

# Package ‘lactater’

July 22, 2025

**Title** Tools for Analyzing Lactate Thresholds

**Version** 0.2.0

**Description** Set of tools for analyzing lactate thresholds from a step incremental test to exhaustion. Easily analyze the methods Log-log, Onset of Blood Lactate Accumulation (OBLA), Baseline plus (Bsln+), Dmax, Lactate Turning Point (LTP), and Lactate / Intensity ratio (LTratio) in cycling, running, or swimming. Beaver WL, Wasserman K, Whipp BJ (1985) <doi:10.1152/jappl.1985.59.6.1936>. Heck H, Mader A, Hess G, Mücke S, Müller R, Hollmann W (1985) <doi:10.1055/s-2008-1025824>. Kindermann W, Simon G, Keul J (1979) <doi:10.1007/BF00421101>. Skinner JS, McLellan TH (1980) <doi:10.1080/02701367.1980.10609285>. Berg A, Jakob E, Lehmann M, Dickhuth HH, Huber G, Keul J (1990) PMID 2408033. Zoladz JA, Rademaker AC, Sargeant AJ (1995) <doi:10.1113/jphysiol.1995.sp020959>. Cheng B, Kuipers H, Snyder A, Keizer H, Jeukendrup A, Hesselink M (1992) <doi:10.1055/s-2007-1021309>. Bishop D, Jenkins DG, Mackinnon LT (1998) <doi:10.1097/00005768-199808000-00014>. Hughson RL, Weisiger KH, Swanson GD (1987) <doi:10.1152/jappl.1987.62.5.1975>. Jamnick NA, Botella J, Pyne DB, Bishop DJ (2018) <doi:10.1371/journal.pone.0199794>. Hofmann P, Tschakert G (2017) <doi:10.3389/fphys.2017.00337>. Hofmann P, Pokan R, von Duvillard SP, Seibert FJ, Zweiker R, Schmid P (1997) <doi:10.1097/00005768-199706000-00005>. Pokan R, Hofmann P, Von Duvillard SP, et al. (1997) <doi:10.1097/00005768-199708000-00009>. Dickhuth H-H, Yin L, Niess A, et al. (1999) <doi:10.1055/s-2007-971105>.

**License** MIT + file LICENSE

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.2.3

**Suggests** bsplus, covr, datapasta, glue, knitr, miniUI, rhandsontable, rmarkdown, shiny, shinyjs, shinyWidgets, spelling, testthat (>= 3.0.0)

**Imports** magrittr, broom, dplyr, ggplot2, ggtext, patchwork, lubridate, minpack.lm, pracma, rlang, segmented, stringr, tidyr, forcats

**Depends** R (>= 2.10)  
**Language** en-US  
**Config/testthat/edition** 3  
**NeedsCompilation** no  
**Author** Felipe Mattioni Maturana [aut, cre] (ORCID:  
    <<https://orcid.org/0000-0002-4221-6104>>)  
**Maintainer** Felipe Mattioni Maturana <felipe.mattioni@med.uni-tuebingen.de>  
**Repository** CRAN  
**Date/Publication** 2023-11-16 15:40:02 UTC

Contents

demo_data . . . . .	2
lactate_curve . . . . .	3
lactate_threshold . . . . .	4
plot_methods . . . . .	8
run_data_input . . . . .	8
<b>Index</b>	<b>9</b>

---

demo_data	<i>Demo data</i>
-----------	------------------

---

Description

A dataset containing the lactate and heart rate data collected from a step-incremental test as an example

Usage

demo\_data

Format

- A data frame with 8 rows and 5 variables:
- step** the number of the step, starting at zero for the baseline.
  - length** the length of each step.
  - intensity** the intensity performed on each step (in this case in watts).
  - lactate** the blood lactate concentration.
  - heart\_rate** the heart rate associated with that step.

---

lactate_curve	<i>Lactate curve</i>
---------------	----------------------

---

## Description

It retrieves the lactate curve for plotting purposes.

## Usage

```
lactate_curve(  
  .data,  
  intensity_column,  
  lactate_column,  
  heart_rate_column,  
  fit = c("3rd degree polynomial", "4th degree polynomial", "B-spline"),  
  include_baseline = FALSE,  
  sport = c("cycling", "running", "swimming")  
)
```

## Arguments

.data	The raw data.
intensity_column	The name of the intensity column.
lactate_column	The name of the lactate column.
heart_rate_column	The name of the heart rate column, if applicable.
fit	The fit you would like to use for plotting the lactate curve. Options are 3rd degree polynomial, 4th degree polynomial, or B-spline.
include_baseline	A boolean to indicate whether to include the baseline value in the fit.
sport	The sport at which the incremental test was performed. One of cycling, running, or swimming.

## Value

a list with the following elements:

data	a tibble containing the raw data with the columns intensity, lactate, and heart_rate.
lactate_curve	a tibble containing the data with the columns intensity and lactate for plotting the lactate curve according to the fit method chosen.
heart_rate_response	a tibble containing the data with the columns intensity and heart_rate for plotting the heart rate response using the linear method.

