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TOTAL ENERGY EXPENDITURE: SOFTWARE ESTIMATION AS A NEW APPROACH

GASTO ENERGÉTICO TOTAL: ESTIMATIVA POR SOFTWARE COMO UMA NOVA ABORDAGEM

João Paulo Silva Wiciuk[1*], Tatiana Martins Féres de Souza[2], Bárbara Edwards[2], Gabriel Marcos Barbosa[2], Amanda Campeloto Mastro[2], Cristiane Soares Ferreira Bortolini[2], Romeu Paulo Martins Silva[2], Miguel Junior Sordi Bortolini[2]

[1]Curso de Engenharia Elétrica, Centro de Ciências Exatas e Tecnológicas (CCET), 2Centro de Ciências da Saúde e do Desporto, Universidade Federal do Acre (Ufac).

*Autor correspondente: joaowiciuk@hotmail.com

ABSTRACT

Quantifying total energy expenditure is essential to management of the main comorbidities of 21st century. The present work aims to discuss a new approach to the calculation of total energy expenditure (TEE). To evaluate the TEE there is a need for more precise indirect methods. Software and an algorithm are presented and discussed as an alternative to current indirect estimation methods. We conclude that the new approach can bring significant advantages of precision and accessibility when compared to alternative ones.

Keywords: Physical activity, Software, Questionnaires

RESUMO

Quantificar gasto energético total é imprescindível no manejo das principais comorbidades do século 21. O presente trabalho tem como objetivo discutir uma nova abordagem para o cálculo do gasto energético total (GET). Para avaliar o GET há necessidade de métodos indiretos mais precisos. Um software e um algoritmo são apresentados e discutidos como alternativa para os correntes métodos indiretos de estimativa. Conclui-se que a nova abordagem pode trazer vantagens significativas de precisão e acessibilidade quando comparada às outras.

Palavras-chave: Atividade física, Software, Questionários.

The total energy expenditure (TEE) corresponds to the energy consumption by a subject in a 24 hours period. Its calculation involves three components: basal energy expenditure, energy expenditure of physical activities and diet-induced thermogenesis [1] as described in the Equation I.

$$\Delta E = \Delta B + \Delta A + \Delta t \qquad \text{(I)}$$

with:

ΔE: Total energy expenditure (kcal/day)

ΔB: Basal energy expenditure (kcal/ day)

ΔA: Physical activity energy expenditure (kcal/ day)

Δt: Diet-induced thermogenesis (kcal/ day)

Health professionals use TEE to correctly balance the caloric intake and expenditure of patients during meal plan and physical activity prescriptions [2]. There are direct and indirect

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methods for TEE evaluation [3]. Direct ones are precise, expensive and time-consuming in their application. In opposite, indirect methods are less precise, but they have low costs and their simplicity makes them more accessible [4].

The Equation I ΔB component is conventionally estimated by Harris-Benedict regression equations [5] while Δt contributes very little to ΔE total value [1]. Thus, indirect methods to obtain TEE concentrate interests in the ΔA component estimation related to physical activity.

Among the self-reported methods for ΔA estimation, the most used is the International Physical Activity Questionnaire (IPAQ) [6]. Despite its popularity IPAQ was reported to be inefficient for the classification of physical activity levels [7]. In contrast, a compendium of metabolic equivalents of different activities has been described and updated recently [8]. Although its construction was based on direct methods its use to estimate energy expenditure in physical activities can produce less accurate results [9] and also not be proper in all cases [8].

Based on Ainsworth, Haskell [8] and Byrne, Hills [9] the present work develops a new approach for the indirect estimation of ΔA. In this approach the level of individuals physical activity can be measured with greater precision, fastness and lower cost compared to other indirect methods.

The assembled [10] and updated [8] compendium has been translated to Portuguese, subdivided into categories and stored in a database. Next, a computer software was developed in which the user interface simulates a physical activity questionnaire. This software was then fed previously with compendium stored version. The result can be seen in Figures 1 and 2.

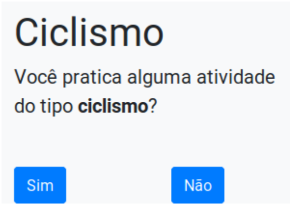

Figure 1 – Screen of activity selection.

