evinlo

EVINLO EXPLAINERS

Overnight changes, explained

How Evinlo notices when several of your overnight signals move away from your usual together, and why it never says more than that. Not a diagnosis.

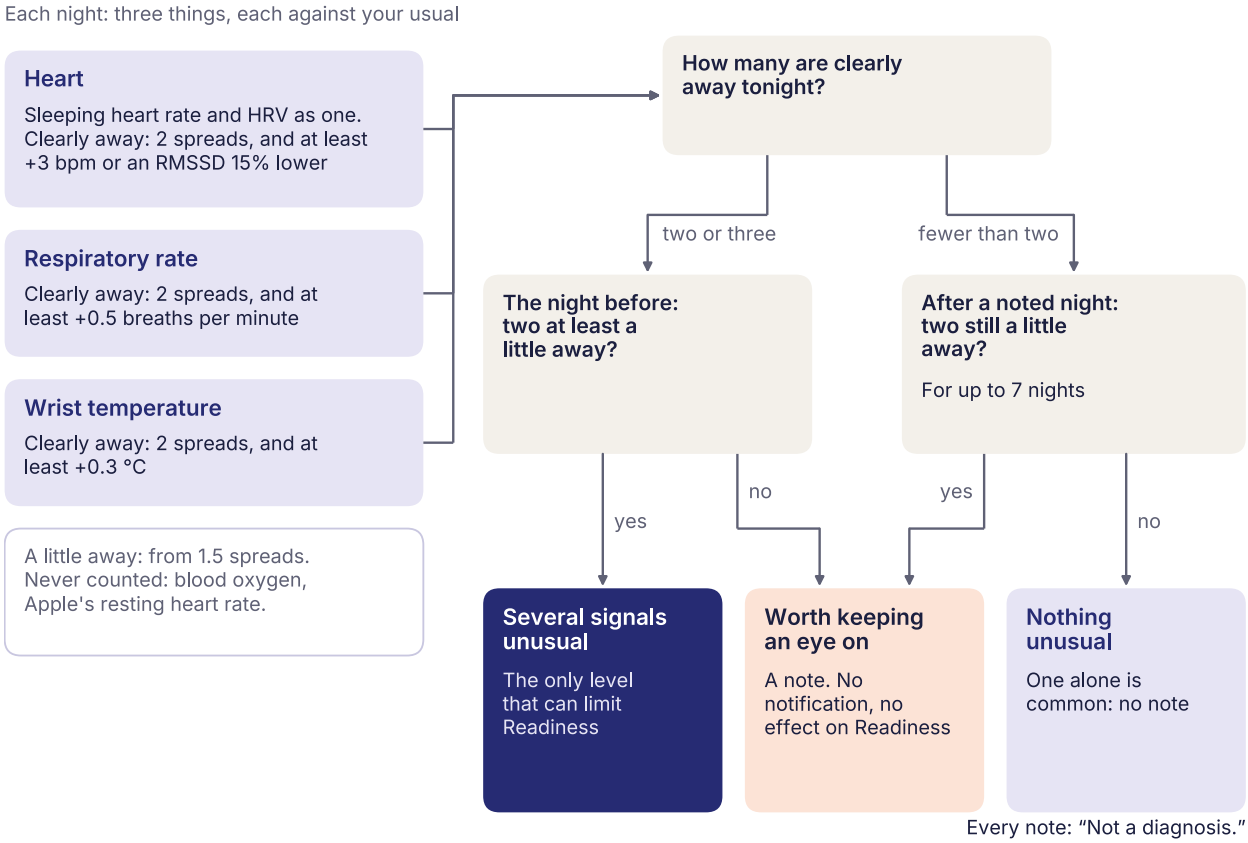


ALGORITHM
Overnight changes 1.0.0

WRITTEN
October 2026

The one-minute version

Your heart rate, your breathing and your wrist temperature move a little every night. Now and then one of them moves a lot, and that is common. **Overnight changes** answers one narrow question: did **several** of them move away from your usual **together**?



The check in one picture. Each night, three things are compared with your usual. Two of them clearly away on one night is worth keeping an eye on; when the night before was already away too, several signals are unusual. A single signal never makes a note.

