evinlo

EVINLO EXPLAINERS

Sleep, explained

How Evinlo scores a night against your own sleep need, keeps a fair count of the sleep you missed, and plans tonight, from what your watch recorded.

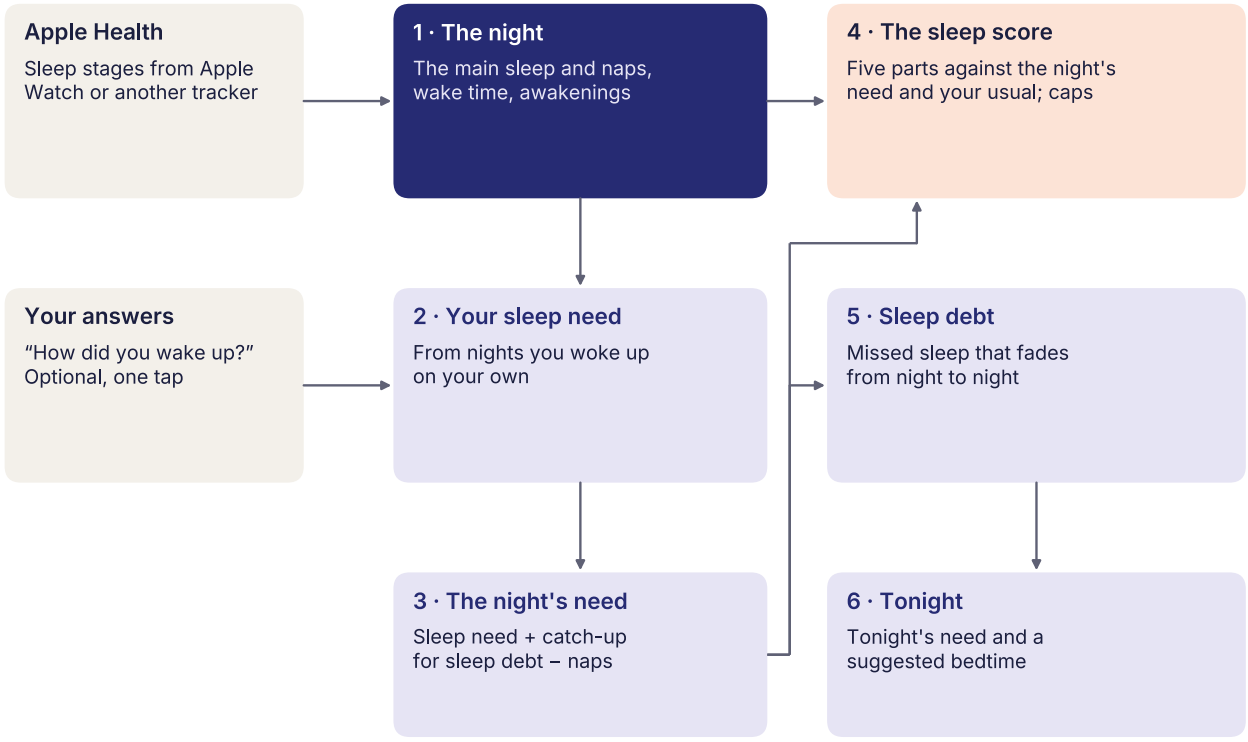


ALGORITHM
Sleep 1.3.0

WRITTEN
October 2026

The one-minute version

Evinlo looks at last night the way your watch recorded it, and asks one question first: **how long did you sleep, against the sleep you seem to need?** Then it asks how unbroken and how regular the night was. The answer is a score from 0 to 100, a count of the sleep you missed, and a plan for tonight.



The sleep section in six steps. Evinlo finds last night in Apple Health, learns your sleep need from nights you woke up on your own, adds a catch-up for missed sleep and takes naps off, scores the night against that need, keeps a running count of sleep debt and works out tonight's need and a bedtime.

IN SHORT

- **Your need, not your habit.** The score compares your night with the sleep you seem to need, learned from nights you woke up on your own. It never takes your usual night as the goal.
- **Five parts, and caps that hold.** Duration counts most. A clearly short or broken night cannot score high, however good the rest looks.
- **A fair count of missed sleep.** Sleep debt adds up what recent nights missed beyond 45 minutes, fades night by night, and is paid back by sleep beyond your need. Extra sleep is not saved up.
- **Tonight follows.** A third of the debt, at most an hour, is added to tonight's need; naps today take some off. A bedtime follows from your usual wake-up.
- **It says what it does not know.** No score in the first week, no personal need before it is clear, and no number for a night that was only partly recorded.

This explainer follows real numbers from synthetic people: **Maya**, who sleeps her need; **Jonas**, who has a late night now and then; and **Sam**, who wakes to an alarm on workdays. All three were made by the app's generator; no part of them comes from a real person.

What goes in

The sleep section reads very little, and only from Apple Health:

What	Where it comes from	What it is used for
Sleep, with stages	Apple Watch, or another tracker or app that saves sleep to Apple Health	The night: when you fell asleep and woke up, time asleep, awakenings, stages
Time in bed	Only from a tracker that recorded the same night	Efficiency, the one part Apple Watch cannot give
Heart rate around a short night	Apple Watch	Only to see whether the watch was worn around a night under 5 hours
Your answer to “How did you wake up?”	One tap on Home or the sleep page, optional	Whether a night counts for your sleep need
A sleep need you set yourself	Settings, optional, 5 to 11 hours	Used instead of Evinlo’s estimate

One source per night. When several sources recorded the same night, Evinlo takes the best one for the whole night: Apple Watch with stages, then another device with stages, then a source without stages, then sleep entered by hand. It never adds two sources together; two trackers counted together would roughly double the time asleep.

What it leaves out. Heart rate variability, sleeping heart rate, breathing and wrist temperature describe how your body recovered, not how you slept. They belong to Readiness, so the sleep score does not count them a second time.

