

Package: peditools2 (via r-universe)

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Title Pediatric and Neonatal Growth Chart Calculations and Parameters

Version 0.1.0

Description Z-scores, probabilities and measurements for pediatric, neonatal and fetal growth charts and standards (CDC, WHO, INTERGROWTH-21st and others) from their published parameters, by the LMS method, the WHO restricted LMS method, the CDC extended BMI method and the INTERGROWTH-21st models. The parameter tables and their references are those of PediTools <<https://peditools.org/>>, where each chart's sources and methods are described.

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URL <https://github.com/jhchou/peditools2>, <https://peditools.org/>

BugReports <https://github.com/jhchou/peditools2/issues>

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growth_add_chart	<i>Add your own charts for the session</i>
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Description

Makes charts of your own (e.g. parameter tables an author shared with you) available to every function of the package until the end of the R session, with the same checks and methods as the built-in charts. Nothing is saved: call it again in a new session (e.g. `growth_add_chart(read.csv("my_chart.csv"))`) at the top of a script).

Usage

```
growth_add_chart(params, metadata = NULL, references = NULL, overwrite = FALSE)
```

Arguments

params	A data frame of parameters, or a list of them (see Details).
metadata	A data frame of chart information (see Details), or NULL.
references	A data frame of the charts' publications (see Details), or NULL.
overwrite	TRUE to replace a chart of the same id (built-in, or added before); FALSE (default): an error.

Details

params is a data frame, or a list of data frames, in the layout of the PediTools parameter files, recognised by their columns:

- **LMS** (the layout of `growth_table()`): chart, measure, sex (or gender; "m", "f", or NA for one table for both sexes), x (or age), L, M, S, and optionally x_units (or age_units) and measure_units.
- **ST3** (the layout of `growth_table()`): chart, measure, sex, x, mu, sigma, nu, tau, and optionally x_units and measure_units.
- **Equations** of a normal model (the layout of `growth_equations()`): chart, measure, sex, x_from, param (mu or sigma), coef, power, log_power, male, x_scale, transform, y_scale, and optionally model ("normal"), x_units and measure_units.

A chart may combine an ST3 table and equations (parts used from their start, as INTERGROWTH-21st newborn size).

metadata (optional) is a data frame with a row per chart (measure NA), and optionally rows for one measure or one sex that override it: chart, measure, sex, x_label (default "age"), x_min and x_max (or age_min, age_max; the published coverage, by default the table's first and last rows; required for equations), z_method ("lms" (default) or "sd23" for LMS tables; "cdf" for the others), x_break (an x between two rows where the table steps), sources_url (a page describing the chart's sources and methods), and x_units, measure_units when params has none. These are the fields of `growth_charts()`; on_website and calculators describe the PediTools calculators, so they are FALSE and NA for added charts.

references (optional) is a data frame in the layout of `growth_references()`: chart, measure (NA: every measure of the chart), role ("clinical" (default), "lms_data", "method" or "resource"), citation (required), and optionally short (default: the citation), position (default: the order given within each role), id, doi, pmid and url.

As for the built-in charts, the coverage may reach at most half a row step beyond a table's end row (use extrapolate = "linear" to go further); rows must increase in x; M and S (sigma, nu, tau) must be positive.

Value

The added charts' rows of `growth_charts()`, invisibly.

See Also

`growth_remove_chart()`; `growth_charts()` (column added).

Examples

```
# An LMS table of your own (here the first rows of CDC's, as an example)
my <- growth_table("cdc_2000_infant", "weight", "f")[1:12, ]
my$chart <- "my_infant_chart"
meta <- data.frame(chart = "my_infant_chart", x_units = "months", measure_units = "kg")
refs <- data.frame(chart = "my_infant_chart", citation = "Author A. My chart. J Growth 2026;1:9.")
growth_add_chart(my, meta, refs)
growth_z(4.1, 1.2, "f", "my_infant_chart", "weight")
```

```
growth_references("my_infant_chart")
growth_remove_chart("my_infant_chart")
```

growth_age_days	<i>Age in days between dates</i>
-----------------	----------------------------------

Description

Whole days from the date of birth to the date of measurement, as PediTools counts them (calendar dates, so no daylight-saving effects). Negative when the date is before the birth.

Usage

```
growth_age_days(birth, date)
```

Arguments

birth, date Dates: Date vectors, or character in the form "YYYY-MM-DD" (each of length 1 or a common length). Date-times (POSIXct) are refused: convert them with as.Date() in the time zone of your data, so that a date does not shift by a day.

Value

Integer days; NA where a date is missing or not a valid date (with a warning).

Examples

```
growth_age_days("2024-02-10", c("2024-02-29", "2024-03-01", "2025-02-10"))
```

growth_charts	<i>The available charts</i>
---------------	-----------------------------

Description

One row per chart, measure and sex: everything needed to use a chart's parameters. A chart with one table for both sexes (e.g. fenton_2003, the INTERGROWTH-21st fetal standards) has one row with sex NA.

