From a step test to lactate thresholds

Record the test

One row per stage, the lactate taken in the last 30 s. The resting sample is the row with intensity 0.

intensity	lactate	heart_rate	rpe
0	0.93	96	6
50	0.98	114	7
75	1.23	134	8
…	…	…	…
191	8.64	198	19

`recording_sheet()`	A printable sheet, a web form and a CSV template with these columns.
`read_recording()`	Reads the .xlsx of the form: stages, recovery, the athlete.
`demo_data`	The test above; `lactate_tests` has 16 more, four sports.

A last stage not completed

Enter its time-weighted intensity: the last completed stage plus the increment × seconds done / seconds of a stage. Or leave it out with `max_intensity`.

Make tests comparable

Same diet and training in the 24 to 48 h before, same time of day, stages of 3 min or more, two or three stages below the first rise, the same sampling site, sample type and analyzer every time.

Sources and the strength of each point: the *Best practices* article.

Sports and units

sport	Intensity	Also shown
cycling	W	per kg with a body mass
running	km/h	pace, min/km
swimming	m/s	pace, min/100 m
rowing	W	500 m split

Estimate every threshold

```
results <- lactate_threshold(
  demo_data, intensity, lactate, heart_rate,
  rpe_column = rpe, sport = "cycling"
)
```

Method	What it finds
Log-log	Where two lines through log lactate and log intensity cross
OBLA 2.0–4.0	A fixed lactate, 2 to 4 mmol/L
Bsln+ 0.5–1.5	0.5 to 1.5 mmol/L above the resting value
D_{max} family	The point furthest below a line to the last stage
LTP1, LTP2	The turn points of three straight segments
LT_{ratio}, IAT	The lowest lactate / intensity; 1.5 mmol/L above it
Keul, Simon	Running only: where the curve rises 1.26 or 1 mmol/L per km/h
Stegmann	A tangent from recovery to the curve

Useful arguments

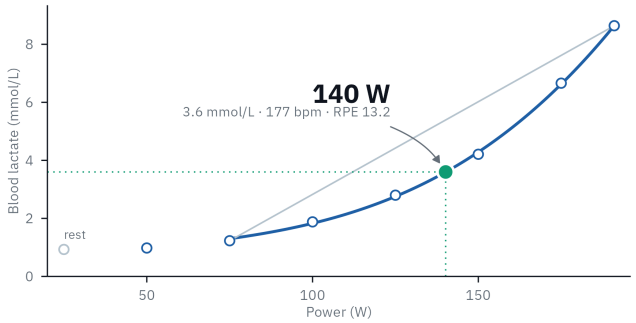
`method`	Some methods only, e.g. `c("Dmax", "LTP")`
`fit`	The curve: polynomial (3rd or 4th degree) or B-spline
`sport`	cycling, rowing (W), running (km/h), swimming (m/s)
`ci = TRUE`	Bootstrap confidence intervals
`recovery`	Recovery samples and `stage_duration`, for Stegmann
`sample`	blood, plasma, sweat or interstitial fluid
`.by`	Many tests in one call, e.g. `.by = "athlete"`

Fine-tune the methods

`fixed`	OBLA targets, mmol/L; default 2 to 4
`baseline_plus`	Bsln+ rises, mmol/L; default 0.5, 1, 1.5
`iat_rise`	The IAT rise above LT_{ratio}; default 1.5
`dmax_anchor`	Where the D_{max} lines start and end
`ltp_breakpoints`	1 for a test that stopped before LTP2
`max_intensity`	Leave out stages above it

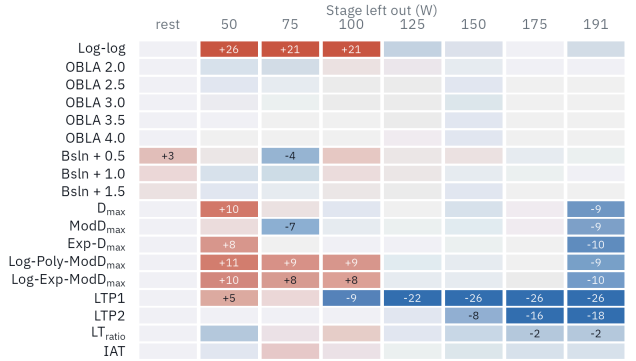
Look, then check

```
autoplot(results)                       # every method
autoplot(results, method = "ModDmax") # one method
```



One method: the curve, its line, and the threshold at 140 W.