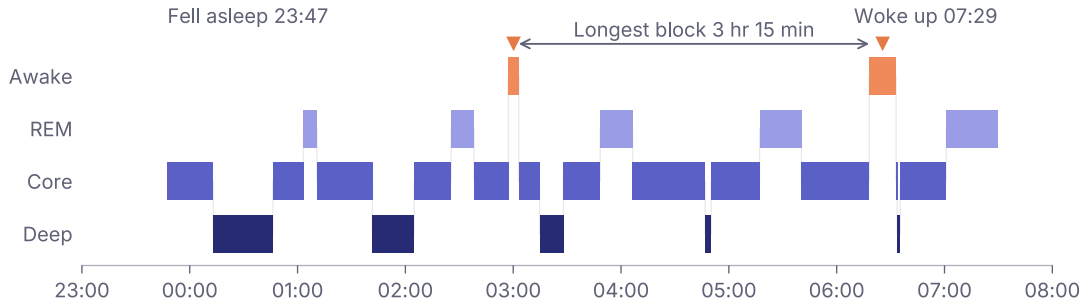
How it works, step by step

Step 1: find the night

Apple Health stores sleep as many short pieces: a stretch of core sleep, a minute awake, some REM. Evinlo puts each source’s pieces together into **sessions**, bridging gaps shorter than 60 minutes. A gap without any recording counts as unrecorded time: part of the night, but never time asleep.

- **The main sleep.** Each session belongs to the day you woke up; a wake-up at 18:00 or later belongs to the next day. The day’s main sleep is the session with the longest stretch from falling asleep to the final wake-up, as long as it holds at least 3 hours of sleep or its middle lies between 20:00 and 10:00. So an afternoon nap never becomes “last night”.
- **Naps.** Every other session with at least 10 minutes asleep is a nap. Naps are never scored, but they lower the need of the night after them (Step 3).
- **Awakenings.** Being awake for 5 minutes or more counts as an awakening. Shorter moments still count as time awake, but they do not split the night.
- **Incomplete nights.** A night with more than 30 minutes of unrecorded gaps is incomplete. So is an Apple Watch night under 5 hours when the watch recorded almost no heart rate around it: fewer than 3 readings in the 2 hours before falling asleep, or fewer than 2 in the hour after waking. An

incomplete night has no score and stays out of every count below.

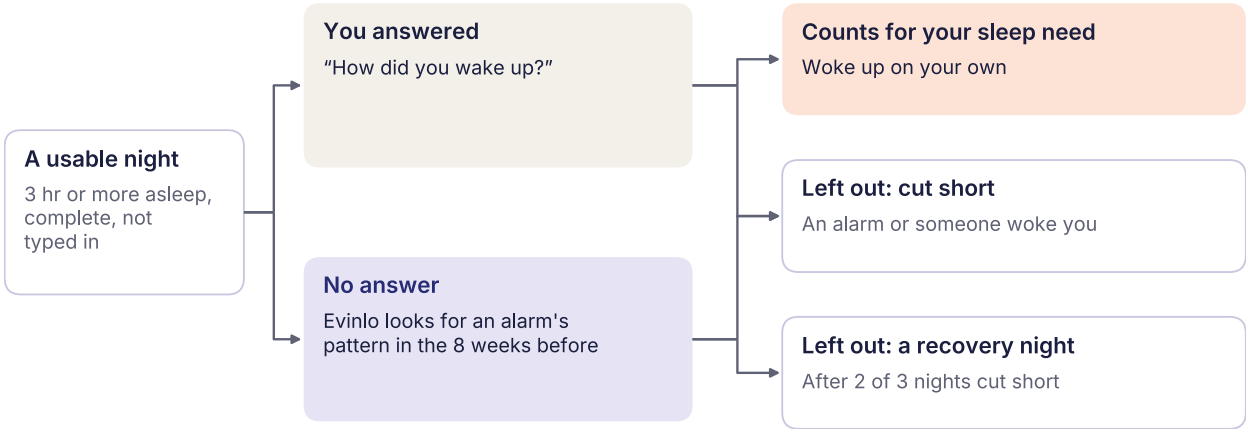


Maya's night of Monday to Tuesday, as her watch recorded it. The two marks above the Awake lane are her two awakenings of 5 minutes or more; the longest stretch between them was 3 hr 15 min.

Maya fell asleep at 23:47 and woke up at 07:29. She slept 7 hr 21 min, was awake for 21 minutes in between, and had 2 awakenings. A night counts as final an hour after its last recorded sleep, because a later recording could still be joined to it.

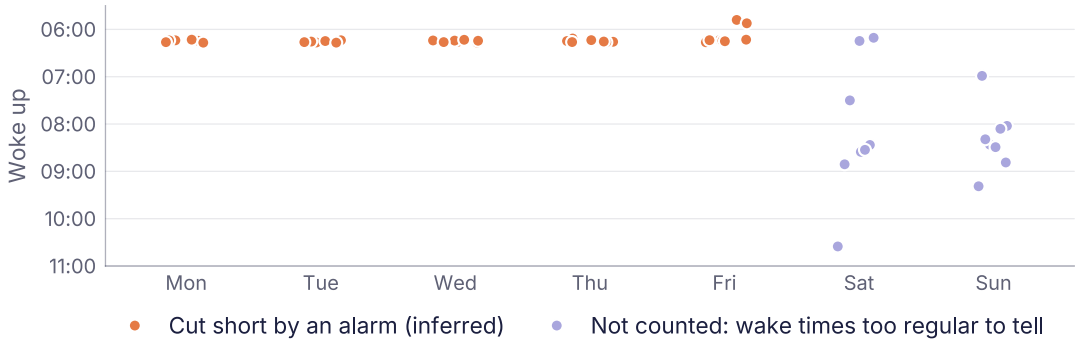
Step 2: learn your sleep need

Evinlo does not ask how much sleep you need. It **learns it from nights you woke up on your own**, because a night cut short by an alarm says more about the alarm than about you. Evinlo cannot see alarms, so it decides night by night:



How a night counts for your sleep need. Your answer to "How did you wake up?" decides when you gave one. Without an answer, Evinlo looks for the pattern an alarm leaves. A night right after two of three nights cut short is a recovery night and is left out too.

