evinlo

EVINLO EXPLAINERS

Fitness trends, explained

How Evinlo turns six months of Apple's own estimates into a direction, and says "No clear change" whenever the weeks do not show one.

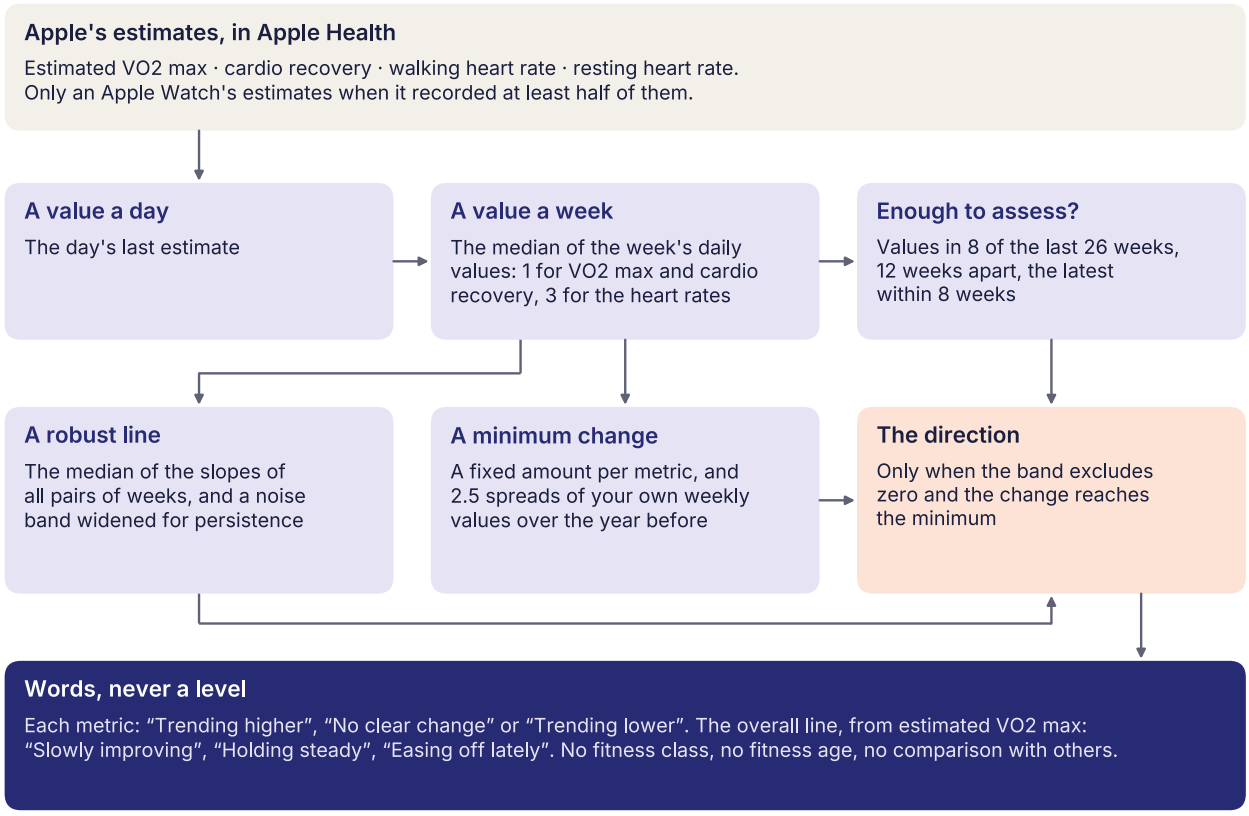


ALGORITHM
Fitness trends 1.0.1

WRITTEN
October 2026

The one-minute version

Evinlo follows four of Apple's estimates over the last six months: **estimated VO2 max, cardio recovery, walking heart rate and resting heart rate**. For each it says which way it is moving: "Trending higher", "No clear change" or "Trending lower". There is no fitness level, no fitness age and no comparison with other people: only the direction of your own values.