IN SHORT

- **Three things are watched:** your heart (the sleeping heart rate and HRV as one), your respiratory rate and your wrist temperature. Blood oxygen is shown and never counted.
- **"Clearly away"** means at least 2 spreads from your usual in the direction the check watches (a spread is how much your nights usually vary), and a minimum change in the signal's own unit.
- **Two clearly away on one night** reads "Worth keeping an eye on". One alone is never a note.
- **"Several signals unusual"** needs two clearly away tonight and two at least a little away the night before. Only this level can limit Readiness.
- **It describes a change, never a cause.** It cannot tell a hard weekend from the start of an illness. **Not a diagnosis.**

What goes in

The check measures nothing itself. It reads the night the **overnight layer** has evaluated, the part of Evinlo that turns what your watch recorded overnight into nightly values and usual ranges (see "The overnight layer, explained"), and a few facts Evinlo already knows about the night.

What	From	What the check uses it for
The heart signal	The overnight layer: HRV and the sleeping heart rate merged	The heart's distance from your usual
The sleeping heart rate and the RMSSD, against their usual for the hours measured	The overnight layer	The heart's minimum change
Respiratory rate and wrist temperature	The overnight layer	Their distances and changes
The night before	The same, one night earlier	Whether the change continues
A short or a late night	The sleep section	Named next to a note
The time zone of each night, the watch that recorded it	The night itself	Travel and a new watch, named next to a note
Yesterday's activity	Movement	A day well above your usual, named next to a note

Never part of the check: blood oxygen (shown next to it, for reference), Apple's resting heart rate (it never stands in for the heart here), symptoms you may have logged in Apple Health (not read in this version), and anything about how you feel.

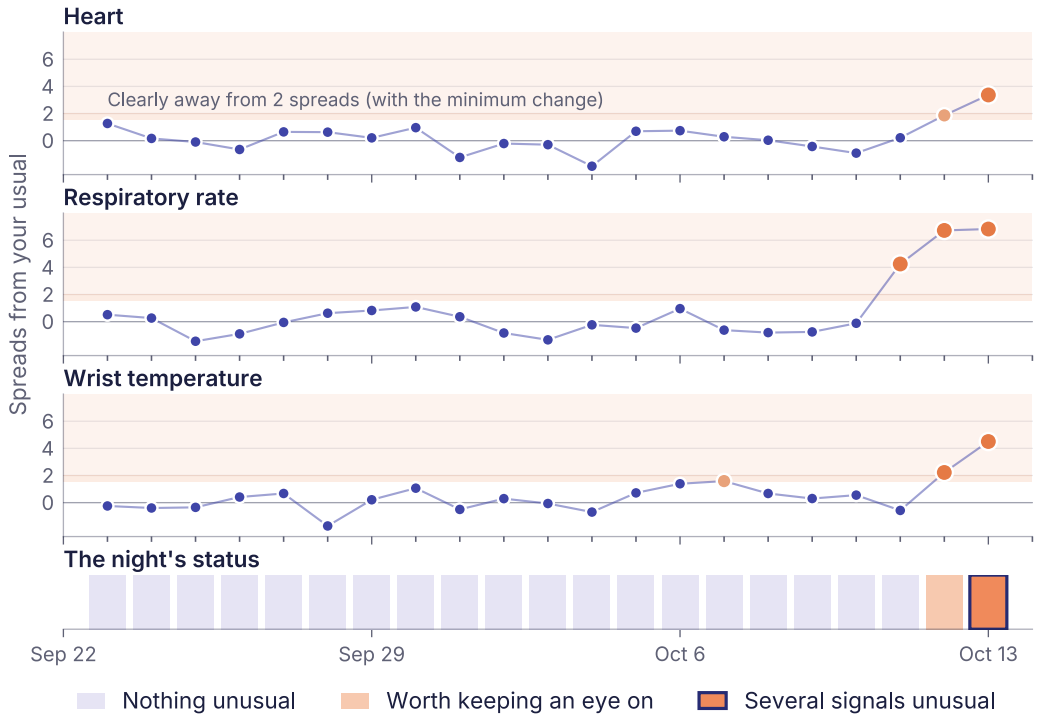
How it works, step by step

Step 1: three things, each a distance from your usual

The check watches three **components**:

- **Heart.** The sleeping heart rate and HRV mostly move together. Counting both would turn one cause into "two signals", so the heart counts once, as the overnight layer's merged heart signal. It is compared with your usual **for the hours that were measured**, so a short night does not make the heart look away just for being short.
- **Respiratory rate.**
- **Wrist temperature.**

Each gets a **distance**: how many spreads it sits from your usual, counted in the direction the check watches. That is a higher sleeping heart rate or a lower HRV, a higher respiratory rate, a warmer wrist. A value away in the other direction (a calmer heart, a cooler wrist) counts for nothing here. A spread is how much your nights usually vary around their middle (1.4826 times their median absolute deviation, a robust cousin of the standard deviation), so 2 spreads is far for a steady person and for a restless one alike.



