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ORIGINAL ARTICLE

How accurate are predictive formulas calculating energy expenditure in adolescent patients with anorexia nervosa?☆

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Summary
Background & aims: To compare resting energy expenditure, measured by indirect calorimetry, to values estimated by different predictive formulas in adolescent patients with anorexia nervosa.
Methods: We studied 22 female in-patients with a mean age of 14.7 years (SD 1.2). Resting energy expenditure was measured by indirect calorimetry (Deltatrac™ II MBM-200). We compared measured resting energy expenditure to values estimated by several predictive formulas [Fleisch, Harris-Benedict, FAO, Schofield-HW, Schebendach] using the intraclass correlation coefficient and the Bland–Altman method.
Results: Body mass index increased significantly ($P<0.001$). Measured resting energy expenditure increased during hospitalization ($P<0.05$). All formulas overestimated resting energy expenditure with respect to indirect calorimetry except the Schebendach formula. The intraclass correlation between indirect calorimetry and the formulas were poor (0.09–0.20). We observed a poor clinical agreement (Bland–Altman).
Conclusions: Body mass index and resting energy expenditure increased during hospitalization. The majority of the predictive formulas overestimate resting energy expenditure in adolescent patients with anorexia nervosa. Therefore, indirect calorimetry may be a very useful tool for calculating caloric requirements in these patients.

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Introduction

Anorexia nervosa is a psychiatric disease classified as an eating disorder (DSM IV). This disease is characterized by refusal to maintain normal weight for height, an intense fear of gaining weight, a disturbance in the perception of body weight, size, or shape, and, in post-menarchal females, presence of secondary amenorrhea for three consecutive menstrual cycles.[1]

Nutritional rehabilitation is important because many patients are severely malnourished and because other treatments (psychotherapy, psychotropic drugs) are more effective when they have recovered some weight.[2,3]

As many patients present a poor nutritional status at diagnosis, they are prone to develop a refeeding syndrome, especially in patients with BMI lower than 10 kg/m^2, that can have very serious consequences (arrhythmia, sudden death, etc.).[4] Therefore, it is very important to know the energy requirements of these patients during the hospitalization period and after discharge.

Several authors have pointed out that although the energy requirements are low at admission, they increase during hospitalization due to a rise in resting and post-prandial energy expenditure.[5–12]

According to the American Psychiatric Association guidelines, nutritional rehabilitation programs should permit controlled weight gain (1–1.5 kg/week for most inpatients and 250–500 g/week for most outpatients). Intake levels should usually start at 30–40 kcal/kg/day (approximately 1000–1600 kcal/day) and should be increased progressively to 40–60 kcal/kg/day or even more.[3]

The elective methods for measurement of energy expenditure are direct and indirect calorimetry and the doubly labeled water method.[13–16] Indirect calorimetry (IC) is the most commonly used. It measures resting energy expenditure (REE) with the subject in supine position after an overnight fast. However, it is not available in the majority of hospitals because of its cost in terms of financial and human resources. Therefore, in clinical practice, energy requirements are calculated using several predictive formulas, whose validity is debated even in healthy subjects.[17,18] These formulas measure basal energy expenditure (BEE). BEE is the heat produced by an individual at least 10 h after food intake, with the individual awake, in supine position, at normal body and ambient temperature, and free of physical and psychological stress. Except in stressed patients (intensive care, polytrauma, and burn patients), in clinical practice, the terms REE and BEE are used interchangeably.[19,20]

BEE comprises 50–80% of total energy expenditure (TEE), with food-induced thermogenesis (10%) and physical activity (very variable among patients) being the other components. TEE can be estimated by multiplying BEE by different factors (activity factor and stress factor).[20–22]

The objective of our study was to compare REE measured by IC to values estimated by several predictive formulas in adolescent patients with AN and, secondarily, to study the evolution of REE during hospitalization.

Materials and methods

We performed a prospective study with 22 in-patients with AN (according to DSM-IV criteria). Patients were hospitalized in the Division of Adolescent Psychiatric Medicine. All patients were adolescent females with a mean age of 14.7 years (SD 1.2; range 12–17). A nutritional assessment was performed in all the patients in the first 72 h at admission including anthropometry and indirect calorimetry. In 11 patients, this evaluation was repeated before discharge.

All patients except one were postmenarchal. The patient with primary amenorrhoea was in puberal stage III.

At admission our patients were in a restrictive phase of their disease. Our nutritional rehabilitation program includes an admission diet with 30–40 kcal/kg/day (approximately 1000–1600 kcal), that will be increased during the hospitalization according to the weight gain-curve to 40–60 kcal/kg/day (2000–2500 kcal/day) or even more, in some cases.

The length of the hospitalization was variable depending on each case according to the psychiatrist's criterion (restore weight, normalize eating patterns, achieve normal perceptions of hunger and satiety, and correct biological and psychological sequelae of malnutrition). Patients stayed in hospital until they have reached 85–95% of their ideal weight. Mean hospitalization time was 54.1 ± 22.3 days (range 21–91).

Anthropometry

Weight and height were measured, using a platform balance (Seca®) and stadiometer, to the nearest 0.2 kg and 0.1 cm, respectively. BMI was calculated by dividing the subject's weight in kilograms by height in meters squared.

Skinfold thicknesses of the triceps (TSF) and subscapular (SSF) were obtained in triplicate using a Holtain caliper (pressure 10 g/mm^2, accurate to 0.2 mm). Mid-arm circumference (MAC) was obtained in triplicate, using a metric scale, to the nearest 0.1 cm. Skinfolds and circumferences were taken according to International Standards.[23] Mid-arm muscle circumference (MAMC) was calculated using the formula $\text{MAMC} = \text{MAC} - \pi\ \text{TSF}$.

Fat mass (FM) and fat free mass (FFM) were calculated from skinfold thicknesses.[24]

Indirect calorimetry

Indirect calorimetry was performed using a Deltatrac™ II MBM-200 metabolic monitor (open-circuit calorimeter). Measurements were taken for 30 min after an overnight fast with the patient in supine position. The metabolic monitor measures the volume of oxygen expended (VO_2) and the volume of CO_2 produced (VCO_2) and REE is calculated using the Weir formula.

Statistical analysis

We used non-parametric tests due to the limited number of patients. We used the Wilcoxon test to compare the study variables at admission and at discharge, and to compare REE, measured by IC, to the values obtained with several predictive equations [Fleisch, Harris-Benedict (HB), FAO, Schofield-HW (SHW), Schebendach].[25–29] To study the concordance between IC and these formulas, we used