How a direction comes about. Apple's estimates become one value a day and one a week; with enough weeks, a robust line runs through them; a direction is called only when the line clears both its noise band and a minimum change.

IN SHORT

- **Weeks, not days.** A single estimate can be off by several units. Evinlo works with the median of each week.
- **Only with enough weeks.** Values in at least 8 of the last 26 weeks, spread over at least 12, the latest within 8. Otherwise the page says what is missing.
- **A line that one odd week cannot turn.** Its slope is the median of the slopes of all pairs of weeks.
- **Two hurdles.** The noise band of the slope must exclude zero, and the change must reach a minimum that grows with how much your own weeks wander.
- **Slow by design.** The current week is shown and never assessed, so a direction changes at most once a week.

What goes in

Metric	What Apple records	A week needs
Estimated VO2 max	Apple Watch's estimate of cardio fitness, from your heart rate during outdoor walks, runs and hikes	1 daily value
Cardio recovery	How far your heart rate falls in the first minute after some workouts	1 daily value
Walking heart rate	Apple's daily average while you walk	3 daily values
Resting heart rate	Apple's daily estimate	3 daily values

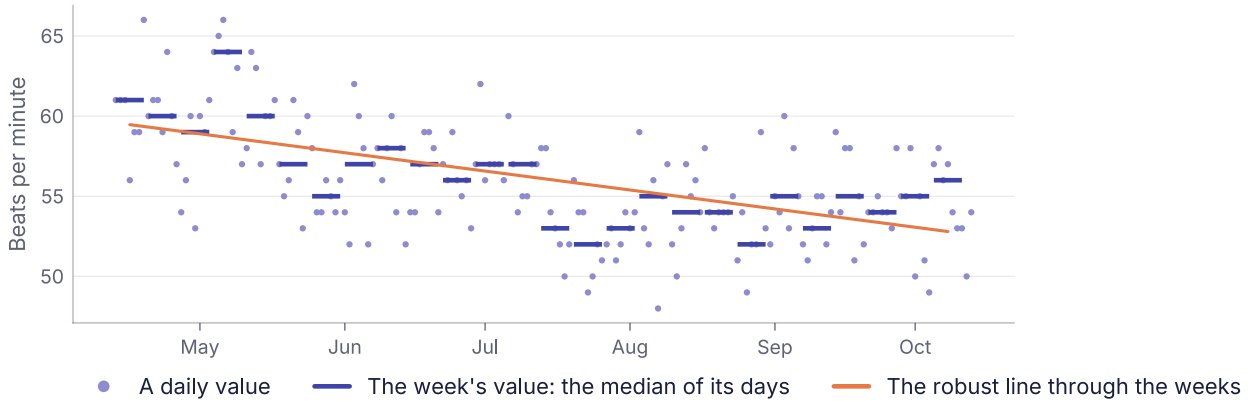
One kind of source. When an Apple Watch recorded at least half of a metric's samples of the last six months, only its samples count, so the estimates of different makers are never mixed in one trend. Otherwise all samples count.

Evinlo reads nothing else for fitness: no workouts, no weight, no age. Fitness trends stand apart from the day: they look at months, and the app works them out as of the moment it reads them.

How it works, step by step

Step 1: a value a day, a value a week

- **A daily value** is the last estimate of a day. Apple replaces the resting and the walking heart rate of the current and the previous day as the day goes on, so the last one counts.
- **A weekly value** is the median of the daily values of a week, from Monday to Sunday in your time zone, wherever you live: the day your region starts the week on changes nothing. A week needs one value for estimated VO2 max and cardio recovery, and three for the two heart rates; otherwise it has no value.
- **The current week** is shown, as "This week so far", and never assessed.



Resting heart rate of Maya with a fitness that changes (a synthetic person), over the 26 complete weeks before the week of 12 October and the days of that week so far. The generator lowers her resting heart rate by 6 bpm over these weeks. The line is the robust line of the next steps.