Maya with an episode: the three distances over the three weeks up to 13 October, and the status of each night. Light marks are a little away, warm marks clearly away. On 11 October only her respiratory rate is clearly away; on 12 October two components are; on 13 October all three, after a night that was already away.

Step 2: clearly away, a little away

Component	Clearly away (a “vote”) needs	A little away
Heart	2 spreads, **and** a sleeping heart rate at least 3 bpm above its usual or an RMSSD at least 15% below it	1.5 spreads
Respiratory rate	2 spreads, **and** at least 0.5 breaths per minute above its usual	1.5 spreads
Wrist temperature	2 spreads, **and** at least 0.3 °C above its usual	1.5 spreads

The **minimum change** keeps a tiny change from counting for a person whose nights are unusually steady. For the respiratory rate and the wrist temperature it equals two spreads at their smallest, so it holds whenever their distance does. For the heart it adds something: the heart rate itself or a real RMSSD has to have moved, not only the merged signal. RMSSD is the measure of HRV that Evinlo uses (how much each interval between two heartbeats differs from the next). SDNN, the measure the Health app shows, varies a lot from night to night on one-minute recordings, so an SDNN value alone never makes the heart count.

A component with no value or no usual range that night is **not judged**. The heart is not judged on a night without a sleeping heart rate and without HRV: Apple’s resting heart rate never stands in for it here.

Step 3: the night's status

A night is **judged** when at least two components have a level. Then:

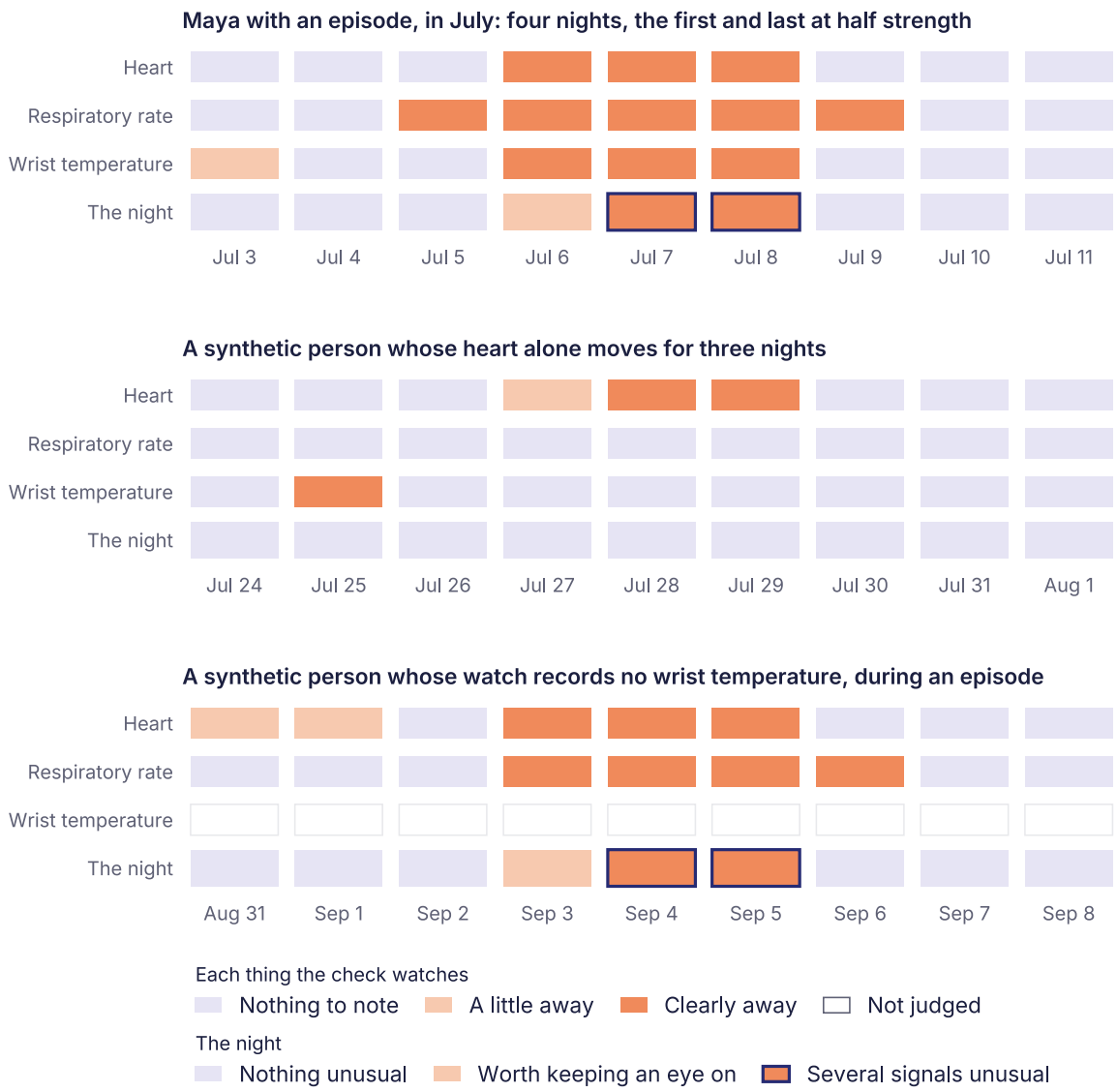
Status	When	What it does
Nothing unusual	Fewer than two clearly away. One alone, however far, is common and never a note	Nothing
Worth keeping an eye on	Two or three clearly away tonight; **or**, after a noted night, two still at least a little away (for at most 7 nights, so the note does not vanish the moment one signal slips under the line)	A note in the app. No notification, no effect on Readiness
Several signals unusual	Two or three clearly away tonight, **and** at least two components at least a little away **the night before**	The note; the only level that can limit Readiness

