Computational Physics 2022

Sommersemester, 3^{h} April, 2023 – 14^{th} Juli, 2023

1) Introduction
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Differentiation and integration

SHORT REPORT

A Mathematical Model for the Determination of Total Area Under Glucose Tolerance and Other Metabolic Curves

MARY M. TAI, MS, EDD

OBJECTIVE — To develop a mathematical model for the determination of total areas under curves from various metabolic studies.

RESEARCH DESIGN AND METHODS — In Tai's Model, the total area under a curve is computed by dividing the area under the curve between two designated values on the *X*-axis (abscissas) into small segments (rectangles and triangles) whose areas can be accurately calculated from their respective geom… total sum of these individual areas thus represents the total a… Validity of the model is established by comparing total area… model to these same areas obtained from graphic method (less… formulas widely applied by researchers under- or overestimat… metabolic curve by a great margin.

RESULTS — Tai's model proves to be able to *1*) determine to… with precision; *2*) calculate area with varied shapes that may or… one or both *X/Y* axes; *3*) estimate total area under a curve plott… intervals (abscissas), whereas other formulas only allow the sa… *4*) compare total areas of metabolic curves produced by differ…

CONCLUSIONS — The Tai model allows flexibility in experime… means, in the case of the glucose-response curve, samples can be ta… intervals and total area under the curve can still be determined wi…

However, except for Wolever et al.'s formula, other formulas tend to under- or overestimate the total area under a metabolic curve by a large margin.

RESEARCH DESIGN AND METHODS

Tai's mathematical model

Tai's model was developed to correct the deficiency of under- or overestimation of the total area under a metabolic curve. This formula also allows calculating the area under a curve with unequal units on the *X*-axis. The strategy of this mathematical model is to divide the total area under a curve into individual small segments such as squares, rectangles, and triangles, whose areas can be precisely deter-

A mathematical model for the determination of total area under glucose tolerance and other metabolic curves

MM Tai - Diabetes care, 1994 - Am Diabetes Assoc

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Differentiation and integration

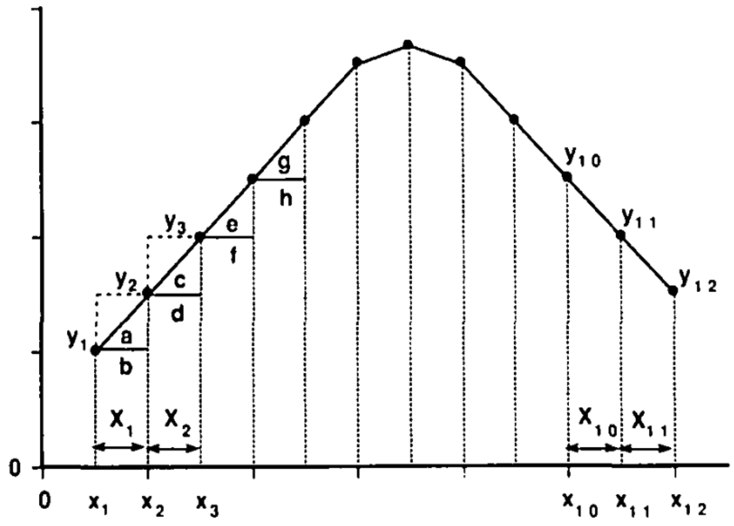
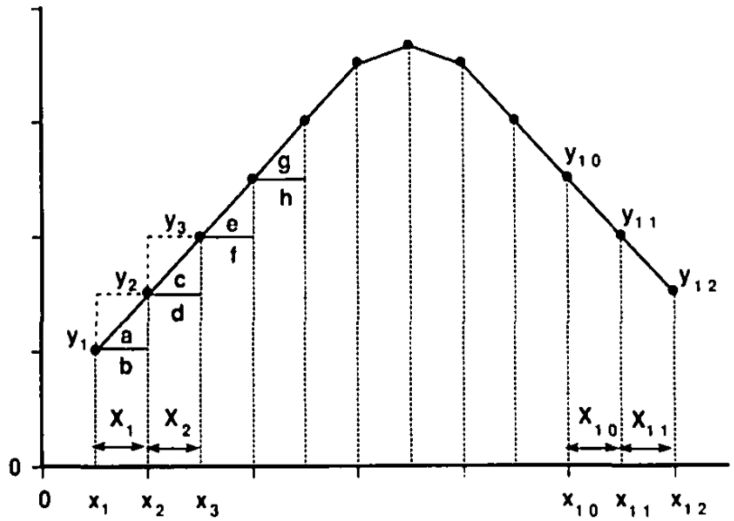


Figure 1—*Total area under the curve is the sum of individual areas of triangles a, c, e, and g and rectangles b, d, f, and h.*

$$\text{Area} = \frac{1}{2}\sum_{i=1}^{n} x_{i-1}\,(y_{i-1} + y_i)$$

(Tai's formula)

Differentiation and integration



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Tai's Formula Is the Trapezoidal Rule

We were disturbed to read the article by M. M. Tai titled "A Mathematical Model for the Determination of Total Area Under Glucose Tolerance and Other Metabolic Curves" (1). The author seems to claim "Tai's formula" as a new method of computing area under a curve. The formula given is simply the trapezoidal rule, published in many beginning calculus texts (for example, see Swokowski [2] or Faires and Faires [3]). Although we do not have a first reference, it is our understanding that the trapezoidal rule was known to Isaac Newton in the 17th century. Further, her article omitted any reference to the magnitude of error of the area approximation when the true curve is unknown, as is the case for measuring glucose tolerance.

The trapezoidal rule is used in undergraduate calculus courses to illustrate and develop the calculus of definite integrals. Calculus students begin estimating area under a known curve by dividing the

statements of the trapezoidal rule include the upper bound of the possible error stated as $M(b - a)^3/12n^2$, where M is the maximum rate of curvature over the x segment, $[a, b]$, and n is the number of x-axis intervals.

Tai stated that her "standard (true value). . . is obtained by plotting the curve on graph paper and counting the number of small units under the curve" (p. 153). By definition, the sum of the area of the small units, which she erroneously refers to as the "true value," should be exactly the area found by the trapezoidal rule. The formula should have been 100% accurate because she defined truth to be exactly the sum of the area of the graph paper trapezoids.

We hope that our comments as mathematics and statistics practitioners help to clarify the origin of the trapezoidal rule and its properties as an approximation of the area under the true curve.

Jane H. Monaco, MS
Randy L. Anderson, PhD

From the Department of Public Health Sciences, Bowman Gray School of Medicine, Wake Forest University, Winston-Salem, North Carolina.

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