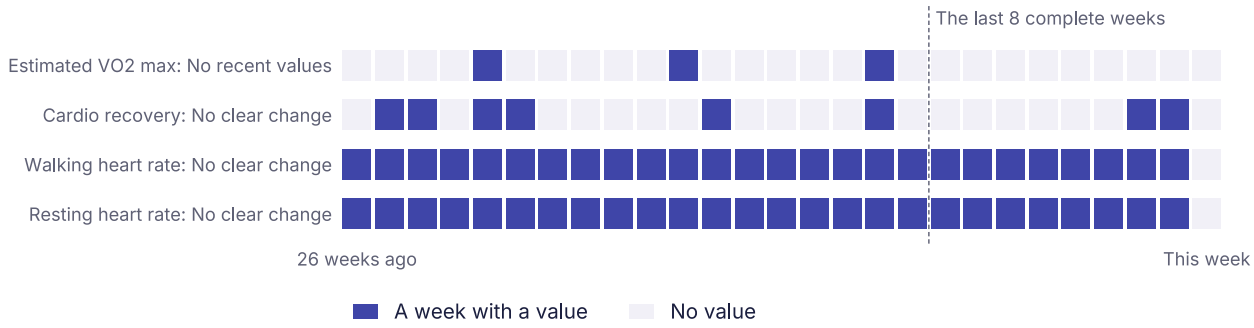
Her weeks run from Monday to Sunday, as everyone's do in Evinlo. In the week of Monday 5 October her seven daily values were, from lowest to highest, 53, 53, 54, 56, 57, 57, 58: the week's value is the median, 56 bpm. Every weekly value in the figure is worked out the same way from the daily values, and matches the export.

Step 2: enough to assess

Over the 26 complete weeks before the current one, a metric is assessed only with:

- values in at least **8** weeks,
- at least **12** weeks between the first and the last of them,
- and the latest within the last **8** complete weeks, or a value in the current week.

Otherwise the page says what is missing: no values yet, no recent values, or too few weeks.

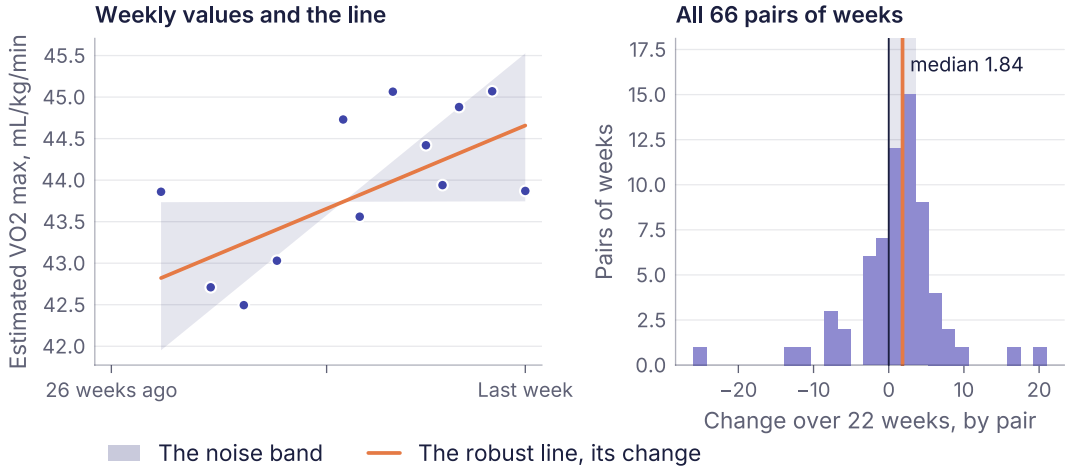


Which of the last 26 weeks have a value, for another synthetic person whose watch estimated VO2 max in three of them only. Cardio recovery, recorded after some workouts, has values in 8 weeks, 24 weeks apart: just enough.

This person's watch estimated VO2 max in 3 of the 26 weeks, last on 5 August. That is more than eight weeks ago, so estimated VO2 max reads "No recent values", and the page's headline, which rests on VO2 max, reads "Not enough data for a direction yet". Cardio recovery has values in 8 weeks, 24 weeks apart, and is assessed.

