

Package ‘SPINA’

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Type Package

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Title Structure Parameter Inference Approach

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Description

SPINA (Structure Parameter Inference Approach) is a methodology to calculate constant structure parameters of endocrine homeostatic systems from steady-state hormone and metabolite concentrations. Methods and equations for thyroid homeostasis (SPINA Thyr) have been described in Dietrich et al. (2012) <[doi:10.1155/2012/351864](https://doi.org/10.1155/2012/351864)> and Dietrich et al. (2016) <[doi:10.3389/fendo.2016.00057](https://doi.org/10.3389/fendo.2016.00057)>, and for glucose homeostasis (SPINA Carb) in Dietrich et al. (2022) <[doi:10.1038/s41598-022-22531-3](https://doi.org/10.1038/s41598-022-22531-3)> and Dietrich et al. (2024) <[doi:10.1111/1753-0407.13525](https://doi.org/10.1111/1753-0407.13525)>.

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Encoding UTF-8

RoxygenNote 8.0.0

URL <https://spina.sourceforge.net>

BugReports <https://sourceforge.net/p/spina/bugs/>

Depends R (>= 3.5)

LazyData true

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

Config/testthat/edition 3

VignetteBuilder knitr

NeedsCompilation no

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Contents

estimated.GD	2
estimated.GDTT	3
estimated.GT	4
estimated.GTT	6
estimated.sGD	7
estimated.sTSHI	8
estimated.TSHI	9
estimated.TTSI	10
HOMA.Beta	11
HOMA.IR	12
HOMA.IS	13
Pilo	14
QUICKI	15
SPINA.DI	16
SPINA.GBeta	17
SPINA.GD	18
SPINA.GDTT	19
SPINA.GR	20
SPINA.GT	21
SPINA.GTT	22
SPINA.sGD	24
Vellore	25
Index	26

estimated.GD	<i>Calculated step-up deiodinase activity (SPINA-GD)</i>
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Description

This function calculates the sum activity of peripheral step-up-deiodinases (SPINA-GD) from steady-state concentrations of free T4 and free T3. SPINA-GD is an inferred representation of GD, the total activity of the type 1 deiodinase under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

```
estimated.GD(FT4, FT3)
```

Arguments

- | | |
|-----|---------------------------------|
| FT4 | free T4 concentration in pmol/L |
| FT3 | free T3 concentration in pmol/L |

Details

This function is able to do vectorised calculations. See [SPINA.GD](#) for a an implementation with a more modern nomenclature.

Value

Returns SPINA-GD, a calculated biomarker for the sum activity of peripheral step-up deiodinases

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

```
estimated.GD(16.5, 4.5)
```

estimated.GDTT	<i>Calculated step-up deiodinase activity, based on total T4 and T3 (SPINA-GDTT)</i>
----------------	--

Description

This function calculates the sum activity of peripheral step-up-deiodinases (SPINA-GD) from steady-state concentrations of total T4 and total T3. SPINA-GD is an inferred representation of GD, the total activity of the type 1 deiodinase under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

```
estimated.GDTT(T4, T3)
```

Arguments

T4	total T4 concentration in nmol/L
T3	total T3 concentration in nmol/L

Details

This function is able to do vectorised calculations. See [SPINA.GDTT](#) for an implementation with a more modern nomenclature.

Value

Returns SPINA-GD, a calculated biomarker for the sum activity of peripheral step-up deiodinases

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

```
estimated.GDTT(90, 2.5)
```

estimated.GT

Calculated thyroid's secretory capacity (SPINA-GT)

Description

This function calculates the secretory capacity of the thyroid gland for T4 (SPINA-GT) from steady-state concentrations of TSH and free T4. SPINA-GT is an inferred representation of GT, the maximum amount of thyroxine that can be produced by the thyroid under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

```
estimated.GT(TSH, FT4)
```

Arguments

TSH	thyrotropin concentration in mIU/L
FT4	free T4 concentration in pmol/L

Details

This function is able to do vectorised calculations. See [SPINA.GT](#) for a an implementation with a more modern nomenclature.