Usage

```
growth_charts(chart = NULL)
```

Arguments

chart Chart ids to keep; NULL (default) for all.

Value

A data frame with columns:

chart, measure, sex The ids used by every function of the package; sex is "m", "f", or NA for a table used for both sexes.

family How the distribution is given: "lms" (an LMS table, [growth_table\(\)](#)), or the INTERGROWTH-21st parts in order of x: "st3" (a skew t table, [growth_table\(\)](#)) and "normal" (equations for the mean and SD, [growth_equations\(\)](#)).

x_label What x is: "age", "length", "height", "gestational age" or "gestational age at birth".

x_units, measure_units The units of x and of the measurement.

x_min, x_max The coverage: the range of x the chart is published for. It may reach beyond the first or last row by up to half a row step, for tables whose rows are the midpoints of bands.

z_method The Z-score method the chart's authors prescribe: "lms", "sd23" (WHO's restricted LMS method beyond +3 SD) or "cdf" (the inverse normal of the distribution function, INTERGROWTH-21st).

x_break An x between two rows where the table steps (e.g. 730.5 days, where WHO's tables change from lying length to standing height), never interpolated across; NA for none.

n_rows The number of rows of the table in [growth_table\(\)](#) (0 for equations only).

on_website Whether a PediTools calculator uses the chart.

calculators The PediTools calculator ids that use it, separated by commas; NA for none.

sources_url The chart's section of the PediTools Sources and methods page (for a chart with no calculator, the section on its method).

added Whether the chart was added in the session ([growth_add_chart\(\)](#)).

See Also

[growth_references\(\)](#) for each chart's publications.

Examples

```
charts <- growth_charts()
head(charts[c("chart", "measure", "sex", "x_units", "x_min", "x_max")])

growth_charts("who_2006_infant")

# Charts not used by a PediTools calculator
unique(charts$chart[!charts$on_website])
```

growth_convert	<i>Convert units</i>
----------------	----------------------

Description

Converts values between units of the same kind, with the constants PediTools uses: mass ("g", "kg", "lb", "oz"), length ("mm", "cm", "m", "in", "ft"), time ("days", "weeks", "months", "years") and BMI ("kg/m2", and Olsen 2015's "g/cm2*10", numerically the same). The factors are exact by definition: 1 lb = 453.59237 g, 1 oz = 1/16 lb, 1 in = 2.54 cm, 1 week = 7 days, 1 month = 30.4375 days (365.25 / 12), 1 year = 365.25 days, as in the CDC and WHO tables.

Usage

```
growth_convert(x, from, to)
```

Arguments

x	Numeric values.
from, to	Units (each of length 1 or the length of x).

Details

The calculation functions take values in the chart's own units only ([growth_charts\(\)](#): x_units, measure_units); convert before calling them.

Value

The values in to units.

Examples

```
growth_convert(c(30, 365), "days", "months")
growth_convert(7.5, "lb", "kg")

# Ages in days to the x of a chart in months
x_units <- growth_charts("cdc_2000_infant")$x_units[1]
growth_convert(c(14, 200, 400), "days", x_units)
```

growth_corrected_age *Corrected age and postmenstrual age*

Description

The corrected age (the age from the due date, 40 0/7 weeks) and the postmenstrual age (PMA: the gestational age at birth plus the age) of an infant born preterm, as PediTools calculates them: corrected age = age - (280 days - GA at birth), PMA = GA at birth + age.

Usage

```
growth_corrected_age(age_days, ga_weeks, ga_days = 0, units = "days")
```

```
growth_pma(age_days, ga_weeks, ga_days = 0, units = "weeks")
```

Arguments

age_days	Chronological ages in days (e.g. from growth_age_days()).
ga_weeks, ga_days	The gestational age at birth: completed weeks and days (ga_days 0 to 6; default 0). A GA in days only can be given as ga_weeks = 0, ga_days = <days>.
units	The units of the result: "days" (default for the corrected age) or "weeks" (default for the PMA, the x of the preterm charts), or "months", "years".

Details

Whether and until when to correct (e.g. to 2 years, and for which gestational ages) is a clinical convention left to you: the corrected age is calculated for any GA, and is negative before the due date.

Value

Numeric ages in units.

Examples

```
# Born at 28 3/7 weeks, 100 days old
growth_corrected_age(100, 28, 3)
growth_corrected_age(100, 28, 3, units = "months")
growth_pma(100, 28, 3)

# The x for Fenton 2013 from a GA at birth and a date
age <- growth_age_days("2026-01-05", "2026-02-20")
growth_pma(age, 26, 4)
```

growth_curves

*Percentile and Z-score curves***Description**

The measurement at each percentile (or Z-score) along each chart's x, for plotting with any library: crossed over every chart, measure, sex, curve and x. The values are those of `growth_y()`, by the same methods. As on the website's charts, a curve breaks where the table steps (lying length to standing height), where the INTERGROWTH-21st parts change, and where a value is undefined (the segment column).