Step 3: a robust line

- **The slope** is the median of the slopes of all pairs of weeks (Theil–Sen; Sen, 1968). A single outlying week cannot turn it. **The fitted change** is that slope over the weeks between the first and the last value.
- **The noise band** is the range of slopes that the ups and downs of your weeks still leave open: Sen's interval for the slope, at $z = 1.96$ (the value a usual 95% interval uses). It is widened for persistence: a week above the line tends to be followed by another one above it, and an interval that treats every week as independent of the next is too narrow. Its variance is multiplied by $(1 + r) \div (1 - r)$, with r the lag-1 autocorrelation of the values around the line (how much each week's distance from the line resembles the week before's), kept between 0 and 0.9. **The band is a filter against wander, not a confidence level.**



Left: the 12 weeks with an estimated VO2 max of Maya with a fitness that changes, and the robust line through them; the fan shows the slopes of the noise band, turned around the middle of the line. Right: the change over 22 weeks that each of the 66 pairs of weeks points to. The line takes their median; the band, shaded, lies entirely above zero.

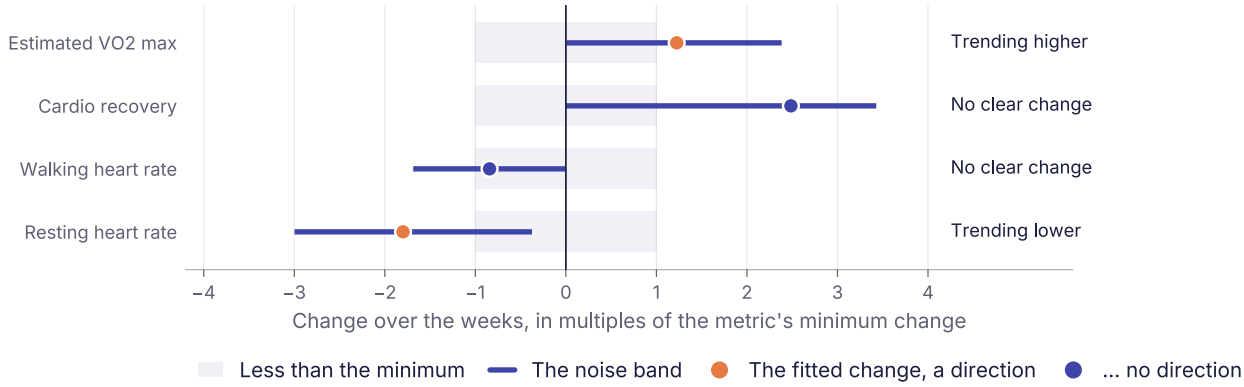
For estimated VO2 max she has 12 weeks with a value, 22 weeks apart. Their 66 pairs give a median change of 1.84 mL/kg/min over those weeks, and a band of 0.01 to 3.58. Her weeks' distances from the line show no persistence ($r = 0$), so the band is Sen's interval as it is. Her resting heart rate shows some ($r = 0.38$), which widens its band.

Step 4: a minimum change

A line that clears its band can still be too small to matter. The fitted change must also reach a **minimum**:

- a fixed amount per metric: **1.5 mL/kg/min** for estimated VO2 max, **4 bpm** for cardio recovery, **3 bpm** for the two heart rates;
- and **2.5 spreads** of your own weekly values over the 52 weeks before the window, when at least 12 of those weeks have a value. A spread is how much your weeks usually wander around their middle (1.4826 × their median absolute deviation, a robust cousin of the standard deviation). Someone whose weeks wander widely needs a larger change before it reads as a direction.