Value

Returns SPINA-GT, a calculated biomarker for thyroid's secretory capacity (aka thyroid output)

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. *J Thyroid Res.* 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. *Front Endocrinol (Lausanne).* 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

```
estimated.GT(1.0, 16.5)
```

estimated.GTT	<i>Calculated thyroid's secretory capacity, based on total T4 (SPINA-GTT)</i>
---------------	---

Description

This function calculates the secretory capacity of the thyroid gland for T4 (SPINA-GT) from steady-state concentrations of TSH and total T4. SPINA-GT is an inferred representation of GT, the maximum amount of thyroxine that can be produced by the thyroid under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

```
estimated.GTT(TSH, T4)
```

Arguments

TSH	thyrotropin concentration in mIU/L
T4	total T4 concentration in nmol/L

Details

This function is able to do vectorised calculations. See [SPINA.GTT](#) for an implementation with a more modern nomenclature.

Value

Returns SPINA-GTT, a calculated biomarker for thyroid's secretory capacity (aka thyroid output)

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

```
estimated.GTT(1.0, 90)
```

```
estimated.sGD
```

Calculated standardised step-up deiodinase activity (SPINA-sGD)

Description

This function calculates the sum activity of peripheral step-up-deiodinases (SPINA-GD) from steady-state concentrations of free T4 and free T3. SPINA-GD is an inferred representation of GD, the total activity of the type 1 deiodinase under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA). The result is delivered in standardised form (z-transformed).

Usage

```
estimated.sGD(FT4, FT3, mean = 30, sd = 5)
```

Arguments

FT4	free T4 concentration in pmol/L
FT3	free T3 concentration in pmol/L
mean	mean SPINA-GD (optional, default value 30)
sd	standard deviation of SPINA-GD (optional, default value 5)

Details

This function is able to do vectorised calculations. See [SPINA.sGD](#) for an implementation with a more modern nomenclature.

Value

Returns standardised SPINA-GD, a calculated biomarker for the sum activity of peripheral step-up deiodinases (z-transformed variant)

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

```
estimated.sGD(16.5, 4.5)
```

estimated.sTSHI	<i>Standardised Jostel's TSH index (sTSHI, sJTI)</i>
-----------------	--

Description

This function calculates Jostel's TSH index (TSHI, JTI) from steady-state concentrations of TSH and free T4. The result is delivered in standardised form (z-transformed).

Usage

```
estimated.sTSHI(TSH, FT4, mean = 2.7, sd = 0.676)
```

Arguments

TSH	thyrotropin concentration in mIU/L
FT4	free T4 concentration in pmol/L
mean	mean TSH index (optional, standard value 2.7)
sd	standard deviation of TSH index (optional, standard value 0.676)

Details

This function is able to do vectorised calculations.

Value

Returns the the standardised TSH index, a calculated biomarker for the thyrotropic function of the anterior pituitary gland (z-transformed variant)

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Jostel A, Ryder WD, Shalet SM. The use of thyroid function tests in the diagnosis of hypopituitarism: definition and evaluation of the TSH Index. Clin Endocrinol (Oxf). 2009 Oct;71(4):529-34. doi: 10.1111/j.1365-2265.2009.03534.x. Epub 2009 Feb 18. PMID: 19226261.

Examples

```
estimated.sTSHI(1.0, 16.5)
```

estimated.TSHI	<i>Jostel's TSH index (TSHI, JTI)</i>
----------------	---------------------------------------

Description

This function calculates Jostel's TSH index (TSHI, JTI) from steady-state concentrations of TSH and free T4.

Usage

```
estimated.TSHI(TSH, FT4)
```

Arguments

TSH	thyrotropin concentration in mIU/L
FT4	free T4 concentration in pmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the TSH index, a calculated biomarker for the thyrotropic function of the anterior pituitary gland

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Jostel A, Ryder WD, Shalet SM. The use of thyroid function tests in the diagnosis of hypopituitarism: definition and evaluation of the TSH Index. Clin Endocrinol (Oxf). 2009 Oct;71(4):529-34. doi: 10.1111/j.1365-2265.2009.03534.x. Epub 2009 Feb 18. PMID: 19226261.