## Examples

```
## Not run:
lactate_curve(
  .data = demo_data,
  intensity_column = "intensity",
  lactate_column = "lactate",
  heart_rate_column = "heart_rate",
  fit = "3rd degree polynomial",
  include_baseline = TRUE,
  sport = "cycling"
)

## End(Not run)
```

---

lactate_threshold	<i>Lactate threshold</i>
-------------------	--------------------------

---

## Description

This is a general function that applies several lactate threshold methods at the same time.

## Usage

```
lactate_threshold(
  .data,
  intensity_column,
  lactate_column,
  heart_rate_column,
  method = c("Log-log", "OBLA", "Bsln+", "Dmax", "LTP", "LTratio"),
  fit = c("3rd degree polynomial", "4th degree polynomial", "B-spline"),
  include_baseline = FALSE,
  sport = c("cycling", "running", "swimming"),
  loglog_restrainer = 1,
  plot = TRUE
)
```

## Arguments

.data	The raw data.
intensity_column	The name of the intensity column.
lactate_column	The name of the lactate column.
heart_rate_column	The name of the heart rate column, if applicable.
method	The lactate threshold method to calculate. It can be one or many of the following: Log-log, OBLA, Bsln+, Dmax, LTP, LTratio. See Details for more information. Default to c("Log-log", "OBLA", "Bsln+", "Dmax", "LTP", "LTratio").

fit	The fit you would like to use for finding the lactate values associated to each one of the lactate thresholds. Please, note that a few lactate thresholds have default methods for this and cannot be changed. Options are 3rd degree polynomial, 4th degree polynomial, or B-spline. See Details.
include_baseline	A boolean to indicate whether to include the baseline value in the fit.
sport	The sport at which the incremental test was performed. One of cycling, running, or swimming.
loglog_restrainer	A scalar from 0 to 1 indicating the percentage of the data that you would like to restrain for fitting the Log-Log method. For example, 1 means no restriction (fits using the whole data), and 0.5 means that only the first 50% of the data will be used. Default to 1.
plot	A boolean to indicate whether to generate a plot from each one of the methods. Default to TRUE.

## Details

### Log-log:

The lactate response (i.e., log of lactate vs intensity) is divided into two segments. A segmented regression is then performed such that the lactate curve would present one breaking point. The exercise intensity at which the breaking point occurs is then considered as Log-log (Beaver et al., 1985). Caution: this method might require a double-check via a visual inspection, depending in some cases.

### OBLA:

The Onset of Blood Lactate Accumulation (OBLA) is the exercise intensity at fixed lactate of 2.0, 2.5, 3.0, 3.5, and 4.0 mmol/L (Heck et al., 1985; Kindermann et al., 1979; Skinner & McLellan, 1980). The lactate curve is usually fitted using a 3rd order polynomial regression curve, but the user can define another method (4th degree polynomial or B-spline).

### Bsln+:

In the baseline plus method (Bsln+), the exercise intensity at which lactate increases to 0.5, 1.0, and 1.5 mmol/L above baseline (resting) values is considered (Berg et al., 1990; Zoladz et al., 1995). The lactate curve is usually fitted using a 3rd order polynomial regression curve, but the user can define another method (4th degree polynomial or B-spline).

### Dmax:

#### *Dmax:*

The exercise intensity that yields the maximum perpendicular distance to the straight line between the first and the last data point (Cheng et al., 1992). The lactate curve is fitted using a 3rd order polynomial regression curve, and it can't be changed.

#### *Modified Dmax (ModDmax):*

The exercise intensity that yields the maximum perpendicular distance to the straight line between data point preceding the first rise in lactate greater than 0.4 mmol/L and the last data point (Bishop et al., 1998). The lactate curve is fitted using a 3rd order polynomial regression curve, and it can't be changed.

*Exponential Dmax (Exp-Dmax):*

The exercise intensity on the exponential plus-constant regression lactate curve that yields the maximum perpendicular distance to the straight line between the first and the last data point (Hughson et al., 1987). The lactate curve is fitted using an exponential curve, and it can't be changed.

*Log-log modified Dmax (Log-Poly-ModDmax):*

The exercise intensity that yields the maximum perpendicular distance to the straight line between Log-log and the last data point in the 3rd order polynomial regression curve (Jamnick et al., 2018). The lactate curve is fitted using a 3rd order polynomial regression curve, and it can't be changed.

*Log-log exponential Dmax (Log-Exp-ModDmax):*

The exercise intensity that yields the maximum perpendicular distance to the straight line between Log-log and the last data point in the exponential curve (Jamnick et al., 2018). The lactate curve is fitted using an exponential curve, and it can't be changed.

**LTP:***Lactate Turning Point 1 (LTP1) and Lactate Turning Point 2 (LTP2):*

the lactate response is divided into three segments. A segmented regression is performed such that the lactate curve yields two breaking points. The first breaking point, representing the first rise in lactate above resting levels, is considered as LTP1. The second breaking point, representing an accelerated lactate accumulation, is then considered as LTP2 (Hofmann & Tschakert, 2017; Hofmann et al., 1997; Pokan et al., 1997). Caution: this method might require a double-check via a visual inspection, depending in some cases.