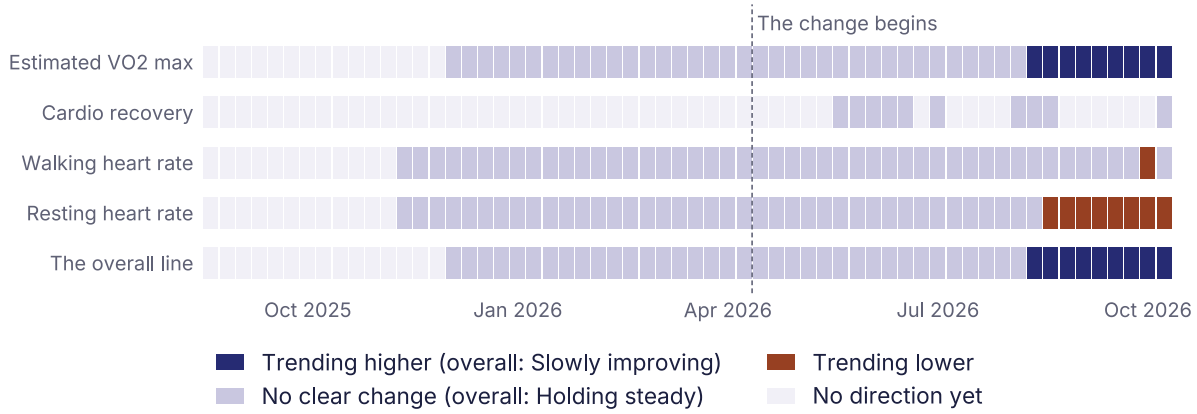
A direction is called only when the band excludes zero **and** the change reaches the minimum. Everything else reads "No clear change".



The four metrics of Maya with a fitness that changes, as of the week of 12 October. Each change and its noise band is drawn in multiples of the metric's own minimum, so the shaded area is "less than the minimum". Estimated VO2 max and resting heart rate clear both hurdles. The bands of cardio recovery and walking heart rate reach zero.

Step 5: words, and the weeks after

Every metric reads "Trending higher", "No clear change" or "Trending lower", and under its value how much it moved, for example "Up 1.8 mL/kg/min over 5 months". The **overall line** says "Slowly improving" or "Easing off lately" only when estimated VO2 max itself has that direction and no other assessed metric points the other way; "Holding steady" when estimated VO2 max is assessed without a direction. A rising heart rate alone is never called declining fitness. VO2 max is always "estimated".



The direction of each metric in each of 60 weeks, for Maya with a fitness that changes, as the app worked it out on each Tuesday. The generator's change begins 26 weeks before the end. Estimated VO2 max reads "Trending higher" in its last 9 weeks; resting heart rate reads "Trending lower" in the last 8 weeks, and walking heart rate once, the week before the last.

Over these 60 weeks a verdict never turned directly from higher to lower or back (0 times). Estimated VO2 max was first called a direction in the week of 17 August, when the change had run for about four months, and has read "Trending higher" ever since.

A worked example

Meet **Maya with a fitness that changes**. She is a synthetic person: the nights and days of Maya, with 420 days of history, and over the last 26 weeks the generator raises her estimated VO2 max by 3 mL/kg/min and her cardio recovery by 8 bpm, and lowers her walking and resting heart rate by 6 bpm each: twice the smallest change the rule calls a direction. The numbers are the app's on Tuesday 13 October at 12:00, in the week of Monday 12 October.

Metric	Weeks with a value	Fitted change	Noise band	Minimum	Reads
Estimated VO2 max	12 of 26	+1.84	0.01 to 3.58	1.5 mL/kg/min	Trending higher
Cardio recovery	8 of 26	+9.94	0.00 to 13.71	4 bpm	No clear change
Walking heart rate	26 of 26	−6.25	−12.50 to 0.00	7.41 bpm	No clear change
Resting heart rate	26 of 26	−6.67	−11.11 to −1.39	3.71 bpm	Trending lower