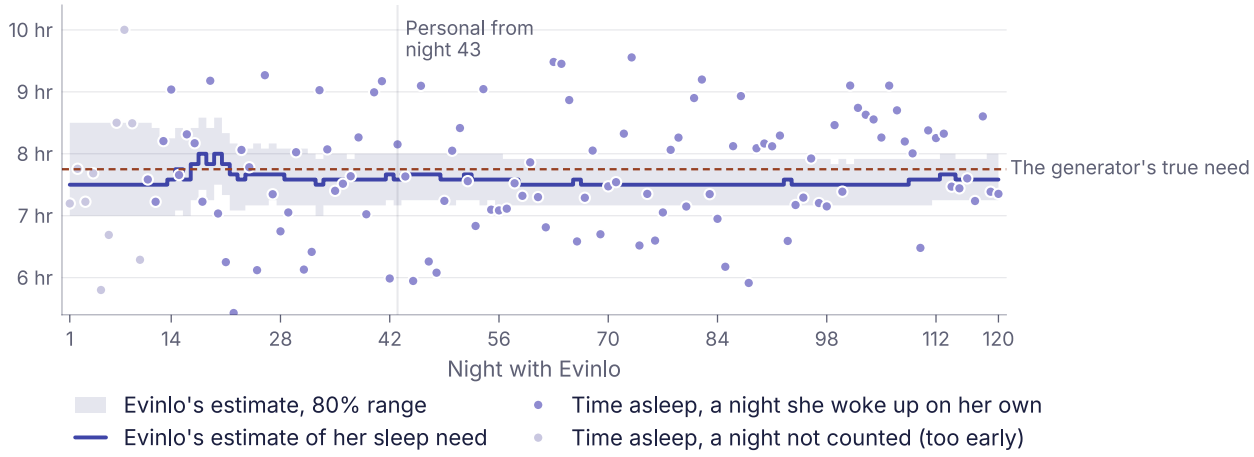
Without an answer, Evinlo looks for an alarm's pattern in the 8 weeks before the night. A weekday whose wake-up times hardly vary (a spread of 20 minutes at most, over at least 4 nights) and whose usual wake-up is at least 45 minutes earlier than on the other days looks alarm-driven. A night on such a weekday that ends within 30 minutes of its usual wake-up counts as cut short.



Sam's wake-up times in the 8 weeks before Tuesday 13 October. On workdays he wakes within minutes of 06:14, every time. When five or more weekdays look like that, Evinlo cannot tell his free mornings from his alarm, so no night counts.

Sam is a hard case, on purpose. He has 5 alarm-like weekdays, so Evinlo cannot learn his need from the pattern. It works with the starting value of 7 hr 30 min, says that it can't learn his need while he wakes at about the same time every day, and that answering "How did you wake up?" would let it learn. Sam's true need, which only the generator knows, is 8 hr 15 min.

The estimate. Evinlo takes the **median** (the middle value) time asleep of the nights that counted in the last 90 days and pulls it toward a starting value of 7 hr 30 min. With few nights the starting value weighs a lot; with many it hardly matters. The estimate stays between 7 hr and 9 hr 30 min and moves in 5-minute steps.



Maya's first 120 nights. Each dot is a night's time asleep. The line is Evinlo's estimate of her sleep need, the band its 80% range. The estimate starts at 7 hr 30 min and settles a little under the true need the generator gave her.

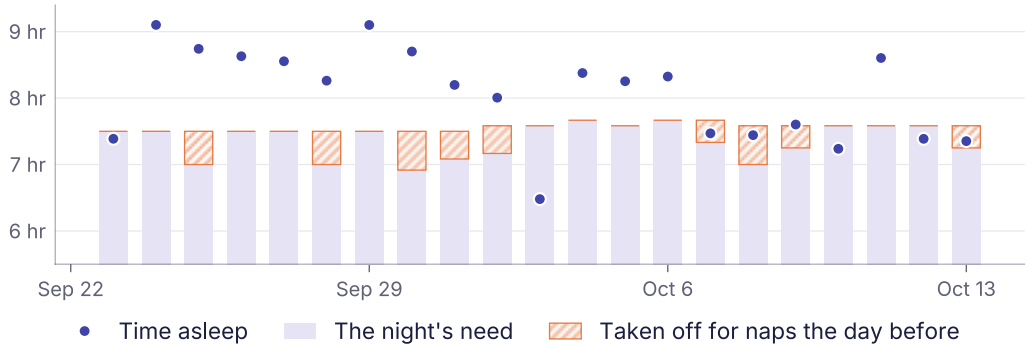
The app calls the estimate **personal** after 28 nights that counted, at least 42 days of history and a range no wider than ±30 minutes. For Maya, that was from night 43 on. On Tuesday her estimate is 7 hr 35 min, likely between 7 hr 15 min and 8 hr, from her 90 nights of the last 90 days. The generator gave her a true need of 7 hr 45 min. Evinlo sees only the nights, and their median sits a little under the need the generator drew them around.

Step 3: the night's need

A night is never scored against the sleep need alone. **The night's need** is:

> your sleep need + a catch-up for sleep debt − what naps took off

- **The catch-up** is a third of your sleep debt (Step 6), at most one hour, in 5-minute steps, and nothing while the debt is under 15 minutes.
- **Naps** the day before take their time asleep off the night's need, rounded to 5 minutes and at most 90 minutes, and never so much that the need falls below 6 hours. Naps lower the need; they never pay back sleep debt and never enter the estimated need.



The same nights as Maya's, given an afternoon nap now and then. Each bar is a night's need; the hatched part is what naps the day before took off it. The dots are the time she slept.

On the Monday afternoon before her Tuesday night, the napping version of Maya slept 22 min from 15:36. That counts as 20 min, so her night's need is 7 hr 15 min instead of 7 hr 35 min. The same 7 hr 21 min of sleep then scores 94 instead of 92.

Step 4: score the night

The score has five parts. Each part turns one measurement into 0 to 100 points along a fixed line with a few knots, and the score is the weighted sum of the parts that have data.

Part	Weight	What it measures
Duration	40%	Time asleep against the night's need
Continuity	25%	Time awake after falling asleep (half of the part), the longest stretch without an awakening (a quarter), the number of awakenings (a quarter)
Timing	15%	The middle of the night against its median of the last 14 days
Stages	10%	Deep sleep in minutes and REM sleep (the stage with most dreaming) as a share, each against your own usual; only values below your usual cost points
Efficiency	10%	Time asleep divided by time in bed; only when a tracker recorded time in bed