Usage

```
growth_curves(
  chart,
  measure,
  sex = NULL,
  p = c(0.03, 0.1, 0.5, 0.9, 0.97),
  z = NULL,
  labels = NULL,
  x = NULL,
  n = 300,
  extrapolate = "coverage",
  sd23 = NULL,
  cdc_bmi_ext = NULL
)
```

Arguments

chart	Chart ids.
measure	Measures; NULL (default) for every measure of the charts. Every chart must have every measure given.
sex	"m", "f", "male" or "female"; NULL (default) for both. A table used for both sexes is always included (with sex NA).
p	Probabilities of the curves (the percentile / 100). Default: the 3rd, 10th, 50th, 90th and 97th percentiles.
z	Z-scores of the curves, instead of p.
labels	The curves' labels (the curve column): NULL (default) for "P3", "P50", ... (or "Z-2", "Z0", "Z+2", ...); a character vector with a label for each value of p (or z), in their order; or a function of p (or z) returning them, e.g. <code>function(p) paste0(100 * p, "th")</code> . Labels must be unique.
x	The x of the points, the same for every table; NULL (default): n + 1 points evenly over each table's coverage. Points outside the range allowed by extrapolate are NA.
n	The number of intervals of the default grid.

extrapolate	Which x are calculated: "coverage" (default) the chart's published coverage (x_min to x_max in <code>growth_charts()</code> , which may reach half a row step beyond the end rows of tables whose rows are band midpoints); "none" only between the table's first and last rows (for INTERGROWTH-21st charts, the coverage); "linear" any x, the parameters beyond the coverage on the line through the two end rows (for the INTERGROWTH-21st equations, the equations themselves). Outside: NA, with one warning per call.
sd23	NULL (default): WHO's restricted LMS method where the chart's authors prescribe it; TRUE: on every chart (beyond ± 3 SD, the line whose spread is the distance between the 2 and 3 SD values of the chart's own distribution); FALSE: off.
cdc_bmi_ext	NULL (default) or TRUE: the CDC extended BMI method on <code>cdc_2000_bmi</code> (an error on any other chart with TRUE); FALSE: plain LMS.

Value

A data frame, one row per point: chart, measure, sex (NA for a table for both sexes), curve (a label: "P3", "P50", ... or "Z-2", "Z0", ...), p, z, x, y (NA where undefined or outside the allowed range), segment (a curve's pieces: a line connects only points of the same segment) and beyond_coverage (with extrapolate = "linear").

See Also

`growth_plot()` to draw them with ggplot2.

Examples

```
curves <- growth_curves("who_2006_infant", "weight", "f")
head(curves)

# Z-score lines at given ages, with labels of your own
growth_curves("cdc_2000_infant", "length", "m",
  z = -2:2, labels = c("-2 SD", "-1 SD", "median", "+1 SD", "+2 SD"), x = c(0, 12, 24)
)

# With base graphics
curves <- growth_curves("cdc_2000_bmi", "bmi", "m", p = c(0.05, 0.5, 0.85, 0.95))
plot(y ~ x, curves, type = "n", xlab = "age (months)", ylab = "BMI (kg/m2)")
for (k in split(curves, curves$curve)) lines(k$x, k$y)
```

growth_data_version *The version of the chart data*

Description

The date and the commit of the last change to the PediTools parameter files the package's data were built from.

Usage

```
growth_data_version()
```

Value

A named character vector: date (YYYY-MM-DD) and commit.

Examples

```
growth_data_version()
```

growth_detail

Results in detail

Description

Everything about each value: the result, the parameters at x, the method applied and the status, for checking or studying how the methods behave. The arguments are those of [growth_z\(\)](#) (a measurement y) or [growth_y\(\)](#) (a Z-score z or a probability p); give exactly one of y, z, p. No warnings: the status says why a value is NA.

Usage

```
growth_detail(
  y = NULL,
  x,
  sex,
  chart,
  measure,
  z = NULL,
  p = NULL,
  extrapolate = "coverage",
  sd23 = NULL,
  cdc_bmi_ext = NULL
)
```

Arguments

y	Measurements; or give z or p instead.
x	Ages, or lengths or heights for weight-for-length and weight-for-height, in the chart's x units (x_units in growth_charts() ; to convert: growth_convert() , growth_age_days() , growth_pma() , growth_corrected_age()).
sex	"m", "f", "male" or "female", in any case; other values are NA (with a warning). Ignored for charts with one table for both sexes.
chart, measure	Chart and measure ids, as in growth_charts() .
z	Z-scores.

p	Probabilities (the percentile / 100).
extrapolate	Which x are calculated: "coverage" (default) the chart's published coverage (x_min to x_max in growth_charts() , which may reach half a row step beyond the end rows of tables whose rows are band midpoints); "none" only between the table's first and last rows (for INTERGROWTH-21st charts, the coverage); "linear" any x, the parameters beyond the coverage on the line through the two end rows (for the INTERGROWTH-21st equations, the equations themselves). Outside: NA, with one warning per call.
sd23	NULL (default): WHO's restricted LMS method where the chart's authors prescribe it; TRUE: on every chart (beyond ± 3 SD, the line whose spread is the distance between the 2 and 3 SD values of the chart's own distribution); FALSE: off.
cdc_bmi_ext	NULL (default) or TRUE: the CDC extended BMI method on cdc_2000_bmi (an error on any other chart with TRUE); FALSE: plain LMS.