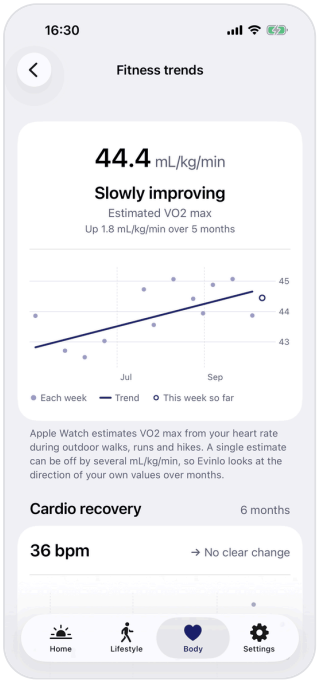
- **Estimated VO2 max** clears both hurdles: the band lies just above zero, and 1.84 is more than 1.5. The spread of her year before is only 0.31 (from 15 weeks), so 2.5 spreads would be less than the fixed minimum, which applies. Its 12 weeks with a value span 22 weeks, so the page says: "Up 1.8 mL/kg/min over 5 months".
- **Cardio recovery** changed by more than twice its minimum, but with 8 weeks its band reaches zero: "No clear change over 6 months". It is recorded after some workouts only, so it will often read that way.
- **Walking heart rate** is noisy. Its spread over the year before is 2.97 bpm (from 34 weeks), so its minimum is 7.41 bpm, and its band too reaches zero.
- **Resting heart rate** clears both: its band ends at −1.39, and −6.67 is beyond its minimum of 3.71 bpm, from a spread of 1.48. The page: "Down 7 bpm over 6 months".

The overall line rests on estimated VO2 max, which trends higher, and no assessed metric points the other way (a falling resting heart rate points the same way): **"Slowly improving"**.

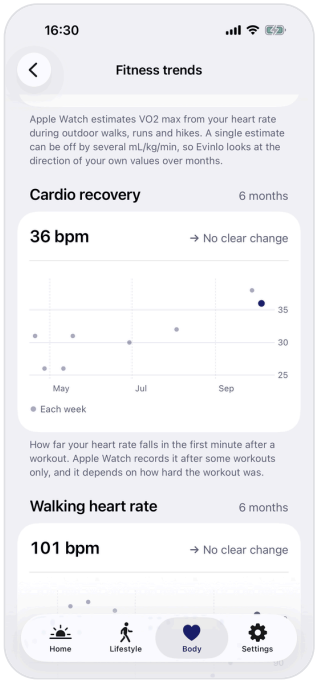
The same person without any change reads differently. Her estimated VO2 max moves by −0.68 with a band of −2.55 to 1.04, across zero: "Holding steady".

What you see in the app

The app's synthetic data mode on Tuesday 13 October at 16:30. Top: Maya with a fitness that changes. Bottom: no change, few estimates, and Maya with 120 days.



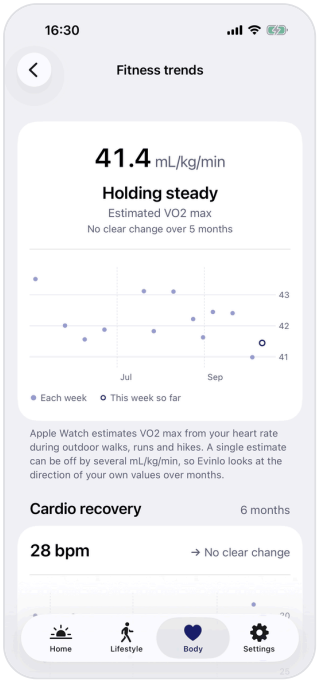
"Slowly improving"; this week so far as an open dot.



Cardio recovery and walking heart rate.



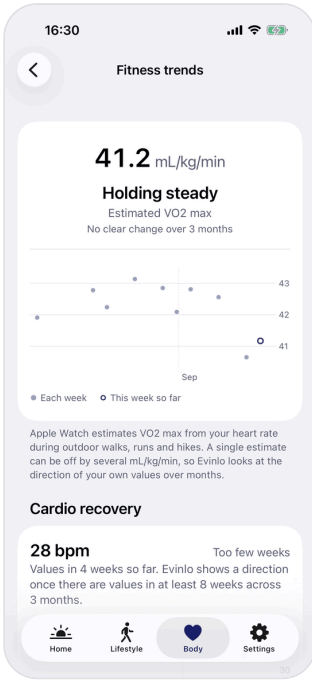
Resting heart rate, "Trending lower".