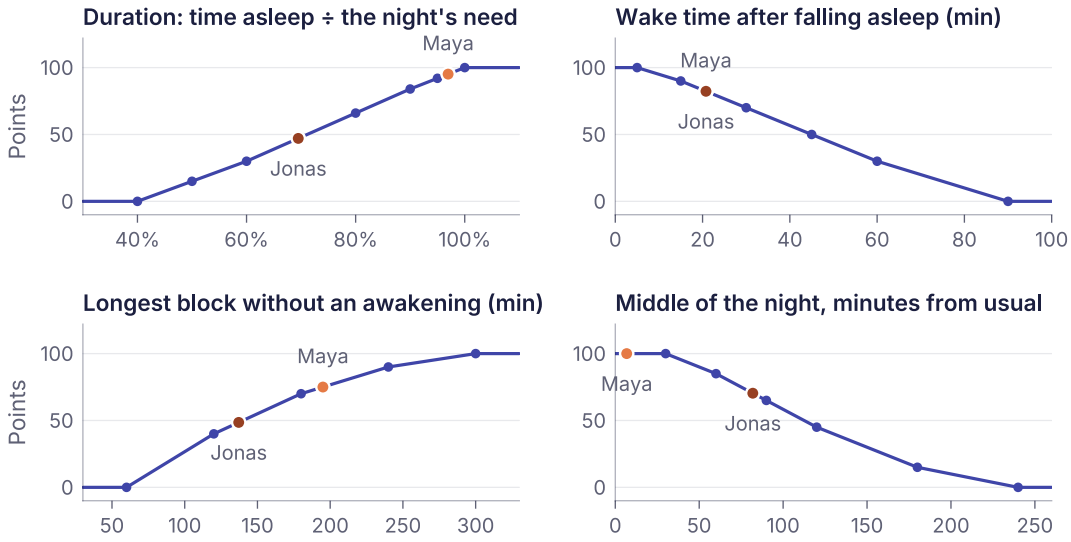
Apple Watch does not record when you went to bed, so on an Apple Watch night efficiency is not counted and its weight is shared out: duration then counts 44.4%, continuity 27.8%, timing 16.7% and stages 11.1%.

Maya's parts on Tuesday: duration 95, continuity 80, timing 100, stages 98. Her score is 92, against a usual of 96 (the median of her scores in the four weeks before).

Two more rules shape the parts:

- **Longer than your need.** Duration keeps its 100 points up to an allowance of your need (at least 7 hours) plus 60 minutes plus recent sleep debt, and loses up to 22.5 points beyond it. That costs at most 10 points of the score, and only once your need is personal or set by you.

- **Stages compare you with you.** Deep sleep and REM are compared with your own nights of the last 60 days, on the same kind of source and watch. A stage at or above your usual costs nothing.

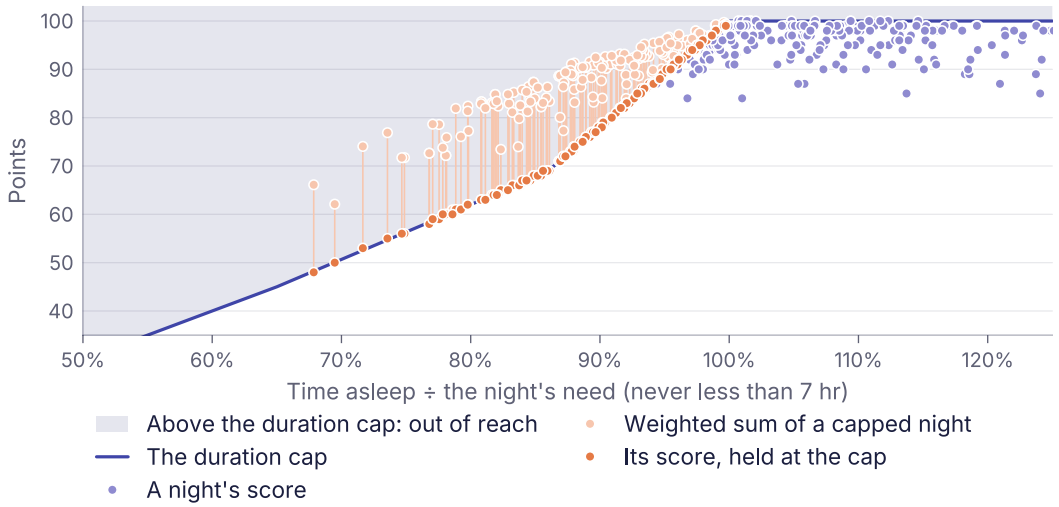


How four of the parts earn their points. Maya's Tuesday night is in Daybreak, Jonas's in rust. Both were awake for 21 minutes after falling asleep; Jonas slept much less, and later.

Step 5: caps for short and broken nights

The weights alone would let a very short night look fine when everything else was good. So two **caps** limit the score, whatever the parts add up to:

- **The duration cap** follows time asleep against the night's need: 69% of it caps the score at about 50, 86% at 69, 93% at 85. For this cap the need is never taken as less than 7 hours, so a low setting cannot hide short sleep: a night under 5 hours scores at most 52, a night under 6 hours at most 69.
- **The cap for broken sleep** is the lowest of three limits: on time awake (over 30 minutes), on the longest block (under 150 minutes) and on continuity points (under 75).



Every scored night of Maya, Maya with naps, Jonas and Sam. Above the line is out of reach. When a night's weighted sum lies above the line, its score is held at the cap (the light dot is the sum, the dark one the score).

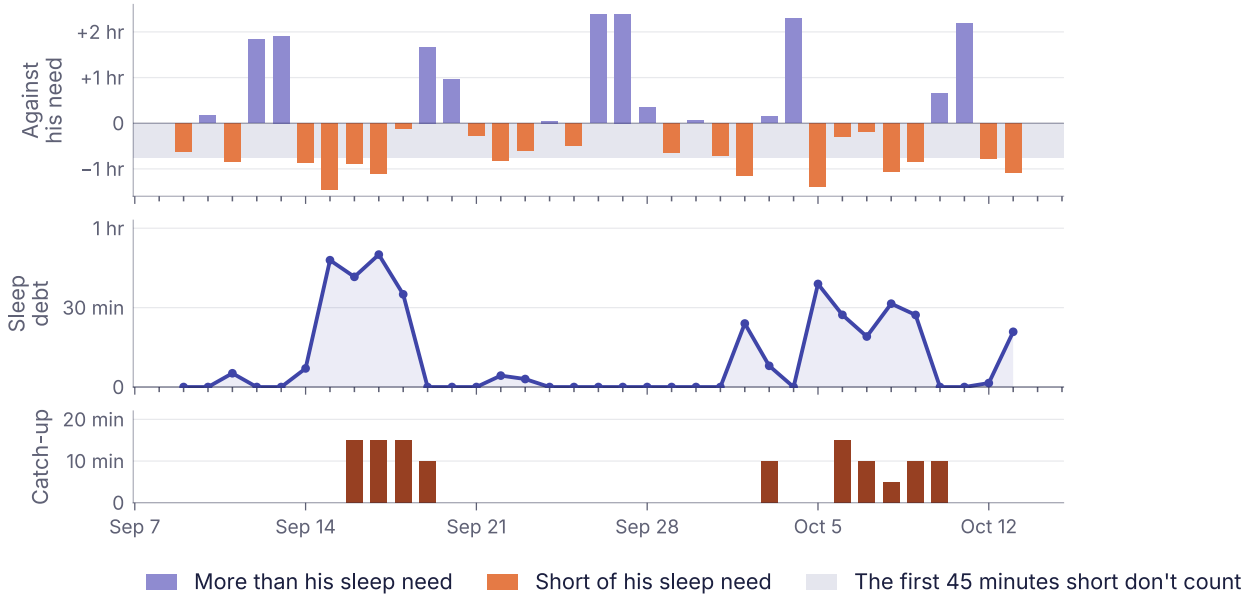
On these four sleepers the duration cap held the score on 192 of the 456 nights they had scores for, by 10 points at the median and by 22 at most. The caps are continuous lines, so one more minute of sleep never makes the score jump.

