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Original article

Resting energy expenditure in malnourished older patients at hospital admission and three months after discharge: Predictive equations versus measurements

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SUMMARY

Background: Predicting resting energy expenditure (REE) in malnourished hospitalized older patients is important for establishing optimal goals for nutritional intake. Measuring REE by indirect calorimetry is hardly feasible in most clinical settings.
Objective: To study the most accurate and precise REE predictive equation for malnourished older patients at hospital admission and again three months after discharge.
Design: Twenty-three equations based on weight, height, gender, age, fat free mass (FFM) and/or fat mass (FM) and eleven fixed factors of kcal/kg were compared to measured REE. REE was measured by indirect calorimetry. Accuracy of REE equations was evaluated by the percentage patients predicted within 10% of REE measured, the mean percentage difference between predicted and measured values (bias) and the Root Mean Squared prediction Error (RMSE).
Results: REE was measured in 194 patients at hospital admission (mean 1473 kcal/d) and again three months after hospital discharge in 107 patients (mean 1448 kcal/d). The best equations predicted 40% accuracy at hospital admission (Lazzer, FAO/WHO-wh and Owen) and 63% three months after discharge (FAO/WHO-wh). Equations combined with FFM, height or illness factor predicted slightly better. Fixed factors produce large RMSE's. All predictive equations showed proportional bias, with overestimation of low REE values and underestimation of high REE values. Correction by regression analysis did not improve results.
Conclusions: The REE predictive equations are not adequate to predict REE in malnourished hospitalized older patients. There is an urgent need for either a new accurate REE predictive equation, or accurate easy-to-use equipment to measure REE in clinical practice.

1. Introduction

The number of people in Europe aged 65–79 years is expected to increase approximately 35% between 2010 and 2030.[1] Elderly are especially vulnerable to malnutrition as they often have several co-morbidities that are chronic and progressive. Adverse effects of malnutrition vary from impaired wound healing and postoperative complications to mortality.[2] Poor nutritional status has not only been associated with in-hospital adverse effects, but also with adverse effects both pre-admission and post-discharge. These effects include a trend for increased need for re-hospitalization, significantly higher total mortality, a higher general practitioner consultation rate, higher medication prescription rate, longer rehabilitation, an increased need for nursing home admission, increased likelihood of requiring home health care after discharge and early institutionalization.[3,4] The prevalence of malnutrition in free-living elderly is 13–37%[5–8] and can increase up to 93%[9–12] in hospital admitted elderly.

Malnutrition is often reversible and can be treated by a dietitian, general practitioner or medical specialist. For establishing optimal goals for dietary intake it is important to predict resting energy expenditure (REE). This requires knowledge of individual energy requirements and relies on accurate methods of assessment. Energy expenditure can be measured by indirect calorimetry and

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provides an indication of patients' energy requirements.[13] This method is hardly feasible in most clinical settings, due to time consuming measurements, lack of trained personnel and expensive equipment. In clinical practice, predictive equations to determine REE in malnourished older patients are used as an alternative to solve this problem.

REE predictive equations have generally been developed in healthy populations or in critically ill patients. Specific equations for predicting REE in malnourished hospitalized older patients are lacking. Earlier we showed that the percentage accurate predictions for in patients (not elderly) was only about 40%.[14] Melzer et al.[15] showed for healthy elderly (>70 years) that the Harris-Benedict equation resulted in 72% accurate predictions, suggesting that being old per se is not limiting the accuracy. The existing REE predictive equations have not been tested in a mixed diagnosed group of malnourished hospitalized older patients.

The aim of this study was to find the most accurate and precise REE predictive equation. As part of evidence-based practise, the literature was systematically searched for REE predictive equations. Subsequently REE equations were compared with measured REE data from indirect calorimetry at hospital admission and again three months after discharge in malnourished older patients aged ≥60 years.

2. Methods

2.1. Patients

The patients were recruited between March 2006 and September 2009 from the clinical departments of Internal Medicine, Traumatology, Orthopaedics, and Vascular Surgery of the VU University Medical Center Amsterdam. Patients were admitted in acute (49%) or chronic condition (51%).