No change: "Holding steady".



Few estimates: no direction yet.



120 days: "Holding steady".

Each chart shows the weekly values, the line when a direction was called, and this week so far. Under each value the page says how much it moved, or why it shows no direction.

Honest limits

- **Apple's VO2 max is an estimate**, with a wide error against laboratory tests, and it moves with heat, terrain and weight too. That is why Evinlo shows the direction of your own estimates and never a level.
- **Season.** Resting heart rate tends to be a little higher in winter than in summer in large cohorts (Quer et al., 2020). A swing of that size stays under the minimum. A person whose resting heart rate swings twice as far can still read "Trending higher" in spring or autumn, because the values really did rise over those months. The trend describes the last months and predicts nothing.
- **A trend that has run for more than a year.** The spread of the year before cannot tell a long trend from wander: a change at the same pace through that whole year widens the spread, so the last six months can read "No clear change" although the chart shows a clear line.
- **Sparse metrics.** Cardio recovery is recorded after some workouts only, so it is likely to read "Too few weeks" most of the time. Walking heart rate is noisy, so it is likely to read "No clear change" even while it changes.
- **A new watch** may shift the values. This version does not restart the trend.
- **Directions, not verdicts.** A falling resting heart rate often goes with better fitness, but many other things move it, and Evinlo never says why a value moved.

For the experts

Version

`FitnessAlgorithm.version` is **1.0.1** (weeks from Monday to Sunday in every region); the trends carry it. A change to a rule or parameter below is a new version, made through a proposal and a replay (`docs/scoring.md`, “Changing an algorithm”).

Every parameter

Parameter (`FitnessParameters.v1`)	Value	What it does
`weeks`	26	The complete weeks assessed, before the current one
`minimumWeeksWithValue`; `minimumSpanWeeks`	8; 12	Weeks with a value; weeks between the first and the last
`staleAfterWeeks`	8	The latest value must lie within this many complete weeks (or in the current week)
`minimumDailyValues`	VO2 max 1, cardio recovery 1, walking 3, resting 3	Daily values a week needs
`bandZ`	1.96	The z of the noise band
`persistenceRange`	0…0.9	The range r is kept in
`minimumChange`	VO2 max 1.5 mL/kg/min; cardio recovery 4 bpm; walking 3 bpm; resting 3 bpm	The fixed minimum
`minimumChangeSpreads`	2.5	The minimum against your own spread
`spreadWindowWeeks`; `spreadMinimumWeeks`	52; 12	The year before the window; weeks with a value it needs
`dominantSourceShare`	0.5	An Apple Watch from this share of the samples: its samples only
`RobustLine.persistenceCeiling`	0.99	r never comes closer to 1 than this, whatever the range

Formulas

With the n weekly values (x_i, y_i) of the window (x the week, 0 to 25), the slope b is the median of all pair slopes, N of them, and the intercept the median of the rest:

$$b = \operatorname{median}_{i<j} \frac{y_j - y_i}{x_j - x_i}, \qquad a = \operatorname{median}_i \left(y_i - b\, x_i \right), \qquad \Delta = b\,(x_{\text{last}} - x_{\text{first}})$$

The band runs from the sorted pair slope at index $\operatorname{round}\left(\frac{N-C}{2}\right) - 1$ to the one at $\operatorname{round}\left(\frac{N+C}{2}\right)$, both kept inside $0 \ldots N-1$, with

$$C = z\sqrt{\frac{n(n-1)(2n+5)}{18} \cdot \frac{1+r}{1-r}}$$

and r the lag-1 autocorrelation of the residuals $y_i - (a + bx_i)$, in the order of the weeks. A direction needs the band on one side of zero and

$$|\Delta| \geq \max\left(m_{\text{fixed}},\ 2.5 \times 1.4826 \times \text{MAD}(\text{weekly values of the 52 weeks before})\right)$$

Maya's estimated VO2 max: $n = 12$, $N = 66$, $r = 0$, $\Delta = 1.84$, band 0.01 to 3.58, minimum $\max(1.5,\ 2.5 \times 0.31) = 1.5$.

