interval not published
WHOOP	Optical (wrist or arm band)	26 per second for 5.0/MG (press release); 4.0 not published	Not published
Apple Watch	Optical + ECG	Not published	Every 5 min in background, every 5 s in workouts; HRV sample every 4 h (2 h or 15 min with rhythm features on)
Garmin	Optical + ECG (Elevate)	Not published	Workout file: "Smart" or every second, your choice; background not published
Fitbit	Optical + ECG	Not published	Not published
Google Pixel Watch	Optical + ECG	Not published	Not published
Coros	Optical	Not published	Not published

Device	Sensor	Sensor sampling rate (published)	How often heart rate is recorded
Amazfit	Optical (BioTracker)	Not published	"24/7"; interval not published
Ultrahuman Ring	Optical, finger	Not published	Not published

Device	HRV: formula and window	ECG feature	Beat-by-beat data to other apps	Battery	Maker's US price	In the maker's own words
Polar H10	None on the strap; it streams every beat interval for any app to analyse	Raw ECG for developers; no diagnosis, not cleared	Yes — standard Bluetooth and ANT+	About 400 h (coin cell)	\$104.95	95.6% of beat intervals within 2 ms of a reference ECG, 92.9% in running (white paper)
Polar Verity Sense	None; pulse intervals available, but not at the same time as raw light data	None	Yes (pulse intervals)	30 h	\$104.95	Sold as a heart-rate broadcaster for training
Samsung Galaxy Watch	Shown in Vitals; formula and window not published	Yes, FDA-cleared, 500 per second	On the watch only, through the developer kit	390–445 mAh by size; hours not published	From \$379.99	"General wellness only, not for diagnosis"
Oura Ring	5-minute samples across sleep, averaged per night; formula not published (RMSSD in the validation paper)	None	Not published	6–9 days (Ring 5)	\$399 plus membership	Ring 4 claims a 31% improvement in night heart-rate tracking (baseline not stated)
WHOOP	During sleep; formula and window not published	MG only, FDA-cleared	Heart rate only; no beat intervals	4+ days	\$199–\$359 a year, membership	Claims 99% HRV accuracy, citing an independent study funded by the Australian Institute of Sport
Apple Watch	SDNN; window not published	Yes, FDA-authorized, 30 s	Yes, through the Health app (heartbeat series)	24 h (Series 12), 50 h (Ultra 4)	From \$399 / \$799	Cold skin, tattoos and irregular motion hurt; use a strap if inconsistent
Garmin	Overnight; 3-week baseline, 7-day average; formula not published	Select models, FDA-cleared, by region	Heart-rate broadcast; beat intervals not published	12–31 days by model	\$549.99–\$1,099.99	Recommends its HRM-Pro chest strap for training
Fitbit	RMSSD from the longest sleep over 3 h	Charge 6, Sense 2; FDA-cleared	No	7 days (Charge 6)	\$119.95 (Charge 6; list \$159.95)	Only sleeps over 3 hours count
Google Pixel Watch	RMSSD from the longest sleep over 3 h	Yes; plus Loss of Pulse alert	No	30–40 h	From \$229.99 (list \$349.99)	Loss of Pulse not for under-22s or high-risk hearts
Coros	Overnight in 10-minute blocks, 5-night baseline; formula not published	None	Heart-rate broadcast from the arm band; no ANT+	Up to 19 days (Pace 4)	\$249 (Pace 4)	Wrist heart rate is "an estimate"; use a chest strap
Amazfit	Sleep HRV; formula and window not published	None on current models	Not published	10–25 days	\$99.99–\$399.99	Wellness positioning; no accuracy claim found
Ultrahuman Ring	Nightly; formula and window not published	None	Not published	4–6 days	\$349, no subscription	Its own study skipped HRV: different sampling rates, formulas and limited exported data

Device by Device

Polar H10 chest strap — 5 • 5 • 5

It catches 99.6% of beats overall and 99.4% in hard exercise, where the hospital's own portable monitor dropped to 89.8% [27]. For HRV it is "effectively interchangeable" with the lab, with errors under 1% at rest, in deep breathing and on standing [29], and it holds up in a cycling test to exhaustion [28] and in hospital patients [30]. Reviews of chest sensors put it top, with two caveats: a badly placed strap, sweat or a worn electrode surface misreads, and no strap is approved as a medical device [6,7]. It stores no HRV — pair it with an app.

Apple Watch — 5 • 4 • 3

Across 82 studies its heart rate ran a quarter of a beat low, most readings within about seven beats of the ECG [2]; an earlier review and the Stanford benchmark study rank it the most accurate wrist device [1,8]. It topped the wrist devices on a treadmill, bike and elliptical, though nothing coped with an elliptical when the arms pumped [9], and it was the best watch in cardiac rehab patients [10]. Over a full day it stayed within 6% of the ECG in a one-person study [11]. HRV is the weak spot: its beat-to-beat record has gaps, so time-based HRV survives but frequency-based HRV does not [12], and in 78 adults its heart rate matched the lab to about 1% while its HRV-ready beat intervals were out by about 31% [13].

Oura Ring — 5 • 2 • 5

Overnight it is the most accurate consumer device tested: in 13 adults over 536 nights the Gen 4 ring's resting heart rate and HRV were within about 2% and 6% of the ECG [15]. An independent group found the nightly averages close to the ECG, with only one ratio measure and short five-minute snapshots unreliable [23]; the company's own study agrees [22]. Two cautions: accuracy drops in people over 45 unless the ring averages at least half an hour of mostly clean signal — the study used an 80% quality threshold [24] — and in daytime tests the Gen 3 ring was among the four least accurate of ten devices, a group whose errors ran 11 to 16% [16]. A night device, not a workout device.