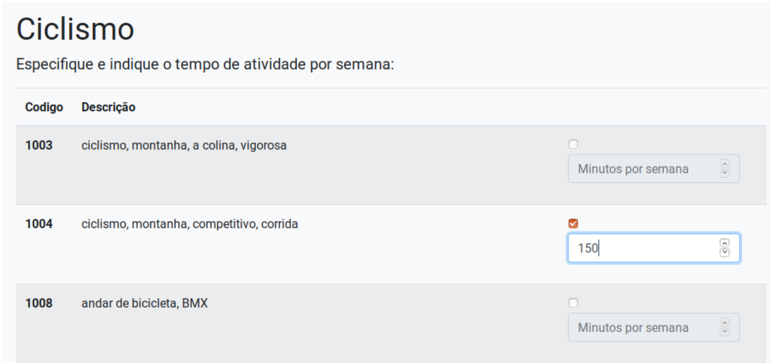

Figure 2 – Screen of activity details.

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A mechanism was created for recording the selected activities. This mechanism also records the gender, weight, height and age of the physical activity practitioner. In addition, the simulated questionnaire has 21 physical activity categories listed and defined in a *major reading* field (Table 1) present in the original version of the compendium.

Table 1 – Categories of activities in which the compendium has been subdivided

1 - Atividade Sexual	8 - Atividades Domésticas	15 - Exercício De Condicionamento Aeróbico
2 – Ciclismo	9 – Ocupação	16 – Dança
3 - Pesca E Caça	10 – Transporte	17 – Diversos
4 - Reparação De Casa	11 - Atividades Religiosas	18 - Tocar Música
5 – Corrida	12 - Cuidados Pessoais	19 - Repouso/Descanso
6 – Caminhada	13 - Atividades De Inverno	20 - Gramado E Jardinagem
7 - Atividades Aquáticas	14 - Atividades Voluntárias	21 – Esportes

Subsequently an algorithm was developed whose function is to receive the information collected in the questionnaire and return the total energy expenditure of the practitioner.

First of all, it uses the Harris-Benedict equations [5] to estimate the ΔB component. Second of all, it iterates through the physical activity list to calculate the ΔA component. In this last procedure the algorithm uses an adaptation from Ainsworth et. al [8] formula to obtain the daily energy expenditure of the individual activities. The original formula is shown in Equation II.

$$\Delta A_n = I_n \times m \times t \qquad \text{(II)}$$

with:

ΔA_n: Energy expenditure of n-th activity (kcal)

I_n: Intensity of n-th activity (MET)

m: Practitioner weight (kg)

t: Total activity time (hours)

Algoritmo 1: TotalEnergyExpendidture

Input variables:

activities: List

gender: String

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```
        weight: Float
        heigh, age: Integer
Output variables:
        ΔE: Float
Start
If gender == ‘Masculino’ then
    ΔB ← 66,4730 + 13,7516 × weight + 5,0033 × heigh − 6.7550 × age
Else
    ΔB ← 655,0955 + 9,5634 × weight + 1,8496 × heigh – 4,6756 × age
End If
Foreach n ← 0 While n < Size(activity) Do
    hour_per_day ← activity[n].min_per_week / 420
    ΔA ← ΔA + activity[n].intensity × weigh × hour_per_day
    n ← n + 1
End Foreach
ΔE ← ΔB + ΔA
Return ΔE
End
```

As one can observe, our algorithm for TEE calculation represents an advantage on indirect approaches as IPAQ. The first one is precision, once the present work used the compendium of physical activities [8] which was built based on direct methods [5]. Moreover, the compendium subdivision into categories and its later integration with the questionnaire software allows the practitioner, at the time of filling, to focus on only one category at a time, which probability increases the efficiency of his physical activities recall. It is also worth mentioning that the algorithm developed for information processing operates with the minimum of human intervention, which reduces the chances of errors and inaccuracies from the manual application of mathematical formulas.

A negative point of the new approach is that it is based on the equation described by Ainsworth et. al [8]. It is known that this formula uses an imprecise value for the resting metabolic rate [9]. However, during the validation process it is intended to integrate correction factors calculated based on the practitioners individual physiological characteristics [9]. It is also intended to develop a second version of the present algorithm that also returns the

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classification in levels of physical activity according previous work [11]. Thus, it is expected that in terms of accuracy, reliability and accessibility the new approach will be used as more efficient indirect method than the current ones used to estimate the total energy expenditure. Future validation should be applied.

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