The order of operations

1. **Read** the samples of the four metrics from the start of the week 78 weeks before the current one (the window and the year before it) up to the moment of the result; nothing later counts.
2. **Source rule** per metric, over the trend window; **daily values**: the sample with the latest end among those that start on a local day; **weekly values**: the median of a week from Monday to Sunday, with enough daily values.
3. **Status:** without complete weeks, "no values" (or "too few weeks" with only the current week); the latest complete week older than 8 weeks and nothing this week, "no recent values"; fewer than 8 weeks or a span under 12, "too few weeks".
4. **Assessment:** the robust line and its band over the complete weeks; the minimum from the year before; the direction.
5. **Words:** each metric's direction and change; the overall line from estimated VO2 max (`FitnessTrends.headline`).

Edge cases

- **Only the current week has values:** "Too few weeks", never a direction.
- **Two estimates on one day:** the one with the later end counts, then the later start, then the larger value, so the choice never depends on the order they arrive in.
- **A disagreeing metric:** estimated VO2 max trends higher but cardio recovery trends lower, for example: the overall line reads "Not enough data for a direction yet", and each metric keeps its own words.
- **The months in the words:** 12 to 15 weeks between the first and the last value are 3 months, 16 to 19 are 4, 20 to 23 are 5, more are 6.

Where it lives in the code

Paths under `Packages/EvinloKit/Sources/EvinloAlgorithms/` unless they say otherwise.

What	Where
Parameters, version, the engine	`Contract/MovementContract.swift` (`FitnessParameters`, `FitnessEngine`)
Status, assessment, the minimum	`Fitness/FitnessTrendCalculation.swift`
Source rule, daily and weekly values	`Fitness/FitnessWeeklyValues.swift`
The robust line and its band	`Fitness/RobustLine.swift`
Read once, as of a moment	`Pipeline/DayPipeline.swift` (`fitnessTrends(asOf:calendar:)`)
The trends and the overall line	`Packages/EvinloKit/Sources/EvinloModels/FitnessTrends.swift`
The words on screen	`App/Evinlo/Data/Wording/FitnessWording.swift`

How it is checked

Guardrail	Rule
FG1	A verdict turns directly from rising to falling, or the reverse, in at most 2% of weeks
FG2, FG3	Two replays agree, and an evaluation uses no sample from its moment on; no result with NaN or ∞
FW1	A metric's verdict changes in at most 15% of weeks
FS1	On one synthetic person without a trend a direction is called in at most 8% of evaluations, and in at most 25% when the weekly values follow one another; over many series at most 6% and 10% (pinned by the package's simulation tests)
FS2	A true change of twice the fixed minimum is found, in its direction, in at least 70% of evaluations for estimated VO2 max; the heart rates are reported and not judged
FS3	A resting heart rate that only follows the year (2 bpm to each side) is called a direction in at most 40% of evaluations

In seeded simulations, a series without any trend was called a direction in fewer than 1 window in 10 even at the strongest persistence tested, where Sen's interval alone called such wander a direction in more than a quarter of the windows. Every figure and number here comes from `evinlo-eval export` on synthetic people (the daily values from `evinlo-eval synthesize` of the same person); the line, its band and the minimum are worked out again and checked against the export.

References

- Sen, *Journal of the American Statistical Association* 63, 1968: the slope estimate and its interval.
- Apple, "Using Apple Watch to Estimate Cardio Fitness with VO2 max", 2021; Caserman et al., *JMIR Biomedical Engineering* 9, 2024; Lambe et al., *PLOS ONE* 20(5), 2025: how VO2 max is estimated and how far an estimate lies from laboratory tests.
- Quer et al., *PLOS ONE* 2020, doi:10.1371/journal.pone.0227709: resting heart rate within a person and across the seasons.
- The complete reference for every rule: docs/scoring.md, "Fitness trends (v1)".

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**.