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Predicted versus measured resting energy expenditure in patients requiring home parenteral nutrition

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ABSTRACT

Objectives: Guidelines from the European Society for Clinical Nutrition and Metabolism (ESPEN) recommend between 20 and 35 kcal/kg daily for patients requiring home parenteral nutrition (PN). Other guidelines use predictive equations. However, these equations have not been validated. Indirect calorimetry is recommended as the gold standard for determining resting energy expenditure (REE). The aim of this study was to compare the frequently used equations with measured REE.
Methods: Seventy-six hospitalized patients suffering from intestinal failure (ages 21–85 y) were enrolled between January 2012 and May 2014. They were eligible for implementation of home parenteral nutrition (HPN) due to short bowel syndrome (54%), intestinal fistulae (24%), cancer obstruction (16%), and radiation-induced intestinal injury (6%). REE measurements were compared with predictive equations by Harris and Benedict (HB), Owen, Ireton-Jones, and Mifflin, as well as recommendations from ESPEN.
Results: In all, 152 calorimetry measurements (two per patient) were performed in 76 patients, after total PN administrations. An average result of REE measurement by indirect calorimetry was 1181 ± 322 kcal/d. Variability in momentary energy expenditure (MEE) from one measurement to the other was 8% ± 7%. Bland-Altman analysis showed a mean bias of –192 ± 300 kcal/d between MEE and estimated energy expenditure using the HB equation, which means that the equation increased the score on average by 192 ± 300 kcal/d. Limits of agreement (LoA) between the two methods was –780 to +396 kcal/d. Estimation energy expenditure using the Ireton-Jones equation gave a mean bias of –359 ± 335 kcal/d. LoA between the two methods was –1015 to +297 kcal/d. For Owen equation, Bland-Altman analysis showed a mean bias of –208 ± 313 kcal/d and the LoA between the two methods was –822 to +406 kcal/d. Using the Mifflin equation, estimation energy expenditure gave a mean bias of –172 ± 312 kcal/d and the LoA between the two methods was –784 to +439 kcal/d. Using the ESPEN range (20–35 kcal/kg daily) analysis showed mean bias of –13 ± 326 kcal/d and the LoA was –652 to +626 kcal/d for 20 kcal/kg daily and mean bias of –909 ± 436 kcal/d with the LoA between the two methods –1764 to –54 kcal/d for 35 kcal/kg daily.
Conclusion: If REE cannot be measured by indirect calorimetry in patients qualified for HPN, the Ireton-Jones equation and the 20 kcal/kg/d ESPEN recommendation seem to be the most appropriate ones as it provides results that constitute the best approximation of calorimetric examination results.

MŁ was responsible for planning the article research design and for preparing the manuscript. PS reviewed the results and the manuscript. ŁG and AG performed the statistical analysis. AB and KM collected and analyzed data. All of the authors read and approved the final manuscript. None of the authors declared any conflicts of financial or personal interests in this study.

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Introduction

Home nutrition is administered to patients who are chronically unable to take enough food via the enteral route or if such supply cannot meet their demand for energy and nutrients [1].

When excessive calories are administered, complications such as metabolic disorders and elevated liver function can be observed [2,3]. Inversely, when too little energy is prescribed, malnutrition can occur [4]. Guidelines recommend administering calorie supply in this population according to predictive equations. Guidelines from the European Society for Clinical Nutrition and Metabolism (ESPEN), the Australasian Society of Parenteral and Enteral Nutrition (AuSPEN), and the British Association of Parenteral and Enteral Nutrition (BAPEN) recommend administering ~20 to 35 kcal/kg to patients suffering from intestinal failure [1,5,6], whereas guidelines from the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) [7] and others [8] propose 25 kcal/kg or 2000 kcal daily. Some clinicians, such as Harris and Benedict [9], Owen [10], Ireton-Jones [11], and Mifflin-St Jeor [12], use predictive equations. However, these equations have been challenged in the past decade due to their low accuracy [13] and because they may lead to over- or underfeeding [14] mainly in the intensive care unit. The aim of this study was to compare the usual predictive equations with measurement of energy expenditure using indirect calorimetry (IC) in the population receiving home parenteral nutrition (HPN), particularly those exposed to complications related to over- or underfeeding, since receiving this regimen for months and years.

Material and methods

The study enrolled 76 patients ages 21 to 85 y (29 women and 47 men) who were hospitalized between January 2012 and May 2014. Study inclusion criterion was the necessity to implement HPN due to short bowel syndrome (SBS; 54%), intestinal fistulae (24%), cancer obstruction (16%), and radiation-induced intestinal injury (6%). All patients were evaluated for risk related to their nutrition status (nutritional risk score [NRS]-2002). Before initiation of HPN, the loss of ≥10% of baseline body weight over a 3-mo period was observed and an NRS-2002 score of ≥3 points was obtained. Patients who qualified for the study had adequate circulatory and respiratory function and stable hemodynamic parameters (Table 1). Each patient was provided with specific information about the testing. All the patients consented to the procedure and institutional review board requirements were fulfilled.