Each night also gets a **headline**, the first one that applies: *A short, broken night*; *A short night* (under 85% of the sleep need, or 60 minutes short of it, judged without the catch-up); *A broken night* (continuity under 60, or a cap for broken sleep that holds the score below 85); *Later than usual* or *Earlier than usual* (the middle of the night 90 minutes or more off); *Longer than your sleep need*; *A restful night* (85 or more); *A solid night*.

Step 6: count the sleep debt

Sleep debt is Evinlo's running count of missed sleep. It is a tally, not a measurement of your body. Each night, oldest first, over the last 14 nights:

- **Only the part of a shortfall beyond 45 minutes counts.** A watch measures a night to within about half an hour, and nights vary around any need. The tolerance keeps that noise out of the count.
- **What a night added fades by 30% with every night that passes:** 70% one night later, about half after two.
- **Sleep beyond your need pays back debt you already have,** minute for minute, up to 2 hours a night. What is left over is dropped: extra sleep is not saved up for a short night that comes later.



Sam's last five weeks. Top: each night against his sleep need. Middle: his sleep debt after each night. Bottom: the catch-up that debt added to the next night's need.

In mid-September Evinlo worked with a need of 7 hr 15 min for Sam, an estimate from his first weeks. On Tuesday 15 September he slept 5 hr 47 min: 88 minutes short, of which 43 counted. With 70% of the 7 min left from Monday, his debt was 48 min. Wednesday's need carried a catch-up of 15 minutes. He slept 6 hr 22 min, 8 minutes counted, and the debt became 42 min: 70% of the 48 plus the new 8. Thursday added more (6 hr 9 min, debt 50 min); on Friday he slept 7 hr 8 min, inside the tolerance, and the debt only faded, to 35 min. On Saturday, with a catch-up of 10 minutes in his need, he slept 8 hr 55 min, and the debt was 0 min.

Step 7: plan tonight

Tonight's need is the same sum as a night's need: your sleep need, plus the catch-up for the debt you have now, minus naps today. The **suggested bedtime** counts back from your usual wake-up for tomorrow: minus tonight's need, minus your usual time awake during the night, minus 15 minutes to fall

asleep, rounded down to 5 minutes. The usual wake-up is the median of the last 8 weeks on tomorrow's weekday, or of workdays or weekend days in the last 4 weeks, or of the last 2 weeks.



Jonas's plan for Tuesday night. Counting back from his usual Wednesday wake-up: his sleep need, the catch-up for his debt, his usual time awake at night and 15 minutes to fall asleep give a bedtime of 22:55.

A nap later in the day moves the bedtime later by what the nap takes off, once Apple Health has the nap.

A worked example

Meet **Jonas**. He is a synthetic person who usually falls asleep around 23:25 and has a late night now and then. On Monday night he fell asleep at 02:03 and woke up at 07:40, about his usual time. It is Tuesday, 13 October 2026, at 16:30. Every number below is what the app shows for him at that moment.

The night. He slept 5 hr 16 min, was awake for 21 min in between, had 2 awakenings, and his longest stretch was 2 hr 17 min. The middle of his night was 82 minutes later than usual. Deep sleep was 54 minutes against his usual 67 (a distance of −1.6 spreads, a spread being how much his deep sleep usually varies from night to night); REM was 25% of staged sleep, above his usual 22%.

The night's need. His sleep need is personal, 7 hr 35 min. He had no debt from earlier nights and took no nap, so the night's need is 7 hr 35 min too.

Part	Measurement	Points	Effective weight
Duration	5 hr 16 min of 7 hr 35 min, 69%	47.1	44.4%
Continuity	21 min awake, longest block 2 hr 17 min, 2 awakenings	73.3	27.8%
Timing	middle of the night 82 minutes later than usual	70.4	16.7%
Stages	deep sleep below his usual, REM above	81.9	11.1%
Efficiency	Apple Watch doesn't record when you went to bed	not counted	

The weighted sum is 62.1, which would read as Fair already. But the **duration cap** applies: 5 hr 16 min is 0.695 of his need, which caps the score at 50.1. The cap for broken sleep, from his longest block, is 91.4 and does not matter tonight. **Score: 50, "A short night"**, against a usual of 97.

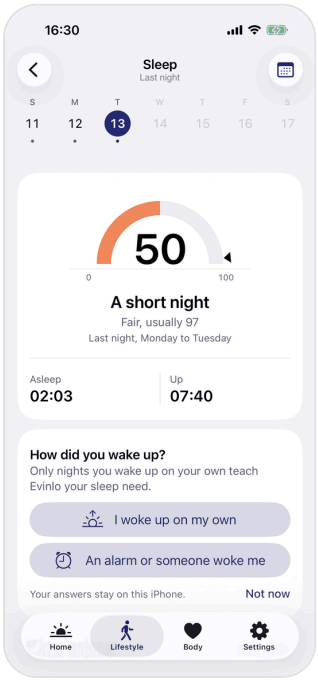
Sleep debt. He was 139 minutes short of his need; the first 45 do not count, so the night adds 93.9 minutes. His sleep debt is 1 hr 34 min.