Examples

```
estimated.TSHI(1.0, 16.5)
```

estimated.TTSI	<i>Thyrotroph thyroid hormone sensitivity index (TTSI)</i>
----------------	--

Description

This function calculates the thyrotroph thyroid hormone sensitivity index (TTSI) from steady-state concentrations of TSH and free T4. This parameter is also referred to as Thyrotroph T4 Resistance Index or TT4RI.

Usage

```
estimated.TTSI(TSH, FT4, lu)
```

Arguments

TSH	thyrotropin concentration in mIU/L
FT4	free T4 concentration in pmol/L
lu	upper limit of the reference interval of FT4 in pmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the TTSI, a calculated biomarker for the sensitivity of pituitary thyrotrophic cells to thyroxine

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Pohlenz J, Weiss RE, Macchia PE, Pannain S, Lau IT, Ho H, Refetoff S. Five new families with resistance to thyroid hormone not caused by mutations in the thyroid hormone receptor beta gene. J Clin Endocrinol Metab. 1999 Nov;84(11):3919-28. doi: 10.1210/jcem.84.11.6080. PMID: 10566629.

Examples

```
estimated.TTSI(1.0, 16.5, 18)
```

HOMA.Beta

Homeostasis model assessment: beta-cell function (HOMA-Beta)

Description

This function calculates the beta-cell function (HOMA-Beta) from steady-state fasting concentrations of insulin and glucose. HOMA-Beta is one of the parameters provided by the homeostasis model assessment.

Usage

```
HOMA.Beta(Insulin, Glucose)
```

Arguments

Insulin	Insulin concentration in pmol/L
Glucose	Glucose concentration in mmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the HOMA-Beta index, a calculated biomarker for beta-cell function

Note

The software functions described in this document are intended for research use only. Hormone or metabolite concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou, Bernhard O. Boehm

Examples

```
HOMA.Beta(63.01, 4.34)
```

HOMA-IR

Homeostasis model assessment: insulin resistance (HOMA-IR)

Description

This function calculates the insulin resistance index (HOMA-IR) from steady-state fasting concentrations of insulin and glucose. HOMA-IR is one of the parameters provided by the homeostasis model assessment.

Usage

```
HOMA-IR(Insulin, Glucose)
```

Arguments

Insulin	Insulin concentration in pmol/L
Glucose	Glucose concentration in mmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the HOMA-IR index, a calculated biomarker for insulin resistance.

Note

The software functions described in this document are intended for research use only. Hormone or metabolite concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou, Bernhard O. Boehm

Examples

```
HOMA.IS(63.01, 4.34)
```

HOMA.IS

Homeostasis model assessment: insulin sensitivity (HOMA-IS)

Description

This function calculates the insulin sensitivity index (HOMA-IS) from steady-state fasting concentrations of insulin and glucose. HOMA-IS is one of the parameters provided by the homeostasis model assessment.

Usage

```
HOMA.IS(Insulin, Glucose)
```

Arguments

Insulin	Insulin concentration in pmol/L
Glucose	Glucose concentration in mmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the HOMA-IS index, a calculated biomarker for insulin sensitivity

Note

The software functions described in this document are intended for research use only. Hormone or metabolite concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou, Bernhard O. Boehm

Examples

HOMA.IS(63.01, 4.34)

Pilo

Data for SPINA

Description

Pilo: Data from Pilo et al. (1990)

Format**"Pilo":**

A data frame with 14 rows and 33 columns

Sex Sex (f: female; m: male)