Value

A data frame, one row per element:

chart, measure, sex, x The inputs (sex normalised to "m"/"f", NA for a chart with one table for both sexes).

y, z, p The measurement, Z-score and probability: the one given as given, the others calculated.

method "lms", "sd23" (the restricted method; also within ± 3 SD, where it equals plain LMS) or "cdc_bmi_ext" (the CDC extended BMI method was used for this value).

status "ok"; "missing" (an input is NA); "outside" (x outside the range allowed by extrapolate); "invalid" (a measurement not finite, or not positive on an LMS chart or an INTERGROWTH-21st equation on the log scale; an infinite Z; a probability not strictly between 0 and 1); "undefined" (the parameters or the method give no value there).

family, part, extrapolated, beyond_coverage As in [growth_params\(\)](#).

L, M, S, mu, sigma, nu, tau, y_scale The parameters at x, as in [growth_params\(\)](#).

p95, ext_sigma On cdc_2000_bmi with the extended method: the BMI at the 95th percentile and the extension's sigma (NA otherwise), e.g. for the BMI as a percentage of P95.

Examples

```
growth_detail(c(3.5, 7.9, 12.5), 6, "m", "who_2006_infant", "weight")
```

```
# BMI as a percentage of the 95th percentile
d <- growth_detail(c(24, 30, 36), 150, "m", "cdc_2000_bmi", "bmi")
100 * d$y / d$p95
```

growth_equations	<i>A chart's equations</i>
------------------	----------------------------

Description

The terms of the INTERGROWTH-21st equations, for the parts of a chart given by equations (family "normal" in [growth_charts\(\)](#)), exactly as published (as in the *gigs* R package 0.5.2), for any number of charts, measures and sexes (crossed). Charts and parts given by tables are in [growth_table\(\)](#).

Usage

```
growth_equations(chart, measure = NULL, sex = NULL)
```

Arguments

chart	Chart ids.
measure	Measures; NULL (default) for every measure of the charts. Every chart must have every measure given.
sex	"m", "f", "male" or "female"; NULL (default) for both. A table used for both sexes is always included (with sex NA).

Details

A parameter (param, mu or sigma) of the part starting at `x_from` is transform applied to the sum of its terms $\text{coef} * t^{\text{power}} * \log(t)^{\text{log_power}}$, with $t = x / x_scale$; a term with `male` 1 applies to boys only. The distribution is normal on the `y_scale` of the measurement ("identity" or "log").

Value

A data frame with columns `chart`, `measure`, `sex` (NA: both sexes), `x_from`, `param`, `coef`, `power`, `log_power`, `male`, `x_scale`, `transform`, `y_scale` and `model`; no rows for charts given by tables.

Examples

```
growth_equations("intergrowth_png", "weight")
```

growth_lms_z *The LMS method on your own parameters*

Description

Z-scores of measurements, and measurements at Z-scores, from L, M and S given directly (e.g. from [growth_params\(\)](#) or a table of your own), by the LMS method or WHO's restricted LMS method.

Usage

```
growth_lms_z(y, L, M, S, sd23 = FALSE)
```

```
growth_lms_y(z, L, M, S, sd23 = FALSE)
```

Arguments

y	Measurements (positive).
L, M, S	The LMS parameters (M and S positive).
sd23	TRUE for WHO's restricted LMS method; FALSE (default) for plain LMS.
z	Z-scores.

Details

The LMS method (Cole and Green 1992): $Z = ((y/M)^L - 1)/(LS)$, or $\log(y/M)/S$ for $L = 0$; $y = M(1 + LSZ)^{1/L}$, or Me^{SZ} for $L = 0$. The restricted method (WHO's "SD23") is the same within ± 3 SD; beyond, the distribution is a straight line whose spread is the distance between the 2 and 3 SD values: $Z = 3 + (y - SD_3)/(SD_3 - SD_2)$ above, $-3 + (y - SD_{-3})/(SD_{-2} - SD_{-3})$ below.

Arguments are recycled: each has length 1 or the common length.

Value

A numeric vector: NA where the input is missing or not valid, or the value does not exist (e.g. $1 + LSZ \leq 0$).

References

Cole TJ, Green PJ. Smoothing reference centile curves: the LMS method and penalized likelihood. *Stat Med.* 1992;11(10):1305-19.

WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva: World Health Organization; 2006 (chapter 7).