Before two components have a usual range, the check says "Not enough to go on yet" and how many earlier nights it has (7 are needed). With usual ranges but too few signals recorded that night, it says so too.

Step 4: the night before

"The night before" is the night of the day before, if the check judged it. If the day before has **no body signals at all** (no night recorded, a night from another tracker, a night that was too short, incomplete or entered by hand), it is the night two days before: people take their watch off when they feel unwell. A night that has body signals is never skipped, also when too few of them were recorded for a judgement; then there is simply no night before.

In July, Maya's night of 5 July had one vote: Nothing unusual. On 6 July all three were clearly away, but the night before had only one at a little away or more: Worth keeping an eye on. On 7 and 8 July: Several signals unusual. On 9 July her wrist temperature was 1.49 spreads away, just under the 1.5 of "a little away", and only her respiratory rate still voted: back to Nothing unusual. Next to the note of 6 July, the page also said what Evinlo could see: a short night. For the person whose heart alone moved, the heart was clearly away on 2 nights in a row, and both nights read Nothing unusual.



Three synthetic people, night by night. Top: Maya in July, with an episode the generator gave her. On 5 July one vote is nothing unusual; on 6 July three votes after a night with one are worth keeping an eye on; on 7 and 8 July several signals are unusual; on 9 July only the respiratory rate is still away. Middle: the heart alone moves, and it is never a note. Bottom: a watch without wrist temperature still reads a strong episode with the two signals it has.

Step 5: notes, earlier notes, and what else moves these signals

Noted nights that follow each other this way form one **note**. The page shows the last 14 nights as a grid, and the **earlier notes** of the last 90 days, each with its highest level and what was clearly away.

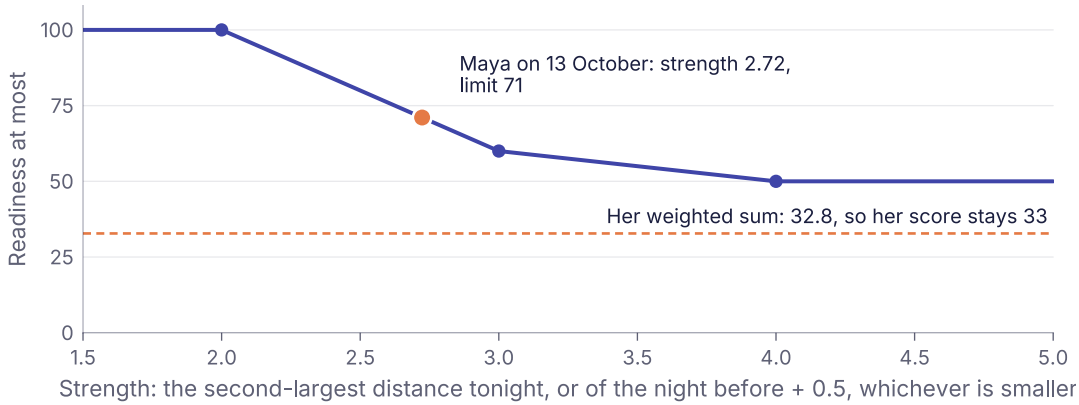
With a note, and also with a single vote, the page lists what Evinlo itself can see about the night and the night before that moves the same signals:

- **a short night:** asleep at least 60 minutes less than the night's need;
- **a late night:** falling asleep at least 90 minutes later than usual;
- **travel:** a time zone at least 2 hours from the night before;
- **hard training:** a day well above your usual activity;
- **a new watch:** another watch than most of the 14 nights before.