**LTratio:**

The lactate response (i.e., ratio of lactate / exercise intensity vs exercise intensity) is interpolated using a B-spline regression curve. LTratio is then defined as the lowest value of the lactate / exercise intensity ratio, which attempts to describe the onset of the lactate increase (Dickhuth et al., 1999).

**Value**

a tibble with the following columns:

method_category	the category of the lactate threshold method.
method	the method used to estimate the lactate threshold
fitting	the fitting method used to predict the lactate curve
intensity	the intensity associated with the estimated lactate threshold
lactate	the lactate concentration associated with the estimated lactate threshold
heart_rate	the heart rate associated with the estimated lactate threshold
plot	the plot produced to display the lactate threshold

## References

- Beaver WL, Wasserman K, Whipp BJ. Improved detection of lactate threshold during exercise using a log-log transformation. *Journal of Applied Physiology*. 1985;59(6):1936–40.
- Heck H, Mader A, Hess G, Mücke S, Müller R, Hollmann W. Justification of the 4-mmol/l Lactate Threshold. *International Journal of Sports Medicine*. 1985;06(03):117–30.
- Kindermann W, Simon G, Keul J. The significance of the aerobic-anaerobic transition for the determination of work load intensities during endurance training. *European Journal of Applied Physiology and Occupational Physiology*. 1979;42(1):25–34.
- Skinner JS, Mclellan TH. The Transition from Aerobic to Anaerobic Metabolism. *Research Quarterly for Exercise and Sport*. 1980;51(1):234–48.
- Berg A, Jakob E, Lehmann M, Dickhuth HH, Huber G, Keul J. Current aspects of modern ergometry. *Pneumologie*. 1990;44(1):2–13.
- Zoladz JA, Rademaker AC, Sargeant AJ. Non-linear relationship between O<sub>2</sub> uptake and power output at high intensities of exercise in humans. *The Journal of Physiology*. 1995;488(1):211–7.
- Cheng B, Kuipers H, Snyder A, Keizer H, Jeukendrup A, Hesselink M. A New Approach for the Determination of Ventilatory and Lactate Thresholds. *International Journal of Sports Medicine*. 1992;13(07):518–22.
- Bishop D, Jenkins DG, Mackinnon LT. The relationship between plasma lactate parameters, W<sub>peak</sub> and 1-h cycling performance in women. *Med Sci Sports Exerc*. 1998;30(8):1270–5.
- Hughson RL, Weisiger KH, Swanson GD. Blood lactate concentration increases as a continuous function in progressive exercise. *Journal of Applied Physiology*. 1987;62(5):1975–81.
- Jamnick NA, Botella J, Pyne DB, Bishop DJ. Manipulating graded exercise test variables affects the validity of the lactate threshold and VO<sub>2</sub>peak. *PLOS ONE*. 2018;13(7):e0199794.
- Hofmann P, Tschakert G. Intensity- and Duration-Based Options to Regulate Endurance Training. *Front Physiol*. 2017;8:337.
- Hofmann P, Pokan R, von Duvillard SP, Seibert FJ, Zweiker R, Schmid P. Heart rate performance curve during incremental cycle ergometer exercise in healthy young male subjects. *Med Sci Sports Exerc*. 1997;29(6):762–8.
- Pokan R, Hofmann P, Von Duvillard SP, et al. Left ventricular function in response to the transition from aerobic to anaerobic metabolism. *Med Sci Sports Exerc*. 1997;29(8):1040–7.
- Dickhuth H-H, Yin L, Niess A, et al. Ventilatory, Lactate-Derived and Catecholamine Thresholds During Incremental Treadmill Running: Relationship and Reproducibility. *International Journal of Sports Medicine*. 1999;20(02):122–7.

## Examples

```
## Not run:
lactate_threshold(
  .data = demo_data,
  intensity_column = "intensity",
  lactate_column = "lactate",
  heart_rate_column = "heart_rate",
  fit = "3rd degree polynomial",
  include_baseline = TRUE,
  sport = "cycling",
```

```
loglog_restrainer = 1,
plot = TRUE
)

## End(Not run)
```

---

plot_methods	Combine lactate threshold methods into one plot
--------------	---

---

**Description**

Combine lactate threshold methods into one plot

**Usage**

```
plot_methods(plots, ...)
```

**Arguments**

plots	The ggplot2 objects to be combined.
...	Additional arguments passed onto patchwork::wrap_plots().

**Value**

a patchwork object

---

run_data_input	Data input widget
----------------	-------------------

---

**Description**

Widget to help with data input.

**Usage**

```
run_data_input(width = 1200, height = 900)
```

**Arguments**

width	The width, in pixels.
height	The height, in pixels.

**Value**

The code to reproduce the manual data input.

# Index

## \* **datasets**

demo\_data, [2](#)

demo\_data, [2](#)

lactate\_curve, [3](#)

lactate\_threshold, [4](#)

plot\_methods, [8](#)

run\_data\_input, [8](#)