WHOOP — 4 • 3 • 4

Its heart rate is reliable, but its HRV error is about the same size as the change you would be looking for — roughly a 2% average error with a swing of about 6% [25]. Overnight it was a clear second to Oura [15]. In exercise it is fine in steady effort, less so when the pace changes [17], and the same band on the upper arm beat the wrist [26]. A large WHOOP night-to-night HRV study was written mostly by company staff [37].

Polar Verity Sense arm band — 5 • 5 • not tested for HRV

On the forearm it had the smallest error of six devices at rest and, with the upper-arm WHOOP, the closest match to the chest strap in a graded treadmill test [26]. In 39 twelve-year-olds doing high-intensity intervals it stayed within about 3% of the strap overall, loosening a little at the hardest efforts [31]. One catch: over a tattoo its resting error jumped to 23%, worse at rest than while running [32]. No published test of its HRV.

Garmin — 4 • 3 • 2

Heart rate is well studied and mid-pack: among the most accurate brands in one review [1], stable through changes of pace on the Vivosmart 4 [17], but 13% off on a hilly trail run on the Fenix 5, where no optical device did well [18], and weakest of five in cardiac rehab on the Forerunner 235 [10]. HRV has been checked once: the Fenix 6 was about 10% off overnight and was dropped from the resting-heart-rate comparison for inconsistent readings [15].

Fitbit — 4 • 3 • not tested for HRV

The most studied brand. Pooled across dozens of studies, Fitbits read about three beats low, single readings up to about 24 beats low or 18 high [3]; older models read 16 beats low in brisk activity [19]. Recent models do better — the Charge 6 was the most accurate of ten devices in a 2026 test [16] and the Charge 5 and Sense 2 led the wrist

devices in another [17]. Oddly, the Charge 4 was least accurate sitting still and typing [20]. Fitbit publishes a nightly RMSSD, but we found no test of it against an ECG.

Samsung Galaxy Watch — 3 • 4 • not tested for HRV

The Active2 read almost four beats high overall and was poorest at rest, but better than the Fitbit during and after exertion [20]. The Watch 6 tracked a treadmill test to exhaustion closely at high effort, with wider scatter at low effort — a study from Sidia, a research institute set up by Samsung [21]. No HRV test found.

Pixel Watch — 4 • 3 • Amazfit — 3 • 3 • Coros and Ultrahuman — not rated

One independent study puts the Pixel Watch 2 second of ten devices at rest and walking, within about 7% of the ECG [16]; its HRV uses Fitbit's method and is likewise untested. Two low-cost Amazfit models stayed inside the 10% error range on a treadmill in 51 heart patients, best at low effort [34], with nothing on current models or HRV. The only Coros paper tests its lactate-threshold estimate, not raw heart rate [33], and for Ultrahuman we found only company-run studies with no ECG comparison. Both may be fine; nobody independent has checked.

What Makes Any Wearable Wrong

Movement is the big one. Error during activity runs about 30% higher than at rest, and devices differ most in handling a change of pace [35]; every wrist device lost accuracy in the first moments of a transition [17], and irregular walking hurt more than heat or cold [16]. Where you wear it matters — upper arm beats forearm beats wrist [26] — and a loose fit or a tattoo under the sensor can break the reading [32]. Skin tone is unresolved: of ten studies, four found darker skin read less accurately, four found no difference, and two were mixed [36]. An irregular heartbeat is the danger case: in atrial fibrillation two popular watches read 9 beats low on average and up to 69 beats low when the true rate was above 140 [14]. Devices have improved — exercise accuracy has climbed steadily over twenty years [5] — but a pooled analysis of HRV devices found the brand mattered less than the posture and the HRV metric chosen [4].

If You Have POTS or Another Dysautonomia

Two things follow from the tables. First, a standing heart-rate test is exactly the moment optical sensors are weakest — a fast rise in the first minute [17]. Do the test with a chest strap, or count your pulse by hand, and let the watch be the backup. Second, HRV is a sensitive but unspecific dial: alcohol, a cold or a hard session all move it [40], so does short or irregular sleep [37], one night is noise and you need at least five of seven nights to see a weekly pattern [37], and the current expert guideline says HRV should not be read as "vagal tone" or nervous-system balance [39]. It cannot diagnose you; a low number is a prompt to rest and check in, not a verdict.

Call your doctor promptly if

- Your device flags an irregular rhythm, or a new resting heart rate above 100 or below 40
- Your heart races or pounds with chest pain, breathlessness at rest, or fainting
- You faint during exercise, or you faint and hurt yourself
- You use a wearable to exercise safely with a heart condition — ask if a strap or supervision is safer
- A number on a screen is driving what you eat, sleep or do — bring it to a visit before acting on it

The Rooted Motion Difference

- We test your device against a chest strap during your visit, and set the two or three numbers worth watching
- Convenient concierge mobile physical therapy delivered where you are.

Want the Numbers Explained for Your Body?

A one-on-one evaluation at home checks your device against a chest strap, sets a standing test you can repeat, and writes to your doctor with what we found.

Move Better. Live Rooted.

Contact Rooted Motion Physical Therapy to schedule your one-on-one evaluation.

Educational disclaimer: This handout is for educational purposes and is not a substitute for an individual evaluation by a licensed healthcare professional. Seek prompt medical evaluation for severe pain, significant weakness, numbness, or symptoms following trauma.

Research Behind This Guide

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