It never guesses at what it cannot see, and says so: alcohol, a warm room, some medications and the menstrual cycle move these signals too. With “Several signals unusual”, the status sentence itself says what else moves these signals, and when both nights were short or late, it says that first.

Step 6: what it does to Readiness

Only “Several signals unusual” can limit Readiness, and only as a backstop. Its **strength** is the second-largest of the three distances tonight, or that of the night before plus half a spread, whichever is smaller. No limit at 2 spreads, 60 at 3, 50 from 4, linear in between.



The several-signals limit of Readiness against its strength. Maya with the episode on 13 October: the limit is 71, and her score is already far below it.

When two signals are this far away, Readiness’s own parts have usually lowered the score already, as on Maya’s day. “Worth keeping an eye on” never limits Readiness, and neither does a single signal. On a day with several signals unusual, Readiness is never called “Ready for effort”.

A worked example

Meet **Maya**. She is a synthetic person: the app's generator made her nights and days, and no part of her comes from a real person. For this example the generator added an **illness-like episode** to her nights: four nights in which her heart rate, breathing and wrist temperature rise and her HRV falls, the first and the last at half strength. The sizes are assumptions, not measurements. Her last night, 12 to 13 October, is the episode's third.

Here are her three nights as the app showed each of them that afternoon. Distances are in spreads, in the direction the check watches. The heart's changes are against her usual for the hours measured, the others against her usual.

Night to	Heart	Respiratory rate	Wrist temperature	Status
11 October	0.21 (+1.3 bpm, HRV +1%)	**4.25** (+1.26 breaths/min)	−0.57 (−0.11 °C)	Nothing unusual
12 October	1.86, a little away (+6.9 bpm, HRV −22%)	**6.72** (+2.11)	**2.22** (+0.45 °C)	Worth keeping an eye on
13 October	**3.37** (+10.4 bpm, HRV −48%)	**6.83** (+2.14)	**4.50** (+0.94 °C)	Several signals unusual

Bold is clearly away. **On 11 October** only her respiratory rate was: one alone is common, and the page said so ("It takes two, because one alone is common."). **On 12 October** two were clearly away, and the night before had just one at a little away or more. **On 13 October** all three were clearly away, and the night before had three at a little away or more. It is the second night in a row with a note, so the page reads: "For the second night in a row, several signals were away from your usual: your heart, your respiratory rate, and your wrist temperature. … A short or late night, alcohol, a hard day and travel move these signals too." And, under every note: "Not a diagnosis."

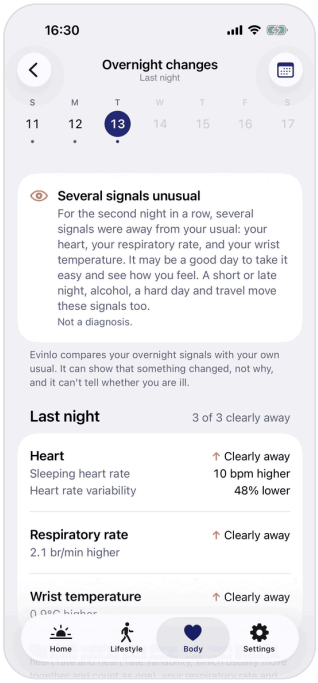
Next to each component, the page shows the change in plain units: 10 bpm higher, 48% lower, 2.1 br/min higher, 0.9°C higher. The grid of recent nights notes one other night of the last 14: the night before.

Her Readiness. The second-largest distance tonight is 4.50; the night before it was 2.22, plus half a spread is 2.72. The smaller, 2.72, is the strength, which limits Readiness to 71. Her parts already add up to 32.8, so the limit does not lower anything: her Readiness is 33, usually 80, and the page says that the limit was in place and did not lower the score this time.