`lactate_checks()`	A checklist of what is easy to miss: missing rest, a lactate dip, a final plateau
`lactate_diagnostics()`	Residuals, influential stages, how far each threshold moves without one stage
`lactate_fit_quality()`	Which curve predicts the stages best



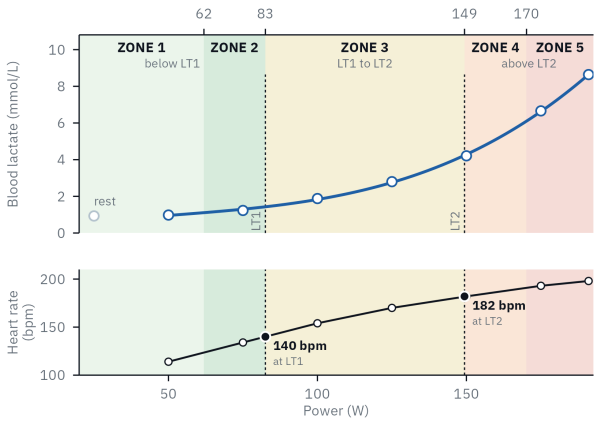
Leave one stage out: red, the threshold rises without that stage; blue, it falls; dark, it rests on it.

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Using the thresholds

Zones and training

```
zones <- lactate_zones(results, model = 5)
## LT1, LT2: from lactate_threshold(lt1 =, lt2 =)
```



LT1 and LT2 split the intensities into moderate, heavy and severe; five zones split the outer two. Below, the heart rate of the stages, read at LT1 and LT2. Every zone gets its heart rate and RPE range; heart-rate zones suit steady efforts, as heart rate lags in short intervals.

`model`	3 zones (the domains) or 5
`split`	Where zones 1|2 and 4|5 sit: `"relative"`, `"seiler"`, or your own
`training_load()`	Time in each zone from training files, by power or heart rate

```
training_load(sessions, zones, column = "power",
              measure = "intensity", interval = 1)
```

Choosing LT1 and LT2

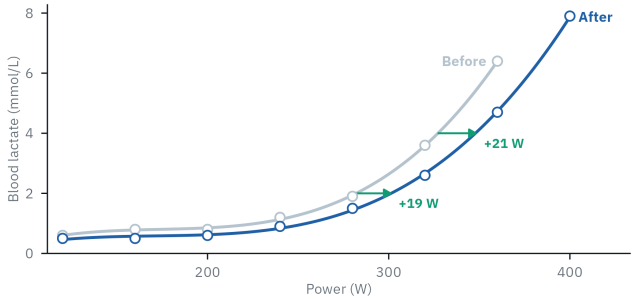
	Methods with some support
LT1	Log-log, Bsln+ 0.5: moderate to heavy domain
LT2	Bsln+ 1.5 (3-min stages), Log-Poly-ModD_{max} (4-min stages): close to the maximal lactate steady state

Jamnick et al. 2018 and 2020; few methods have evidence for the heavy to severe boundary. Report the pair you chose.

Predict and compare

```
predict_performance(results)
own <- calibrate_performance(lab, "ltp2", "time",
  method = "LTP2", sport = "running", distance =
10000)
predict_performance(results, equation = own)
```

Race times (running) and 45-min time-trial power (cycling), each with its 95% range, from published equations or your own athletes.



`compare_tests()`	Is a change larger than the noise of the method?
`curve_shift()`	How far the whole curve moved
`curve_shape()`	Did it shift, or change shape?
`lactate_trend()`	Where a series of tests is heading
`relative_thresholds()`	Per kg, % of peak intensity and heart rate
`reference_percentiles()`	Percentile among people of the same age and sex (cycling, general population)

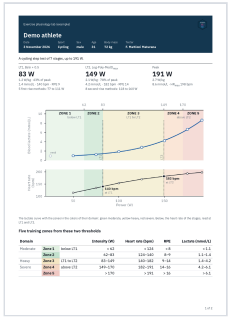
What the predictions rest on

Sport	From	Source
Running	IAT: 5 km to marathon; OBLA 4.0: marathon	Röcker 1998; Sjödin 1981
Cycling	Six thresholds: 45-min time trial	Heuberger 2018, refitted
Rowing, swimming	Your own equation	`calibrate_performance()`

Report and style

```
report_start(results) |>
  report_header(name = "Ana", lab = "Our lab",
                logo = "logo.png") |>
  report_summary() |>
  report_zones() |>
  report_save("ana.html", pdf = TRUE)
```

`test_report()`	The default two-page report in one call; 2-5 tests and their `dates` for the progress
`report_*()`	Header, summary, zones, prediction, checks, test, methods, your own text
`lactate_report()`	Every threshold as a gt table for a paper
`gt_lactater()`	The same look for your own gt tables



The first page of a report: the two thresholds, what they mean, the zones.

Plots

`theme_lactater()`	The look of lactater's plots, for your own
`lactater.style`	`options(lactater.style = "night")`, or `"journal"` for print
`lactater.font`	`options(lactater.font = "IBM Plex Sans")`

Beyond the step test

`vlamax()`	The maximal lactate accumulation rate ($\dot{V}La_{max}$) from a sprint

Learn more

Every method follows its original paper; the articles explain each one, its evidence, and how to read the checks.

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