Age Age in years

Body.Mass Body mass in kg

BSA Body surface area in m²

IDV.T4 initial distribution volume of thyroxine in mL

TT4 Total T4 concentration in µg/dL

TT4.SI Total T4 concentration in nmol/L

TT3 Total T3 concentration in ng/mL

TT3.SI Total T3 concentration in nmol/L

TSH Thyrotropin concentration in mIU/L

SR.T4 Thyroidal secretion rate for T4 in µg/day/m²

SR.T3 Thyroidal secretion rate for T3 in µg/day/m²

CR.F.mean Rate of conversion from T4 to T3 in fast tissue pools in µg/day/m²

CR.S.mean Rate of conversion from T4 to T3 in slow tissue pools in µg/day/m²

CR.T.mean Rate of total conversion from T4 to T3 in µg/day/m²

PAR.T3 Plasma appearance rate for T3 in µg/day/m²

PR.T3.mean Mean production rate for T3 in µg/day/m²

PR.T3 Production rate for T3 in µg/day/m², calculated with alternative method (DiStefano et al. 1982)

CR.S Rate of conversion from T4 to T3 in µg/day/m², calculated with alternative method (DiStefano et al. 1982)

CR.6 Ratio of conversion from T4 to T3 in in %, computed using six-compartment model

CR.2 Ratio of conversion from T4 to T3 in in %, computed using two-compartment model

CR.0 Ratio of conversion from T4 to T3 in in %, computed using noncompartmental approach

QP Mass of the plasma pool for T3 in in µg/m²

QF Mass of the fast tissue pool for T3 in in µg/m²

QS Mass of the slow tissue pool for T3 in in µg/m²

QT Mass of the total tissue pool for T3 in in µg/m²

SPINA_GT Thyroid's secretory capacity (SPINA-GT) in pmol/s

SPINA_GD Sum activity of step-up deiodinases (SPINA-GD) in nmol/s

Source

Pilo A, Iervasi G, Vitek F, Ferdeghini M, Cazzuola F, Bianchi R. Thyroidal and peripheral production of 3,5,3'-triiodothyronine in humans by multicompartmental analysis. *Am J Physiol.* 1990 Apr;258(4 Pt 1):E715-26. PMID 2333963.

DiStefano JJ 3rd, Jang M, Malone TK, Broutman M. Comprehensive kinetics of triiodothyronine production, distribution, and metabolism in blood and tissue pools of the rat using optimized blood-sampling protocols. *Endocrinology.* 1982 Jan;110(1):198-213. doi: 10.1210/endo-110-1-198. PMID: 7053984.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. *Front Endocrinol (Lausanne).* 2016 Jun 9;7:57. doi 10.3389/fendo.2016.00057. PMID 27375554; PMCID PMC4899439.

QUICKI

Quantitative insulin-sensitivity check index (QUICKI)

Description

This function calculates the quantitative insulin sensitivity check index (QUICKI) from steady-state fasting concentrations of insulin and glucose.

Usage

QUICKI(Insulin, Glucose)

Arguments

Insulin	Insulin concentration in pmol/L
Glucose	Glucose concentration in mmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the QUICKI index, a calculated biomarker for insulin sensitivity

Note

The software functions described in this document are intended for research use only. Hormone or metabolite concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou, Bernhard O. Boehm

Examples

```
QUICKI(63.01, 4.34)
```

SPINA.DI

Static disposition index (SPINA-DI)

Description

This function calculates the static disposition index (SPINA-DI) from steady-state fasting concentrations of insulin and glucose. SPINA-DI is an inferred representation of the loop gain of the homeostatic feedback control system. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

```
SPINA.DI(Insulin, Glucose)
```

Arguments

Insulin	Insulin concentration in pmol/L
Glucose	Glucose concentration in mmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the static disposition index (SPINA-DI), a representation of the loop gain of glucose homeostasis as a numeric result representing a single value or a vector, depending on the vector length of the arguments.

Note

The software functions described in this document are intended for research use only. Hormone or metabolite concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou, Bernhard O. Boehm

References

Dietrich JW, Dasgupta R, Anoop S, Jebasingh F, Kurian ME, Inbakumari M, Boehm BO, Thomas N. SPINA Carb: a simple mathematical model supporting fast in-vivo estimation of insulin sensitivity and beta cell function. Sci Rep. 2022 Oct 21;12(1):17659. doi: 10.1038/s41598-022-22531-3. PMID: 36271244; PMCID: PMC9587026.