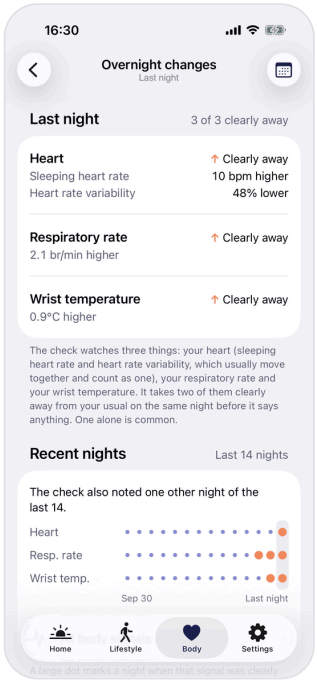
Over her whole history of 120 nights from 16 June, the check had 113 judged nights. On 7 nights exactly one thing was clearly away, and none of them made a note. There were 5 noted nights, all inside the two episodes the generator gave her. For comparison, Maya without the episode on the same morning: Nothing unusual, with her HRV 11% lower than her usual, which the check does not count on its own.

What you see in the app

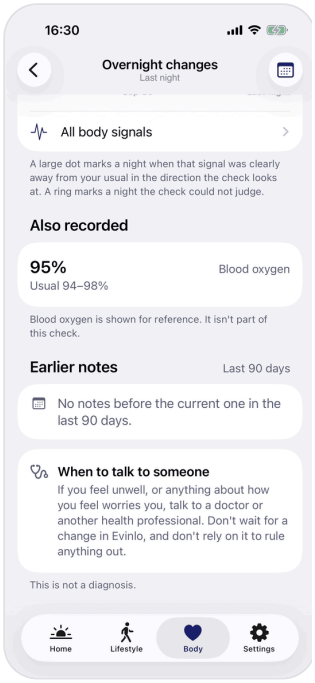
These are Maya's screens with the episode at 16:30 on Tuesday, 13 October, in the app's synthetic data mode, and Maya without it.



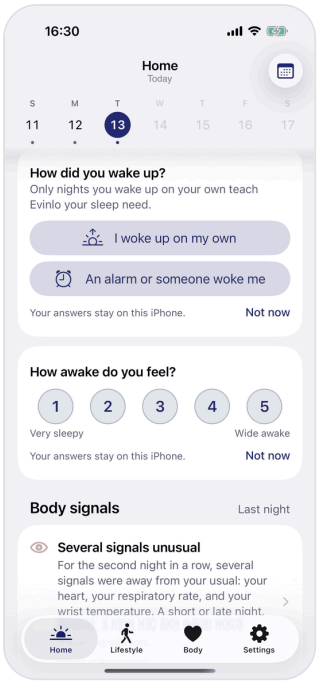
The status, its sentence, and "Not a diagnosis."



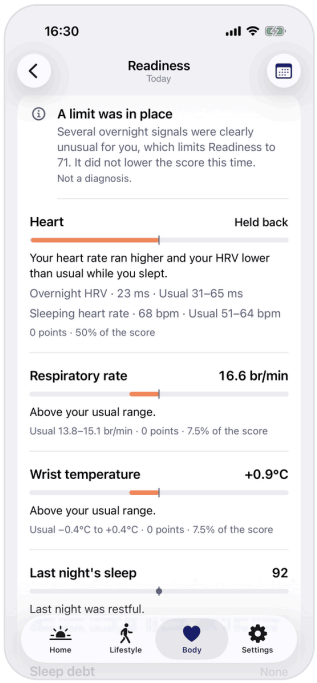
The three components, the grid of 14 nights.



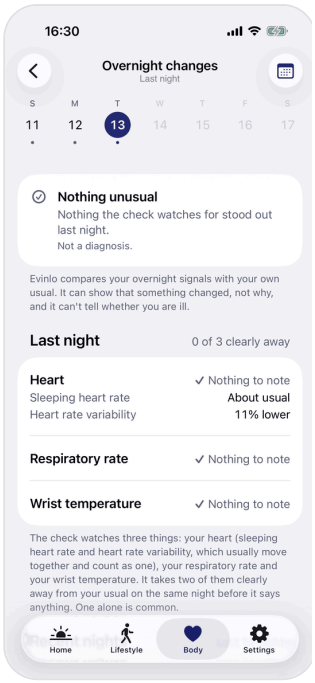
Blood oxygen apart, earlier notes, when to talk to someone.



Home, with the note in the body signals section.



Readiness: "A limit was in place".



Maya without the episode: Nothing unusual.