Tonight. A third of 93.9 minutes, in 5-minute steps, is a catch-up of +30 min. Tonight's need is 7 hr 35 min + 30 min = 8 hr 5 min. His usual Wednesday wake-up is 07:28 (the app writes "around 07:30"), and he is usually awake for 13 min during the night, so Evinlo suggests being in bed by 22:55.

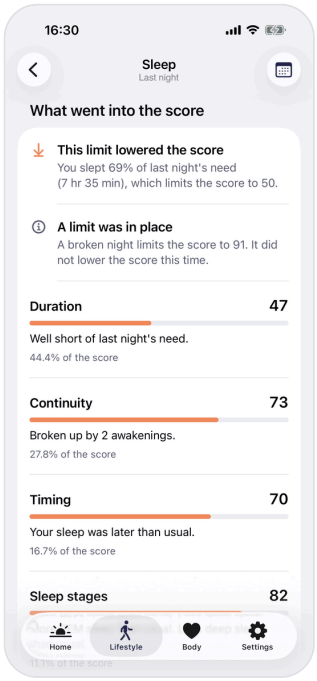
What else follows. Readiness takes the sleep score as one of its parts and is limited by it: Jonas's Readiness is 67 today, "Held back by a short night" (see *Readiness, explained*). And on the sleep page, the alertness estimate adds that after a short night he may feel less awake than usual today (see *Alertness and the daily check-in, explained*).

What you see in the app

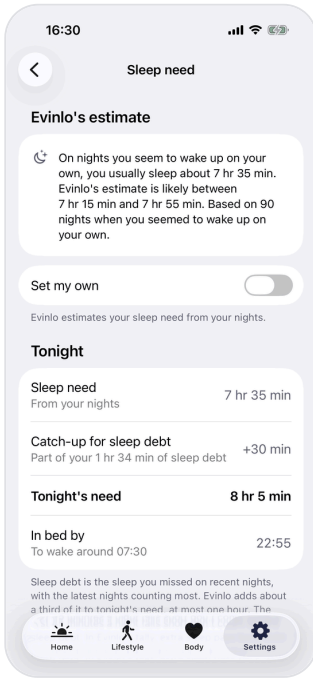
These are Jonas's screens at 16:30 on Tuesday 13 October, taken in the app's synthetic data mode.



The sleep page: 50, "A short night", usually 97.



What went into the score: the duration cap lowered it to 50; the cap for broken sleep (91) did not.



Settings › Sleep need: Evinlo's estimate, and tonight's need with a catch-up of 30 min.

Honest limits

- **A watch estimates sleep.** Stages come from movement and heart rate, not from a sleep lab, and time asleep on a single night can be off by half an hour. That is why stages count little and why missed sleep has a 45-minute tolerance.
- **Evinlo cannot see alarms.** It infers them from your wake-up times, and some patterns it cannot recognise: rotating shifts, an alarm on changing days. Someone who wakes at the same time every day and never answers the question gets no personal need, like Sam.
- **The need is learned from your nights.** A need learned mostly from weekends can run high; one learned from too-early nights runs low. Answering "How did you wake up?" now and then helps most.

- **The 7-hour line is strict.** It follows the recommendation that adults sleep 7 hours or more, which rests mostly on self-reported sleep, and people report about 0.8 hours more sleep than a wrist sensor measures.
- **The debt is a count with a short memory.** It fades within days, while studies found recovery after several short nights to be slower. It shows what you missed, not how tired you will feel; feeling sleepy tracks it poorly.
- **The numbers in the rules are choices.** The weights, the knots, the 45 minutes, the 30% fade and the third are design choices, checked with the evaluation tool. The scoring reference says which rules rest on studies.
- **Jonas, Maya and Sam are generated.** Their nights are tidier than a real person's.

For the experts

Version and order of operations

This explainer describes `SleepAlgorithm.version` **1.3.0**; every night carries the version that scored it. `SleepAnalysis` works out a day in one forward pass over the days of its window (`SleepTimeline`), each night using only the nights before it:

1. **Construct** the nights: sessions per source, each wake date's main sleep and naps, the incomplete rule (`SessionBuilder`, `MainSleepSelection`, `IncompleteNightRule`) and each night's facts (`NightFactsBuilder`).
2. **Classify** the night (the answer, else `AlarmProfile` over the 56 days before, then the recovery rule) and **estimate the need** from the free nights of the 90 days before (`NeedEstimator`, `NeedStatus`); a need you set replaces the estimate.
3. **The night's need and the debt:** the catch-up from the debt after the night before, the nap credit (`NapCredit`), then the debt after the night over the last 14 nights (`SleepDebt`), with the part carried from earlier nights (for Readiness) and the debt behind the long-sleep allowance.
4. **Score** the night (`SleepScorer`) against the timing (14 days) and stage (60 days) baselines, shown from 7 usable nights in 60 days; then **plan** tonight (`PlanBuilder`), alertness and the wake-up question.

Parameters

Every parameter is in `SleepParameters.v1` (`Packages/EvinloKit/Sources/EvinloAlgorithms/Contract/Parameters.swift`). Durations in minutes.

Rule	Parameters
Gaps under 60 min are bridged within a session; a wake-up from 18:00 belongs to the next day	`bridgeGap` 60, `wakeDayCutoffHour` 18
Main sleep: at least 180 min asleep, or a middle between 20:00 the evening before and 10:00	`mainSleepMinimumAsleep` 180, `mainSleepMidSleepEarliest` −240, `mainSleepMidSleepLatest` 600
A nap: 10 min asleep; an awakening: 5 min awake	`napMinimumAsleep` 10, `awakeningMinimum` 5
Time in bed counts when it covers 80% of the night, searched 3 hours around it	`inBedCoverage` 0.8, `inBedSearchMargin` 180