Dietrich JW, Abood A, Dasgupta R, Anoop S, Jebasingh FK, Spurgeon R, Thomas N, Boehm BO. A novel simple disposition index (SPINA-DI) from fasting insulin and glucose concentration as a robust measure of carbohydrate homeostasis. J Diabetes. 2024 Sep;16(9):e13525. doi: 10.1111/1753-0407.13525. Epub 2024 Jan 2. PMID: 38169110; PMCID: PMC11418405.

Examples

```
SPINA.DI(63.01, 4.34)
```

SPINA.GBeta	<i>Calculated secretory capacity of pancreatic beta cells (SPINA-GBeta)</i>
-------------	---

Description

This function calculates the secretory capacity of pancreatic beta cells (SPINA-GBeta) from steady-state fasting concentrations of insulin and glucose. SPINA-GBeta is an inferred representation of GBeta, the maximum amount of insulin that can be produced by beta-cells under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

```
SPINA.GBeta(Insulin, Glucose)
```

Arguments

Insulin	Insulin concentration in pmol/L
Glucose	Glucose concentration in mmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the secretory capacity of pancreatic beta cells (SPINA-GBeta) as a numeric result representing a single value or a vector, depending on the vector length of the arguments. Results are in pmol/s.

Note

The software functions described in this document are intended for research use only. Hormone or metabolite concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou, Bernhard O. Boehm

References

Dietrich JW, Dasgupta R, Anoop S, Jebasingh F, Kurian ME, Inbakumari M, Boehm BO, Thomas N. SPINA Carb: a simple mathematical model supporting fast in-vivo estimation of insulin sensitivity and beta cell function. *Sci Rep.* 2022 Oct 21;12(1):17659. doi: 10.1038/s41598-022-22531-3. PMID: 36271244; PMCID: PMC9587026.

Dietrich JW, Abood A, Dasgupta R, Anoop S, Jebasingh FK, Spurgeon R, Thomas N, Boehm BO. A novel simple disposition index (SPINA-DI) from fasting insulin and glucose concentration as a robust measure of carbohydrate homeostasis. *J Diabetes.* 2024 Sep;16(9):e13525. doi: 10.1111/1753-0407.13525. Epub 2024 Jan 2. PMID: 38169110; PMCID: PMC11418405.

Examples

SPINA.GBeta(63.01, 4.34)

SPINA.GD	<i>Calculated step-up deiodinase activity (SPINA-GD)</i>
----------	--

Description

This function calculates the sum activity of peripheral step-up-deiodinases (SPINA-GD) from steady-state concentrations of free T4 and free T3. SPINA-GD is an inferred representation of GD, the total activity of the type 1 deiodinase under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

SPINA.GD(FT4, FT3)

Arguments

- | | |
|-----|---------------------------------|
| FT4 | free T4 concentration in pmol/L |
| FT3 | free T3 concentration in pmol/L |

Details

This function is able to do vectorised calculations.

Value

Returns SPINA-GD, a calculated biomarker for the sum activity of peripheral step-up deiodinases

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

SPINA.GD(16.5, 4.5)

SPINA.GDTT	<i>Calculated step-up deiodinase activity, based on total T4 and T3 (SPINA-GDTT)</i>
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Description

This function calculates the sum activity of peripheral step-up-deiodinases (SPINA-GD) from steady-state concentrations of total T4 and total T3. SPINA-GD is an inferred representation of GD, the total activity of the type 1 deiodinase under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

SPINA.GDTT(T4, T3)

Arguments

- | | |
|----|----------------------------------|
| T4 | total T4 concentration in nmol/L |
| T3 | tptaö T3 concentration in nmol/L |

Details

This function is able to do vectorised calculations.