Honest limits

- **It cannot tell a strained weekend from the start of an illness.** Two short or late nights, alcohol, a hard day or travel move the same signals in the same direction. When two strained nights in which the wrist temperature moves too were added to quiet stretches of a synthetic person's nights, they reached "several signals unusual" in about one case in five with ordinary night-to-night variation, and in more than half of the cases on a very steady synthetic person. A single strained night almost never did. So the app says it in the sentence itself.
- **A short night alone can make a note more likely.** The heart is compared with your usual for the hours measured; the respiratory rate is not, so the hours alone can move it. The page names a short night next to a note.
- **It answers clear changes and misses mild ones.** Without wrist temperature it has two signals to go on and is weaker.
- **Your usual follows you.** A slow, lasting change becomes the new usual. With a menstrual cycle, the signals move with its phases; the range widens rather than noting each cycle, which also makes the check less sensitive.
- **How often it notes something depends on the person and on design choices.** This explainer promises no rate.
- **It is not a medical device and not a diagnosis.** It can show that something changed, not why, and it cannot tell whether you are ill. If you feel unwell, or anything about how you feel worries you, talk to a doctor or another health professional. Don't wait for a change in Evinlo, and don't rely on it to rule anything out.

For the experts

Version and scope

`IllnessAlgorithm.version` is **1.0.0** and covers the components, votes, levels, the chain of nights, settling and episodes. The values, ranges and the heart signal it reads are the overnight layer's (`OvernightAlgorithm.version` 1.0.0). In the code its types are `IllnessCheck` and `IllnessEngine`, and the evaluation tool calls the area `illness`; the app calls it **Overnight changes**.

Parameters

Parameter	Value	What it does
`IllnessParameters.voteZ`	2.0	A component votes from this distance (with its minimum change)
`raisedZ`	1.5	"A little away" from this distance
`minimumHeartRateRise`	3.0 bpm	The heart's minimum change by heart rate, against the usual for the hours measured
`minimumHRVDropLn`	0.1625	…or by an RMSSD (never SDNN) lower by this much in ln ms, which is 15%
`minimumRespiratoryRise`	0.5 breaths/min	

Parameter	Value	What it does
`minimumTemperatureRise`	0.3 °C	
`componentsNeeded`	2	Components a judgement needs, and votes a note needs
`settlingMaximumNights`	7	Nights a note may stay while two components are still a little away
`severalNeedsNonHeartNightBefore`	false	An evaluation variant: also ask for the respiratory rate or the wrist temperature at 2 spreads the night before. Off in 1.0.0
`recentNightCount`	14	Nights in the grid
`episodeHistoryDays`	90	Days of earlier notes
`travelOffsetHours`	2.0	A time-zone change that counts as travel
`newWatchLookbackNights`	14	Nights a new watch is compared with
`OvernightParameters.statusChainDays`	16	Nights before a day its status can reach back through (the vote night, the night before, up to 7 settling nights, one missing night between each pair)
`ReadinessParameters.severalSignalsCapKnots`	(2, 100), (3, 60), (4, 50)	The Readiness limit against its strength
`severalSignalsPreviousNightAllowance`	0.5	Added to the night before's strength
`UsualComparison.sleepAgainstNeed`, `.clockTime`	60 min, 90 min	"Well below" the need, "well above" the usual onset: a short or late night

Every number here is a **design choice**. Wearable studies found overnight respiratory rate and heart rate raised and HRV lowered around respiratory infections, in groups, and often together with other causes such as alcohol, travel, intense exercise or poor sleep. None of them validated a rule for one person, and none supports these thresholds.

Formulas

With z the unfavourable distance of a component (for the heart, the negative of the heart signal) and Δ its change against the usual (for the heart, the usual for the hours measured):

$$\text{level} = \begin{cases} \text{clearly away} & z \geq 2 \text{ and } \Delta \geq \Delta_{\min} \\ \text{a little away} & z \geq 1.5 \\ \text{nothing to note} & \text{otherwise} \end{cases}$$

With V the votes tonight, R the components at a little away or more tonight, R_b those of the night before:

$$\text{status} = \begin{cases} \text{several signals unusual} & V \geq 2 \text{ and } R_b \geq 2 \\ \text{worth keeping an eye on} & V \geq 2;\ \text{or } R \geq 2, \text{ the night before noted and settling} < 7 \\ \text{nothing unusual} & \text{otherwise} \end{cases}$$

The Readiness limit, with $z_{(2)}$ the second-largest distance of a night:

$$\text{strength} = \min\left(z_{(2)}^{\text{tonight}},\ z_{(2)}^{\text{night before}} + 0.5\right), \qquad \text{limit} = \text{interpolate}\big(\text{strength};\ (2,100),(3,60),(4,50)\big)$$