Rule	Parameters
Stages count less from 5% unstaged sleep, not at all from 10%	`partialStagesFadeStart` 0.05, `partialStagesUnspecifiedShare` 0.10
Incomplete: over 30 min unrecorded; or a watch night under 300 min with under 3 heart-rate readings in the 120 min before or 2 in the 60 min after	`incompleteUnrecorded` 30, `incompleteShortNight` 300, `incompletePreOnsetWindow` 120, `incompletePreOnsetMinimumReadings` 3, `incompletePostWakeWindow` 60, `incompletePostWakeMinimumReadings` 2
A usable night: complete, not typed in, 180 min asleep	`usableMinimumAsleep` 180
Score shown from 7 usable nights in 60 days, settled from 28	`calibrationNights` 7, `establishedNights` 28, `calibrationWindowDays` 60
Timing: median of 14 days, at least 5 nights	`timingWindowDays` 14, `timingMinimumNights` 5
Stages: 60 days, at least 5 nights, settled from 14; spreads at least 8 min (deep) and 2.5 points (REM), × 1.5 while early	`stageWindowDays` 60, `stageMinimumNights` 5, `stageEstablishedNights` 14, `deepScaleFloor` 8, `remShareScaleFloor` 0.025, `provisionalFloorFactor` 1.5
“Usually NN”: median of the shown scores of 28 days, at least 7	`usualScoreDays` 28, `usualScoreMinimumNights` 7
Alarm profile: 56 days, at least 10 usable nights; a tight weekday has 4 nights and a spread of at most 20 min	`alarmWindowDays` 56, `classificationMinimumNights` 10, `alarmWeekdayMinimumNights` 4, `alarmSpread` 20
Alarm-like: 45 min earlier than the other nights (at least 4 of them); with fewer, every tight weekday once there are 5	`alarmEarlierBy` 45, `alarmReferenceMinimumNights` 4
Cut short within 30 min of the weekday’s usual wake-up; no night free from the pattern with 5 alarm-like weekdays	`alarmBand` 30, `alarmWeekdaysWithoutFreeNights` 5
Recovery night: 2 of the 3 nights before cut short	`recoveryLookbackNights` 3, `recoveryConstrainedMinimum` 2
Need: 90 days; starting value 450 min with a spread of 45 min; a free night’s own spread around the need 15 min	`needWindowDays` 90, `needPrior` 450, `needPriorSD` 45, `needSystematicSD` 15
Need between 420 and 570 min, in 5-min steps	`needMinimum` 420, `needMaximum` 570, `needRounding` 5
Spread of the free nights: 60 min below 3 nights; else 1.4826 × MAD (the median absolute deviation), at least 54 min up to 20 nights, falling to 30 at 40	`needSpreadFewNights` 60, `needFewNights` 3, `needSpreadFloorEarly` 54, `needSpreadFloorEarlyUntil` 20, `needSpreadFloor` 30, `needSpreadFloorFrom` 40
Standard error 1.2533 × spread ÷ √k, at least 3 min; 80% range ± 1.2816 spreads	`needMedianEfficiency` 1.2533, `needStandardErrorFloor` 3, `needIntervalZ` 1.2816
Personal from 28 free nights, 42 days and ±30 min; kept with 21 nights and ±40 min while it qualified in the 30 days before	`personalFreeNights` 28, `personalDays` 42, `personalMaxHalfWidth` 30, `personalKeepFreeNights` 21, `personalKeepMaxHalfWidth` 40, `personalKeepDays` 30
Debt: 14 nights, 45 min tolerance, at most 120 min repaid a night, 0.7 kept a night, no credit kept	`debtNights` 14, `debtTolerance` 45, `debtSurplusCap` 120, `debtRetention` 0.7 (`debtFading` geometric), `debtCreditMax` 0
Catch-up: a third, at most 60 min, 5-min steps, none under 15 min of debt	`debtShareTonight` 1/3, `debtAdjustmentMax` 60, `debtRounding` 5, `debtAdjustmentMinDebt` 15
Nap credit: at most 90 min; the need never below 360 min	`napCreditMaximum` 90, `napCreditNeedFloor` 360
Weights 0.40, 0.25, 0.15, 0.10, 0.10; continuity shares 0.5, 0.25, 0.25	`durationWeight`, `continuityWeight`, `timingWeight`, `stagesWeight`, `efficiencyWeight`; `continuityWASOShare`, `continuityBlockShare`, `continuityAwakeningsShare`
Long sleep: allowance + 60 min; the full 22.5 points after 120 min more	`longSleepAllowance` 60, `longSleepRamp` 120, `longSleepMaxDeduction` 22.5

Rule	Parameters
The duration cap takes the need as at least 420 min	`capNeedFloor` 420
Headlines: short under 0.85 of the need or 60 min short; broken under 60 points; 90 min off rhythm; restful from 85	`shortRatio` 0.85, `shortMinutes` 60, `brokenContinuity` 60, `offRhythm` 90, `restfulScore` 85
Plan: same weekday over 8 weeks (4 nights), else weekdays or weekend days of 28 days (4), else 14 days (3); usual time awake over 14 nights; 15 min to fall asleep; 5-min steps	`planSameWeekdayWeeks` 8, `planMinimumNights` 4, `planWeekPartDays` 28, `planFallbackDays` 14, `planFallbackMinimumNights` 3, `planTimeAwakeNights` 14, `fallAsleepAllowance` 15, `bedtimeRounding` 5
The wake-up question closes 30 min before tonight's bedtime, else at 21:00	`wakeQuestionCloseBeforeBed` 30, `wakeQuestionCloseHour` 21

The mappings

All linear between the knots and flat beyond them (`Knot`, `interpolated(at:)`).

Mapping (parameter)	Knots (input → points or highest score)
Duration: asleep ÷ need · `durationKnots`	0.40 → 0, 0.50 → 15, 0.60 → 30, 0.70 → 48, 0.80 → 66, 0.90 → 84, 0.95 → 92, 1.00 → 100
Time awake after falling asleep (min) · `wasoKnots`	5 → 100, 15 → 90, 30 → 70, 45 → 50, 60 → 30, 90 → 0
Longest block (min) · `blockKnots`	60 → 0, 120 → 40, 180 → 70, 240 → 90, 300 → 100
Awakenings · `awakeningKnots`	0 → 100, 1 → 95, 2 → 80, 3 → 60, 4 → 40, 6 → 0
Timing: distance from usual (min) · `timingKnots`	30 → 100, 60 → 85, 90 → 65, 120 → 45, 180 → 15, 240 → 0
Stages: distance from your usual in spreads, only below it · `stageKnots`	−3.5 → 0, −3 → 15, −2 → 50, −1 → 85, −0.5 → 100
Efficiency (%) · `efficiencyKnots`	65 → 0, 75 → 25, 85 → 70, 92 → 100
Duration cap: asleep ÷ max(need, 7 h) · `durationCapKnots`	0.30 → 15, 0.50 → 30, 0.65 → 45, 0.80 → 62, 0.86 → 69, 0.93 → 85, 1.00 → 100
Cap on time awake (min) · `wasoCapKnots`	30 → 100, 45 → 84, 60 → 70, 90 → 60, 120 → 50
Cap on the longest block (min) · `blockCapKnots`	60 → 45, 90 → 60, 120 → 80, 150 → 100
Cap on continuity points · `continuityCapKnots`	0 → 60, 60 → 84, 75 → 100