See Also

[growth_z\(\)](#) and [growth_y\(\)](#) to use a chart's parameters at any x.

Examples

```
growth_lms_z(c(8.5, 10.2), L = -0.0757, M = 8.9014, S = 0.10846)
growth_lms_y(-2:2, L = -0.0757, M = 8.9014, S = 0.10846)

# Beyond +-3 SD the restricted method differs
growth_lms_z(14, L = -0.0757, M = 8.9014, S = 0.10846, sd23 = c(FALSE, TRUE))
```

growth_params	<i>Parameters at any x</i>
---------------	----------------------------

Description

A chart's parameters at each x: interpolated between the table's rows as for [growth_z\(\)](#), with the same extrapolate modes. Vectorised over every argument.

Usage

```
growth_params(x, sex, chart, measure, extrapolate = "coverage")
```

Arguments

x	Ages, or lengths or heights for weight-for-length and weight-for-height, in the chart's x units (x_units in growth_charts() ; to convert: growth_convert() , growth_age_days() , growth_pma() , growth_corrected_age()).
sex	"m", "f", "male" or "female", in any case; other values are NA (with a warning). Ignored for charts with one table for both sexes.
chart, measure	Chart and measure ids, as in growth_charts() .
extrapolate	Which x are calculated: "coverage" (default) the chart's published coverage (x_min to x_max in growth_charts() , which may reach half a row step beyond the end rows of tables whose rows are band midpoints); "none" only between the table's first and last rows (for INTERGROWTH-21st charts, the coverage); "linear" any x, the parameters beyond the coverage on the line through the two end rows (for the INTERGROWTH-21st equations, the equations themselves). Outside: NA, with one warning per call.

Value

A data frame, one row per element: chart, measure, sex (NA for a chart with one table for both sexes), x, family (the chart's, as in [growth_charts\(\)](#)), part (the distribution used at x: "lms", "st3" or "normal"), the parameters (L, M, S for LMS; mu, sigma, nu, tau for ST3; mu, sigma and y_scale for the INTERGROWTH-21st equations, where y_scale "log" means they are the mean and SD of log(y); only the columns of the families of the charts given), status ("ok", "missing", "outside" or "undefined"), extrapolated (the parameters are on the line beyond the end rows, or the equations beyond the coverage) and beyond_coverage (x is outside the published coverage, with extrapolate = "linear").

See Also

`growth_table()` and `growth_equations()` for the published parameters; `growth_lms_z()` and `growth_st3_z()` to use parameters directly.

Examples

```
growth_params(c(9.5, 10, 10.5), "f", "cdc_2000_infant", "weight")

# Fenton 2003: published from 22 0/7 weeks, the first row at 22.5 weeks
growth_params(22.2, NA, "fenton_2003", "weight")
```

growth_plot

*Plot growth charts with ggplot2***Description**

Draws percentile (or Z-score) curves of one or more charts, optionally with measurements from a data frame, and returns a ggplot object (add `+ ggplot2::theme(...)`, `+ ggplot2::labs(...)` and so on). Needs the ggplot2 package.

Usage

```
growth_plot(
  chart,
  measure,
  sex = NULL,
  data = NULL,
  x_col = NULL,
  y_col = NULL,
  id_col = NULL,
  sex_col = NULL,
  p = c(0.03, 0.1, 0.5, 0.9, 0.97),
  z = NULL,
  labels = NULL,
  xlim = NULL,
  n = 300,
  extrapolate = "coverage",
  sd23 = NULL,
  cdc_bmi_ext = NULL
)
```

Arguments

chart	Chart ids.
measure	Measures; NULL (default) for every measure of the charts. Every chart must have every measure given.

sex	"m", "f", "male" or "female"; NULL (default) for both. A table used for both sexes is always included (with sex NA).
data	A data frame of measurements to plot, or NULL.
x_col, y_col	The names of the columns of data with x and the measurement (see Details).
id_col	The name of a column of data identifying each person (their points are joined), or NULL.
sex_col	The name of a column of data with each point's sex ("m", "f", "male", "female"), or NULL: needed when both sexes are drawn.
p	Probabilities of the curves (the percentile / 100). Default: the 3rd, 10th, 50th, 90th and 97th percentiles.
z	Z-scores of the curves, instead of p.
labels	The labels at the right end of the curves: as in growth_curves() (NULL for "P3", ...; a label for each value of p or z; or a function of them), or FALSE for none.
xlim	The range of x to draw, or NULL for each chart's coverage.
n	The number of intervals of the default grid.
extrapolate	Which x are calculated: "coverage" (default) the chart's published coverage (x_min to x_max in growth_charts() , which may reach half a row step beyond the end rows of tables whose rows are band midpoints); "none" only between the table's first and last rows (for INTERGROWTH-21st charts, the coverage); "linear" any x, the parameters beyond the coverage on the line through the two end rows (for the INTERGROWTH-21st equations, the equations themselves). Outside: NA, with one warning per call.
sd23, cdc_bmi_ext	As in growth_z() ; c(FALSE, TRUE) draws both, to compare.