Indirect calorimetry

Resting energy expenditure (REE) was assessed using an IC (MedGraphics CCM Express, MFI Medical Equipment Inc., San Diego, CA, USA). The first measurement was done after administration of the initial nutrition bag; the next measurement was done after the second total PN (TPN) bags to ensure reliable results. That time period was chosen to perform measurements based on studies [15] showing that diet-induced thermogenesis related to the administration of continuous PN. The IC was calibrated before each testing. Testing was done under the same conditions in all patients, that is, at the same time (1100–1200) in the same treatment room, with patients in the semi-supine position. Conditions in which the tests were performed met specific standards. Temperature in the study room was 24°C; patients did not receive enteral nutrition (EN) or PN for at least 3 h before the measurement and did not participate in any physical activity for at least 30 min before testing. The duration of each test was 30 min and the study participant was instructed to remain motionless or at rest during this time.

Table 1
Physical characteristics of study participants (N = 76)

Parameters	Mean ± SD	
	Men (n = 47)	Women (n = 29)
Age (y)	51 ± 16	52 ± 16
Weight (kg)	60.8 ± 12	57.9 ± 13.7
BMI (kg/m^2)	19.6 ± 4	21.5 ± 5
Saturation (%)	94 ± 3	95 ± 2
Temperature (°C)	36.7 ± 0.2	36.6 ± 0.3
C-reactive protein (mg/L)	9 ± 4	11 ± 5
Pulse rate (bpm)	65 ± 13	68 ± 10

BMI, body mass index

Table 2
Predictive equations to calculate resting energy expenditure

Harris-Benedict equation (1919)
Men: 66.5 + (13.75 × body weight [kg]) + (5.003 × height [cm]) – (6.775 × age [y])
Women: 655.1 + (9.563 × body weight [kg]) + (1.85 × height [cm]) – (4.676 × age [y])
Ireton-Jones equation (2002):
629 – (11 × age [y]) + (25 × body weight [kg]) – (609 × obesity*)
Owen equation (1986–1987):
Men: 879 + 10.2 × body weight [kg]
Women: 795 + 7.18 × body weight [kg]
Mifflin equation (1990):
Men: 10 × body weight [kg] + 6.25 × height [cm] − 5 × age [y] + 5
Women: 10 × body weight [kg] + 6.25 × height [cm] − 5 × age [y] − 161

* Present = 1, absent = 0.

Predictive equations

The equations evaluated in this study included the four most commonly used and cited in the literature (Harris and Benedict [HB] [9], Owen [10], Ireton-Jones [11], and Mifflin [12]) as well as the formulas proposed by the ESPEN, AuSPEN, and BAPEN guidelines (20–35 kcal/kg daily). Table 2 presents these equations.

Statistical analysis

Analyses were done using SPSS V.21.0 software (SPSS, Chicago, IL) for Windows. All the results were expressed as mean ± SD. The first and second REE measurements were used as independent measurements and the variance was calculated as the average squared deviation from the population. The agreement between REE and predictive energy expenditure values was analyzed using Bland-Altman plots [16]. We calculated the frequency (%) of energy expenditure estimates, using the different equations, to predict energy expenditure to within 80% and 110% of the REE. The number of estimates that were <80% or >110% of momentary energy expenditure (MEE) were also calculated. Cumulative energy balance that would have arisen had the patients been fed for 3 mo according to prediction equation estimates was also evaluated. Assessment of predictions was done using a linear regression analysis and coefficient of determination R^2.

Results

We performed 152 calorimetry measurements in 76 patients, twice after the first and second TPN bags to ensure reliable results. Table 1 presents the characteristics of the study group. An average result of REE measurement by IC was 1181 ± 322 kcal/d. The results in women were slightly lower than in men (1131 ± 242 kcal/d in the women, and 1212 ± 361 kcal/d in the men); $t[150] = 1.528$; $P = 0.129$. Variability in REE from one measurement to the other was 8% ± 7%. Bland-Altman analysis showed a mean bias of –192 ± 300 kcal/d between REE and estimated energy expenditure using the HB equation (Fig. 1), which meant that the equation increased the score on average by 192 ± 300 kcal/d. Limits of agreement (LoA) between the two methods were –780 to +396 kcal/d (Table 3). Estimation energy expenditure using the Ireton-Jones equation gave a mean bias of –359 ± 335 kcal/d (Fig. 1). The LoA between the two methods was –1015 to +297 kcal/d (Table 3). For the Owen equation, Bland-Altman analysis showed a mean bias of –208 ± 313 kcal/d (Fig. 1) and the LoA between the two methods was –822 to +406 kcal/d (Table 3). Using the Mifflin equation, estimation energy expenditure gave a mean bias of –172 ± 312 kcal/d (Fig. 1) and the LoA between the two methods was –784 to +439 kcal/d (Table 3). Bland-Altman analysis showed a mean bias of –13 ± 326 kcal/d for the 20 kcal/kg and the –909 ± 436 for the 35 kcal/kg daily proposed by the ESPEN guidelines (Fig. 1). The wide LoA in each case highlighted the potential under- and overfeeding of individual patients if such prediction equations were used. Because patients achieving intakes within 80% to 110%