Value

Returns SPINA-GD, a calculated biomarker for the sum activity of peripheral step-up deiodinases

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

```
SPINA.GD(TT(90, 2.5))
```

SPINA.GR

Calculated insulin receptor gain (SPINA-GR)

Description

This function calculates the insulin receptor gain (SPINA-GR) from steady-state fasting concentrations of insulin and glucose. SPINA-GR is an inferred representation of GR, the maximum insulin signaling under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

```
SPINA.GR(Insulin, Glucose)
```

Arguments

Insulin	Insulin concentration in pmol/L
Glucose	Glucose concentration in mmol/L

Details

This function is able to do vectorised calculations.

Value

Returns the insulin receptor gain (SPINA-GR), a calculated biomarker of insulin sensitivity as a numeric result representing a single value or a vector, depending on the vector length of the arguments. Results are in mol/s.

Note

The software functions described in this document are intended for research use only. Hormone or metabolite concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou, Bernhard O. Boehm

References

Dietrich JW, Dasgupta R, Anoop S, Jebasingh F, Kurian ME, Inbakumari M, Boehm BO, Thomas N. SPINA Carb: a simple mathematical model supporting fast in-vivo estimation of insulin sensitivity and beta cell function. *Sci Rep.* 2022 Oct 21;12(1):17659. doi: 10.1038/s41598-022-22531-3. PMID: 36271244; PMCID: PMC9587026.

Dietrich JW, Abood A, Dasgupta R, Anoop S, Jebasingh FK, Spurgeon R, Thomas N, Boehm BO. A novel simple disposition index (SPINA-DI) from fasting insulin and glucose concentration as a robust measure of carbohydrate homeostasis. *J Diabetes.* 2024 Sep;16(9):e13525. doi: 10.1111/1753-0407.13525. Epub 2024 Jan 2. PMID: 38169110; PMCID: PMC11418405.

Examples

SPINA.GR(63.01, 4.34)

SPINA.GT	<i>Calculated thyroid's secretory capacity (SPINA-GT)</i>
----------	---

Description

This function calculates the secretory capacity of the thyroid gland for T4 (SPINA-GT) from steady-state concentrations of TSH and free T4. SPINA-GT is an inferred representation of GT, the maximum amount of thyroxine that can be produced by the thyroid under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

SPINA.GT(TSH, FT4)

Arguments

TSH	thyrotropin concentration in mIU/L
FT4	free T4 concentration in pmol/L

Details

This function is able to do vectorised calculations.

Value

Returns SPINA-GT, a calculated biomarker for thyroid's secretory capacity (aka thyroid output)

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

```
SPINA.GT(1.0, 16.5)
```

SPINA.GTT	<i>Calculated thyroid's secretory capacity, based on total T4 (SPINA-GTT)</i>
-----------	---

Description

This function calculates the secretory capacity of the thyroid gland for T4 (SPINA-GT) from steady-state concentrations of TSH and total T4. SPINA-GTT is an inferred representation of GT, the maximum amount of thyroxine that can be produced by the thyroid under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA).

Usage

SPINA.GTT(TSH, T4)

Arguments

TSH	thyrotropin concentration in mIU/L
T4	total T4 concentration in nmol/L

Details

This function is able to do vectorised calculations.

Value

Returns SPINA-GTT, a calculated biomarker for thyroid's secretory capacity (aka thyroid output)

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaridis A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

SPINA.GTT(1.0, 90)

 SPINA.sGD

Calculated standardised step-up deiodinase activity (SPINA-sGD)

Description

This function calculates the sum activity of peripheral step-up-deiodinases (SPINA-GD) from steady-state concentrations of free T4 and free T3. SPINA-GD is an inferred representation of GD, the total activity of the type 1 deiodinase under stimulated conditions. This parameter is an implementation of the structure parameter inference approach (SPINA). The result is delivered in standardised form (z-transformed).

Usage

```
SPINA.sGD(FT4, FT3, mean = 30, sd = 5)
```

Arguments

FT4	free T4 concentration in pmol/L
FT3	free T3 concentration in pmol/L
mean	mean SPINA-GD (optional, default value 30)
sd	standard deviation of SPINA-GD (optional, default value 5)

Details

This function is able to do vectorised calculations.