Details

- **Several measures** are drawn one above the other, each with its own y axis; **both sexes** side by side.
- **Comparing charts or methods:** several charts, or sd23 or cdc_bmi_ext given as c(FALSE, TRUE), are drawn in colours, one per chart and method. The charts compared must have the same x units.
- Curves beyond the published coverage (with extrapolate = "linear") are dashed.
- **Measurements:** data with the x and y columns named by x_col and y_col (for several measures, y_col names a column per measure: c(weight = "wt", length = "len")), in the charts' units. id_col joins each person's points by a line; sex_col puts each point on its sex's chart when both sexes are drawn.

Value

A ggplot object.

See Also

[growth_curves\(\)](#) for the curves as data.

Examples

```
growth_plot("who_2006_infant", "weight", "f")

# A child's measurements, on weight and length
d <- data.frame(
  age = c(1, 3, 6, 9, 12), wt = c(4.1, 5.6, 7.0, 7.9, 8.6),
  len = c(54, 60, 65.5, 70, 74)
)
growth_plot("who_2006_infant", c("weight", "length"), "f",
  data = d, x_col = "age",
  y_col = c(weight = "wt", length = "len")
)

# CDC and WHO compared, Z-score lines
growth_plot(c("cdc_2000_infant", "who_2006_infant"), "weight", "m",
  z = c(-2, 0, 2), xlim = c(0, 24)
)

# Labels of your own, or none
growth_plot("who_2006_infant", "length", "m",
  p = c(0.03, 0.5, 0.97), labels = function(p) paste0(100 * p, "th")
)
growth_plot("who_2006_infant", "length", "m", labels = FALSE)

# WHO's restricted method beyond +-3 SD, on and off
growth_plot("who_2006_infant", "weight", "m", z = c(-4, -3, 3, 4), sd23 = c(FALSE, TRUE))
```

growth_references

The publications behind each chart

Description

Each chart and measure's references, as on the PediTools Sources and methods page: the chart's publication, a separate source of its parameters, the source of its Z-score method, and more information.

Usage

```
growth_references(chart = NULL, measure = NULL)
```

Arguments

chart	Chart ids; NULL (default) for all.
measure	Measures; NULL (default) for every measure of the charts.

Value

A data frame, one row per chart, measure and reference, with columns:

chart, measure The chart and measure.

role "clinical" (the chart's publication), "lms_data" (a separate source of the parameters), "method" (the source prescribing its Z-score method) or "resource" (more information, the charts).

position The order within the role.

id, short, citation The reference's id, a short form and the full citation.

doi, pmid Its DOI and PubMed id (NA when it has none).

url Its PubMed page, or its web address.

sources_url The chart's section of the PediTools Sources and methods page, where its sources and methods are described in full.

See Also

[growth_charts\(\)](#); [citation\("peditools2"\)](#) to cite the package.

Examples

```
growth_references("who_2006_infant", "weight")[c("role", "short", "url")]
```

growth_remove_chart	<i>Remove added charts</i>
---------------------	----------------------------

Description

Removes charts added with [growth_add_chart\(\)](#) in this session; a built-in chart they replaced is available again.

Usage

```
growth_remove_chart(chart)
```

Arguments

chart Chart ids added in the session.

Value

The ids removed, invisibly.

Examples

```
my <- growth_table("cdc_2000_infant", "weight", "f")[1:12, ]
my$chart <- "my_infant_chart"
growth_add_chart(my, data.frame(chart = "my_infant_chart", x_units = "months"))
growth_remove_chart("my_infant_chart")
```

growth_st3_z

*The ST3 distribution on your own parameters***Description**

Z-scores of measurements, and measurements at Z-scores, by the skew t distribution "ST3" of the R package gamlss.dist (the INTERGROWTH-21st newborn size standards from 33+0 weeks), from mu, sigma, nu and tau given directly (e.g. from [growth_params\(\)](#)).

Usage

```
growth_st3_z(y, mu, sigma, nu, tau)
```

```
growth_st3_y(z, mu, sigma, nu, tau)
```

Arguments

y	Measurements.
mu, sigma, nu, tau	The ST3 parameters (sigma, nu and tau positive).
z	Z-scores.

Details

ST3 is a Student t with tau degrees of freedom, scaled by sigma/nu below mu and by sigma nu above it: with T the t distribution function, $F(y) = 2T(\nu(y - \mu)/\sigma)/(1 + \nu^2)$ for $y < \mu$ and $1 - F(y) = 2\nu^2(1 - T((y - \mu)/(\sigma\nu)))/(1 + \nu^2)$ for $y \geq \mu$; $Z = \Phi^{-1}(F(y))$ (from the smaller tail, so that Z stays accurate far into the tails). mu is not the median unless nu = 1.

Arguments are recycled: each has length 1 or the common length.