The order of operations

1. The overnight layer evaluates every night of the window, each from its own 60 days (`OvernightEngine.signals(in:)`).

2. `IllnessEngine.nights(in:)` walks the nights in order, starting 16 nights before the first day it needs, so that every chain is exact: for each night with body signals, the levels of the three components (`IllnessLevels`), then the status from tonight's votes, the night before and the settling count (`IllnessChain`).
3. `IllnessEngine.check(for:)` builds what the page shows: the state, the three components with their readings, blood oxygen, the 14 nights, the run of noted nights, the earlier notes (stage C2 of the day pipeline, once the 90 days are read; before that, "Still preparing your history"), and the influences of the night and of the night before.
4. Readiness reads the status and the two strengths for its limit.

Edge cases

- **The first week:** "Not enough to go on yet", with the earlier nights of the second-furthest usual range ("4 so far" of 7).
- **Too few signals** on a night with usual ranges: "Not enough to go on".
- **A night without body signals:** "No overnight data", and the page says why.
- **A watch without wrist temperature:** two components to go on, and the row says so.
- **A night from another tracker between two watch nights** is skipped when the check links nights; a night that has body signals but was not judged breaks the chain.
- **Nothing after a day changes it:** a day's status depends on its own night and the nights before it only.

Where it lives in the code

What	Where
Parameters, version, the engine	`Packages/EvinloKit/Sources/EvinloAlgorithms/Contract/BodySignalsContract.swift`
Levels of one night, votes and minimum changes	`EvinloAlgorithms/BodySignals/IllnessLevels.swift`
The chain of nights, settling, episodes	`EvinloAlgorithms/BodySignals/IllnessChain.swift`
The check as shown, influences	`EvinloAlgorithms/BodySignals/IllnessCheckBuilder.swift`
The model: statuses, components, levels	`Packages/EvinloKit/Sources/EvinloModels/IllnessCheck.swift`
The Readiness limit	`EvinloAlgorithms/Readiness/ReadinessLimits.swift`
The words of the page	`App/Evinlo/Data/Wording/IllnessWording.swift`, `App/Evinlo/Features/Body/Illness/IllnessDetailView.swift`
The tests	`Packages/EvinloKit/Tests/EvinloAlgorithmsTests/BodySignals/`

What the validation checks

The evaluation tool (`Tools/EvinloEval`) replays the nights through the same day pipeline as the app and reports aggregates only.

- **Hard guardrails (BH1 to BH10)** fail on any data: two evaluations are identical; a day's result does not change when later nights are taken away; every status has its votes, its night before and at least two judged components; one signal ten spreads away on a quiet night is never a note; a signal that moves

further in the watched direction never lowers a status; no heart vote on SDNN alone; no vote from fewer than 7 nights; a night without body signals has no status.

- **Injected changes** (`evinlo-eval inject`): strong, moderate and mild episodes, one, two and three strained nights, the heart alone and wrist temperature alone, added to quiet stretches of the replayed nights. Their sizes are assumptions.
- **Synthetic guardrails (BS1 to BS13)** are hard on synthetic people: a steady person is rarely noted; strong episodes reach “several”; one strained night and the heart alone stay below “several”; a watch without wrist temperature still answers a strong episode; a cycle and a slow drift are absorbed; a new person has no status before the eighth night.
- **What the replays showed** on synthetic people of 1,100 nights (eight seeds each): every strong episode of four nights was noted and reached “several”; of moderate episodes five in six were noted and about one in two reached “several”; a single strained night was noted about one time in eight and reached “several” about one time in a hundred; a change of the heart alone reached “several” one time in forty; a watch without wrist temperature still read four strong episodes in five as “several”. A steady synthetic person was noted two to three times a year, read “several” about once in four years, and had a vote on about one night in twelve.

References

- Natarajan A., Su H.-W., Heneghan C., *npj Digital Medicine* 3, 2020, doi:10.1038/s41746-020-00363-7.
- Alavi A. et al., *Nature Medicine* 28, 2022, doi:10.1038/s41591-021-01593-2: an alerting system built on overnight resting heart rate, in which stress, alcohol and travel raised alerts too.
- The complete rules: docs/scoring.md, “Overnight changes”; the values it reads: “Body signals”.

Spotted something unclear or wrong, or want to improve a rule? Evinlo is open source, and every rule can be changed through a proposal and a replay. Start at **evinlo.com/contribute**.