The inclusion criteria were 1) age ≥ 60 years and 2) malnourished, defined as a Body Mass Index (BMI in kg/m^2) ≤ 20 and/or ≥5% unintentional weight loss in the previous month and/or ≥10% unintentional weight loss in the previous six months. Patients were excluded from the study when they suffered from senile dementia, could not understand the Dutch language or were not able to or willing to give informed consent.

The study was approved by the Medical Ethics Committee of the VU University Medical Center Amsterdam.[16]

2.2. Indirect calorimetry

Resting energy expenditure was measured twice; at baseline (within 3 days after admission to the hospital) and three months after hospital discharge (final). Measurements were standardized by internal guidelines.[17]

The indirect calorimetry measurements were performed with a ventilated-hood system (Vmax Encore 29n; Viasys Health Care, Houten, The Netherlands). The patients were in supine position, awake, and had not been physically active for at least 30 min before the measurement. Due to the clinical practice, most patients were not fully post-absorptive before measuring resting energy expenditure by indirect calorimetry. However, we aimed to measure REE more than 2 h after oral dietary intake (16/196 patients were measured within 2 h after oral dietary intake).

The measurements took 30 min and data from the first 5 min of the measurement were excluded. The steady state period during the measurement was with acceptable coefficient of variation of 10%. Measurements of patients with a respiratory quotient (RQ) of <0.7 and >1.0 were excluded.

The Vmax system was calibrated daily for flow and two different standard gases (one with 26% O_2 and 0% CO_2 and one with 16% O_2 and 4% CO_2) immediately before use and every 5 min during the measurement. Oxygen consumption and carbon dioxide production were measured, and energy expenditure was calculated by the Weir equation.[18] Oxygen analyser sensitivity was checked yearly by the supplier.

2.3. Body composition

Body composition was assessed by bio-electrical impedance spectroscopy (multi-frequency ECF/ICF Bio Impedance Spectrum Analyzer, Hydra 4200, Xitron Technologies, San Diego, CA, USA) to determine fat free mass and fat mass. Fat free mass and fat mass were calculated based on the Hanai mixture equation.[19]

Body weight was measured, with patients wearing light indoor clothes and no shoes, on a calibrated electronic scale (Prior MD-1512), with an accuracy of 0.1 kg. A correction factor for clothes was made by deducting weight with 2.0 kg for men and 1.3 kg for women.[20] As measurement of height is often not feasible in this ill, old and frail population, data on height were self-reported. BMI was calculated as actual weight in kilograms divided by the square of height in meters.

2.4. REE predicative equations

PubMed was used for a systematic search for publications on Mesh-derived keys 'Energy metabolism', 'Basal metabolism', 'Indirect calorimetry' and additional terms ('predict*', 'estimat*', 'equation', and 'formula') and age terms ('older', 'elder(ly)', 'age 65 years') in every possible combination. Applied limitations were 'English language' and 'humans'. More references were obtained by screening publications cited looking back and forward.

Due to the limitation of age, only two references were found (Fredrix et al.[21] and Luhrmann et al.[22]). Therefore, we decided to further ignore the age limitation.

Inclusion criteria were as follows: equations based on body weight, height, age, sex and/or fat free mass and fat mass. Equations were excluded when they were based on children, obese persons, critically ill patients in which ventilation parameters were included, specific ethnic groups, small sample size ($n < 40$), complex measurements of body composition as variable, biochemical parameters, indirect calorimetry measurements with poor equipment and total energy expenditure.

From each included study the best performing equations based on the highest value for explained variance (R^2), were included. However, extra equations were included when based on weight and height (versus weight only) or FFM. In total, 23 equations were included in this study.

Because prediction equations do not include an illness factor, a range of illness factors (0–30%) that may improve percentage accurate prediction were added to the different equations.

For each patient, the REE was predicted by the selected equations in kcal/d and compared with measured REE. The actual body weight at the time of the indirect calorimetry measurement was used.

2.5. Fixed factors of kcal per kg

Besides existing predictive equations from the literature, we have calculated a range of 11 different fixed factors of kilocalories per kg body weight (15–40 kcal/kg body weight) to predict REE. For fixed factors, that provide total energy expenditure (TEE), predictions were divided by 1.3 to provide REE. From literature, an amount of 21–22 kcal/kg for REE that was suggested for use in the elderly,[23,24] is comparable with 27.5 kcal/kg for TEE.