Value

A numeric vector; NA where an input is missing or not valid.

References

Rigby RA, Stasinopoulos DM, Heller GZ, De Bastiani F. Distributions for Modeling Location, Scale, and Shape: Using GAMLSS in R. Chapman and Hall/CRC; 2019.

See Also

[growth_z\(\)](#) and [growth_y\(\)](#) to use a chart's parameters at any x; [growth_lms_z\(\)](#) for LMS.

Examples

```
# INTERGROWTH-21st newborn weight, boys, 231 days (33+0 weeks)
growth_st3_z(c(1.5, 2, 2.5), mu = 1.905973, sigma = 0.4027349, nu = 1.095261, tau = 17.05299)
growth_st3_y(c(-2, 0, 2), mu = 1.905973, sigma = 0.4027349, nu = 1.095261, tau = 17.05299)
```

growth_table	<i>A chart's parameter table</i>
--------------	----------------------------------

Description

The rows of the LMS tables (L, M, S) and of the INTERGROWTH-21st ST3 tables (mu, sigma, nu, tau), exactly as published, for any number of charts, measures and sexes (crossed). x and the measurement are in the units given by [growth_charts\(\)](#). Charts given by equations instead (the INTERGROWTH-21st "normal" parts) are in [growth_equations\(\)](#).

Usage

```
growth_table(chart, measure = NULL, sex = NULL)
```

Arguments

chart	Chart ids.
measure	Measures; NULL (default) for every measure of the charts. Every chart must have every measure given.
sex	"m", "f", "male" or "female"; NULL (default) for both. A table used for both sexes is always included (with sex NA).

Value

A data frame with columns chart, measure, sex (NA: both sexes), x, and the parameters: L, M, S for LMS tables, mu, sigma, nu, tau for ST3 tables (only the columns used by the rows returned).

See Also

[growth_charts\(\)](#) for the units and coverage.

Examples

```
head(growth_table("cdc_2000_infant", "weight", "f"))

# The ST3 rows of the INTERGROWTH-21st newborn size standards (from 231 days)
head(growth_table("intergrowth_nbs", "weight", "m"))
```

growth_y

*Measurements at Z-scores or probabilities***Description**

The measurement at each Z-score or probability on a chart: the inverse of [growth_z\(\)](#) and [growth_p\(\)](#), by the same methods (the restricted LMS method beyond ± 3 SD where it applies; on `cdc_2000_bmi`, from the 95th percentile, $BMI = P95 + \sigma \Phi^{-1}((p - 0.90)/0.10)$). Vectorised over every argument.

Usage

```
growth_y(
  z,
  x,
  sex,
  chart,
  measure,
  p = NULL,
  extrapolate = "coverage",
  sd23 = NULL,
  cdc_bmi_ext = NULL
)
```

Arguments

<code>z</code>	Z-scores. Give z or p, not both.
<code>x</code>	Ages, or lengths or heights for weight-for-length and weight-for-height, in the chart's x units (<code>x_units</code> in growth_charts() ; to convert: growth_convert() , growth_age_days() , growth_pma() , growth_corrected_age()).
<code>sex</code>	"m", "f", "male" or "female", in any case; other values are NA (with a warning). Ignored for charts with one table for both sexes.
<code>chart, measure</code>	Chart and measure ids, as in growth_charts() .
<code>p</code>	Probabilities (the percentile / 100), strictly between 0 and 1.
<code>extrapolate</code>	Which x are calculated: "coverage" (default) the chart's published coverage (<code>x_min</code> to <code>x_max</code> in growth_charts() , which may reach half a row step beyond the end rows of tables whose rows are band midpoints); "none" only between the table's first and last rows (for INTERGROWTH-21st charts, the coverage); "linear" any x, the parameters beyond the coverage on the line through the two end rows (for the INTERGROWTH-21st equations, the equations themselves). Outside: NA, with one warning per call.
<code>sd23</code>	NULL (default): WHO's restricted LMS method where the chart's authors prescribe it; TRUE: on every chart (beyond ± 3 SD, the line whose spread is the distance between the 2 and 3 SD values of the chart's own distribution); FALSE: off.
<code>cdc_bmi_ext</code>	NULL (default) or TRUE: the CDC extended BMI method on <code>cdc_2000_bmi</code> (an error on any other chart with TRUE); FALSE: plain LMS.

Value

A numeric vector of measurements in the chart's measure units; NA where an input is missing or not valid, x is outside the range allowed, or the method gives no value (e.g. the LMS curve has none at a very low Z when $L > 0$).

See Also

[growth_z\(\)](#).