Value

Returns standardised SPINA-GD, a calculated biomarker for the sum activity of peripheral step-up deiodinases (z-transformed variant)

Note

The software functions described in this document are intended for research use only. Hormone concentrations should have been obtained simultaneously in order to avoid bias by transition effects.

Author(s)

Johannes W. Dietrich, Eleni Karamitrou

References

Dietrich JW, Landgrafe G, Fotiadou EH. TSH and Thyrotropic Agonists: Key Actors in Thyroid Homeostasis. J Thyroid Res. 2012;2012:351864. doi: 10.1155/2012/351864. Epub 2012 Dec 30. PMID: 23365787; PMCID: PMC3544290.

Dietrich JW, Landgrafe-Mende G, Wiora E, Chatzitomaris A, Klein HH, Midgley JE, Hoermann R. Calculated Parameters of Thyroid Homeostasis: Emerging Tools for Differential Diagnosis and

Clinical Research. Front Endocrinol (Lausanne). 2016 Jun 9;7:57. doi: 10.3389/fendo.2016.00057. PMID: 27375554; PMCID: PMC4899439.

Examples

SPINA.sGD(16.5, 4.5)

Vellore	<i>Data for SPINA</i>
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Description

Vellore: Data from Dietrich et al. (2022 and 2024)

Format

- "Vellore":**
A data frame with 117 rows and 14 columns
- Age** Age in years
- Height** Body height in cm
- Body.Mass** Body mass in kg
- BMI** Body mass index in kg/m^2
- Fasting.Glucose** Fasting glucose concentration in mg/dL
- Fasting.Insulin** Fasting insulin concentration in mIU/L
- SPINA_GR** Insulin receptor gain (SPINA-GR) in mol/s
- SPINA_GBeta** Secretory capacity of pancreatic beta-cells (SPINA-GBeta) in pmol/s
- SPINA_DI** Static disposition index (SPINA-DI)
- HOMA_Beta** Estimate of beta-cell function based on the Homeostasis Model Assessment (HOMA-Beta)
- HOMA_IR** Estimate of insulin resistance based on the Homeostasis Model Assessment (HOMA-IR)
- HOMA_IS** Estimate of insulin sensitivity based on the Homeostasis Model Assessment (HOMA-IS)
- QUICKI_Score** Quantitative Insulin Sensitivity Check Index (QUICKI)

Source

Dietrich JW, Dasgupta R, Anoop S, Jebasingh F, Kurian ME, Inbakumari M, Boehm BO, Thomas N. SPINA Carb: a simple mathematical model supporting fast in-vivo estimation of insulin sensitivity and beta cell function. Sci Rep. 2022 Oct 21;12(1):17659. doi 10.1038/s41598-022-22531-3. PMID 36271244; PMCID PMC9587026.

Dietrich JW, Abood A, Dasgupta R, Anoop S, Jebasingh FK, Spurgeon R, Thomas N, Boehm BO. A novel simple disposition index (SPINA-DI) from fasting insulin and glucose concentration as a robust measure of carbohydrate homeostasis. J Diabetes. 2024 Jan 2. doi: 10.1111/1753-0407.13525. PMID: 38169110.

Index

estimated.GD, [2](#)
estimated.GDTT, [3](#)
estimated.GT, [4](#)
estimated.GTT, [6](#)
estimated.sGD, [7](#)
estimated.sTSHI, [8](#)
estimated.TSHI, [9](#)
estimated.TTSI, [10](#)

HOMA.Beta, [11](#)
HOMA.IR, [12](#)
HOMA.IS, [13](#)

Pilo, [14](#)

QUICKI, [15](#)

SPINA.DI, [16](#)
SPINA.GBeta, [17](#)
SPINA.GD, [3](#), [18](#)
SPINA.GDTT, [4](#), [19](#)
SPINA.GR, [20](#)
SPINA.GT, [5](#), [21](#)
SPINA.GTT, [6](#), [22](#)
SPINA.sGD, [7](#), [24](#)

Vellore, [25](#)