Formulas

The sleep need, with k free nights of median m and the starting value 7.5 h (spread 0.75 h):

$$\mathrm{se} = \max\left(\frac{1.2533\,s}{\sqrt{k}},\ 0.05\right), \qquad \mathrm{need} = \frac{7.5/0.75^2 + m/\mathrm{se}^2}{1/0.75^2 + 1/\mathrm{se}^2}$$

where s is 1.4826 × MAD of the free nights, at least the spread floor. The 80% range is need ± 1.2816 × √(1 ÷ (1/0.75² + 1/se²) + 0.25²) hours.

The sleep debt after a night, as one line (exact up to the cut after 14 nights):

$$\mathrm{debt} = \max\left(0,\ 0.7\,\mathrm{debt}_{\mathrm{before}} + \mathrm{missed} - \mathrm{extra}\right)$$

with missed = shortfall − 45 min when the shortfall (from the sleep need minus the nap credit) is above 45 min, else 0, and extra = time asleep − sleep need, between 0 and 120 min. The catch-up and the night's need:

$$\text{catch-up} = \text{round}_5\left(\min\left(60,\ \tfrac{1}{3}\,\text{debt}\right)\right) \text{ from a debt of } 15 \text{ min}$$

$$\text{need}_{\text{night}} = \text{sleep need} + \text{catch-up} - \text{nap credit}$$

The score, with the weights of the parts that have data and every cap:

$$\text{score} = \text{round}\left(\min\left(\frac{\sum_i w_i\, p_i}{\sum_i w_i},\ \text{cap}_{\text{duration}},\ \text{cap}_{\text{broken}}\right)\right)$$

Jonas's Tuesday night, with efficiency not counted:

$$\frac{0.40 \times 47.1 + 0.25 \times 73.3 + 0.15 \times 70.4 + 0.10 \times 81.9}{0.90} = 62.1, \qquad \min(62.1,\ 50.1,\ 91.4) = 50$$

Edge cases

- **A night that may still change** is final once an hour has passed since its last recorded sleep. Before your usual wake-up time, today's night reads "Your night isn't over yet".
- **Clock changes and travel.** Nights are cut in each sample's own time zone, and durations are measured between instants, so a night across a clock change is neither longer nor shorter than it was.
- **Sleep entered by hand** is shown with its facts and no score, and counts for nothing. Of two watches on one night, the one with more staged minutes is used.
- **A night without data** counts as neither shortfall nor repayment; the debt still fades over it.
- **Answers** count only for their own night, so they change the need and the debt of later nights, never of earlier ones. "An alarm or someone woke me" is the first answer in the notification on purpose: an accidental tap then leaves a night out rather than letting an alarm night in.

Where it lives in the code

All under `Packages/EvinloKit/Sources/EvinloAlgorithms/`: parameters and version in `Contract/Parameters.swift`; sessions, the main sleep, naps and incomplete nights in `Construction/SessionBuilder.swift`, `MainSleepSelection.swift` and `IncompleteNightRule.swift`; a night's facts in `Features/NightFactsBuilder.swift`; the alarm profile in `Classification/AlarmProfile.swift`; classification, need, debt and scoring night by night in `Analysis/SleepTimeline.swift`; the need in `Need/NeedEstimator.swift` and `Need/NeedStatus.swift`; naps in `Need/NapCredit.swift` (the credit rule is `SleepNeed.napCredit` in `EvinloModels/Sleep.swift`); the

debt in `Debt/SleepDebt.swift`; the score in `Score/SleepScorer.swift`, `Score/ScoreComponents.swift` and `Score/ScoreCaps.swift`; tonight's plan in `Plan/PlanBuilder.swift`; the day's result in `Analysis/SleepEngine.swift`.

What the validation checks

The rules are pure Swift without look-ahead; tests in `Packages/EvinloKit/Tests/EvinloAlgorithmsTests` pin every worked example of `docs/scoring.md`. The evaluation tool (`Tools/EvinloEval`) replays the same code day by day on synthetic sleepers, whose generator knows the true need and which nights an alarm cut short, and judges hard guardrails, among them:

- nights under 5 hours never score above 52, under 6 hours never above 69; a night headed Short or Broken is never Excellent;
- no jump of more than 2 points when a cap's input moves by a minute around a knot; within the long-sleep allowance more sleep never lowers the score, and the deduction never costs more than 10 points;
- the same data gives the same result, and later data never changes an earlier night;
- for a sleeper who wakes on their own, the estimated need lies within 15 minutes of the true need, the debt reaches 30 minutes on at most 20% of days, a typical day has no catch-up, and every isolated night 90 minutes or more short is followed by a catch-up;
- on synthetic alarm users, at least 70% of the alarm nights are recognised, and the need is within 30 minutes of the truth or not called personal.

References

- Van Dongen H. P. A. et al., "The cumulative cost of additional wakefulness", *Sleep* 26(2), 2003.
- Belenky G. et al., "Patterns of performance degradation and restoration during sleep restriction and subsequent recovery", *Journal of Sleep Research* 12, 2003.
- Banks S. et al., "Neurobehavioral dynamics following chronic sleep restriction: dose-response effects of one night for recovery", *Sleep* 33(8), 2010.
- Kitamura S. et al., "Estimating individual optimal sleep duration and potential sleep debt", *Scientific Reports* 6, 2016.
- Watson N. F. et al., the joint consensus recommendation on adult sleep duration, *Sleep* 38(6), 2015; Lauderdale D. S. et al., "Self-reported and measured sleep duration: how similar are they?", *Epidemiology* 19(6), 2008.
- Schyvens A. M. et al., "A performance validation of six commercial wrist-worn wearable sleep-tracking devices for sleep stage scoring compared to polysomnography", *Sleep Advances* 6(2), 2025.
- Every rule with its sources and the replays behind version 1.3.0: docs/scoring.md, "Sleep score".

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**.