Examples

```
# The 3rd, 50th and 97th percentile weights of a girl of 9.5 months
growth_y(p = c(0.03, 0.5, 0.97), x = 9.5, sex = "f", chart = "cdc_2000_infant", measure = "weight")

# Expected growth: the weight at 12 months at the same Z-score as 8.2 kg at 9.5 months
z <- growth_z(8.2, 9.5, "f", "cdc_2000_infant", "weight")
growth_y(z, 12, "f", "cdc_2000_infant", "weight")
```

growth_z

Z-scores and probabilities of measurements

Description

The Z-score (`growth_z()`) or the probability (`growth_p()`, the percentile / 100) of each measurement on a chart, by the chart's published method unless switched. Vectorised over every argument.

Usage

```
growth_z(
  y,
  x,
  sex,
  chart,
  measure,
  extrapolate = "coverage",
  sd23 = NULL,
  cdc_bmi_ext = NULL
)

growth_p(
  y,
  x,
  sex,
  chart,
  measure,
  extrapolate = "coverage",
  sd23 = NULL,
  cdc_bmi_ext = NULL
)
```

Arguments

y	Measurements, in the chart's measure units (measure_units in growth_charts()); positive on LMS charts and the INTERGROWTH-21st equations on the log scale.
x	Ages, or lengths or heights for weight-for-length and weight-for-height, in the chart's x units (x_units in growth_charts() ; to convert: growth_convert() , growth_age_days() , growth_pma() , growth_corrected_age()).
sex	"m", "f", "male" or "female", in any case; other values are NA (with a warning). Ignored for charts with one table for both sexes.
chart, measure	Chart and measure ids, as in growth_charts() .
extrapolate	Which x are calculated: "coverage" (default) the chart's published coverage (x_min to x_max in growth_charts() , which may reach half a row step beyond the end rows of tables whose rows are band midpoints); "none" only between the table's first and last rows (for INTERGROWTH-21st charts, the coverage); "linear" any x, the parameters beyond the coverage on the line through the two end rows (for the INTERGROWTH-21st equations, the equations themselves). Outside: NA, with one warning per call.
sd23	NULL (default): WHO's restricted LMS method where the chart's authors prescribe it; TRUE: on every chart (beyond ± 3 SD, the line whose spread is the distance between the 2 and 3 SD values of the chart's own distribution); FALSE: off.
cdc_bmi_ext	NULL (default) or TRUE: the CDC extended BMI method on cdc_2000_bmi (an error on any other chart with TRUE); FALSE: plain LMS.

Details

The parameters at x are interpolated linearly between the rows of the chart's table (never across its step, x_break in [growth_charts\(\)](#)). Methods:

- **LMS** (Cole and Green): every LMS chart.
- **WHO's restricted LMS method beyond ± 3 SD** ("SD23"): the charts whose authors prescribe it (z_method "sd23" in [growth_charts\(\)](#)); sd23 = TRUE applies it to any LMS chart, FALSE turns it off.
- **CDC's extended BMI method** at or above the 95th percentile of cdc_2000_bmi (CDC's recommendation, on by default): the probability is $0.90 + 0.10\Phi((BMI - P95)/\sigma)$, with $\sigma = 0.3728 + 0.5196a - 0.0091a^2$ (boys) or $0.8334 + 0.3712a - 0.0011a^2$ (girls), a the age in years, and $Z = \Phi^{-1}(p)$. cdc_bmi_ext = FALSE gives the plain LMS values.
- **INTERGROWTH-21st** (z_method "cdf"): $Z = \Phi^{-1}(F(y))$ from the distribution of the part used at x: the ST3 skew t ([growth_st3_z\(\)](#)) or a normal distribution whose mean and SD are equations in x (of log(y) when y_scale is "log"). Newborn size uses the very preterm equations before 231 days and the ST3 table from 231 days; the parts are never mixed. sd23 = TRUE applies WHO's restricted method to these too.

Value

A numeric vector, as long as the longest argument (each has length 1 or that length). NA where an input is missing or not valid, or x is outside the range allowed by extrapolate (see [growth_detail\(\)](#) for why).

See Also

[growth_y\(\)](#) for the measurement at a Z-score or probability; [growth_detail\(\)](#) for the parameters, the method used and the status of each value.

Examples

```
# Weight 8.2 kg of a girl of 9.5 months, CDC 2000 infant chart
growth_z(8.2, 9.5, "f", "cdc_2000_infant", "weight")
growth_p(8.2, 9.5, "f", "cdc_2000_infant", "weight")

# Vectorised: one call for a data frame
d <- data.frame(wt = c(7.1, 9.8, 12.4), age = c(6, 12, 24), sex = c("m", "f", "m"))
growth_z(d$wt, d$age, d$sex, "who_2006_infant", "weight")

# WHO's restricted method beyond +-3 SD, and plain LMS
growth_z(3.5, 6, "m", "who_2006_infant", "weight")
growth_z(3.5, 6, "m", "who_2006_infant", "weight", sd23 = FALSE)

# CDC extended BMI above the 95th percentile (age in months)
growth_z(30, 150, "m", "cdc_2000_bmi", "bmi")
growth_z(30, 150, "m", "cdc_2000_bmi", "bmi", cdc_bmi_ext = FALSE)
```

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