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Original article

Agreement between prediction equations and indirect calorimetry to estimate resting energy expenditure in elderly patients on hemodialysis

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SUMMARY

Background/aims: Prediction equations are often applied to estimate the resting energy expenditure (REE) of end-stage renal disease patients. The accuracy of these equations in elderly on hemodialysis (HD) has not been investigated. We aimed to evaluate the agreement between the REE obtained by indirect calorimetry and three prediction equations in elderly patients on HD.
Methods: The REE of 72 elderly individuals (57 on HD and 15 with normal renal function), was measured by indirect calorimetry and compared to the prediction equations of Harris & Benedict, Schofield and the World Health Organization 1985 (WHO). The agreement was assessed by the intraclass correlation coefficient (ICC) and by Bland–Altman plot analysis. The ratio predicted/measured REE was used for classifying the agreement as acceptable (ratio: 0.90 to 1.10) or overestimated (ratio: >1.11).
Results: The REE estimated by the three equations was significantly higher than that obtained by indirect calorimetry (Harris & Benedict: 1339 ± 245 kcal/day; Schofield: 1358 ± 203 kcal/day; WHO: 1385 ± 225 kcal/day *vs.* indirect calorimetry: 1245 ± 283 kcal/day; $P < 0.05$). The ICC was indicative of moderate agreement between indirect calorimetry and the three equations (Harris & Benedict: $r = 0.70$ (95% confidence interval: 0.54; 0.81); Schofield: $r = 0.64$ (0.46; 0.77) and WHO: $r = 0.62$ (0.43; 0.75). Acceptable agreement between the equations and indirect calorimetry was observed in 35% of patients, while overestimation was observed in 50%. Similar results were found in the elderly control group.
Conclusion: The three equations showed a moderate degree of agreement with indirect calorimetry and overestimation was the main error observed. These results suggest that these equations do not provide accurate measurements of REE in elderly on HD.

1. Introduction

The incidence and prevalence of elderly patients on dialysis has been rapidly increasing in recent decades due to the increase in life expectancy. According to the United States Renal Data System from 2011, the adjusted rate of prevalent end-stage renal disease (ESRD) for patients aged 65–74 years has increased by 28% since 2000, while the rate among those aged 75 years or older has grown by 37%.[1] With this figure in mind, it is highly important to devote attention to the general care of the elderly on dialysis treatment.

The nutritional care of hemodialysis (HD) elderly patients can be of particular interest due to the high prevalence of protein energy wasting in HD patients older than 65 years.[2,3] Therefore, it is highly important to adequately estimate the daily energy requirements as a way to treat and avoid worsening of nutritional status. This argument becomes stronger with the finding that protein energy wasting is strongly associated with an increased mortality rate in HD patients.[4]

Energy requirements can be estimated by multiplying the resting energy expenditure (REE) by a factor that accounts for the energy expended by physical activity (physical activity level, PAL). In the clinical setting, REE cannot be routinely measured due to the

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need for a trained professional, to the 8–12 h fast and 30 min of rest before the exam and also to the resource constrains, such as, the high cost of the equipment. Therefore, prediction equations are applied as a first step to calculate daily energy requirements. The European Best Practice Guideline (EBPG) in Nutrition recommends the use of the Harris & Benedict equation and the equation proposed by the World Health Organization (WHO) document from 1985 to estimate the REE.[5] The Schofield equation is also often applied in the general population for this purpose.[6] To the best of our knowledge, the accuracy of these equations has been tested in adult chronic kidney disease (CKD) patients, but not in elderly patients on HD. In a previous report, Kamimura et al. showed that in adult CKD patients, including non-dialysis, HD and peritoneal dialysis patients (aged 50 ± 16 years), the Harris & Benedict and Schofield equations had a moderate degree of reproducibility with indirect calorimetry.[7] In another report including only peritoneal dialysis patients (aged 50 ± 11 years), the mean values of REE estimated by Harris & Benedict, Schofield and WHO equations did not differ from indirect calorimetry, but the Harris & Benedict equation showed a error of overestimation for patients with higher REE.[8] Therefore, these equations have a moderate degree of reproducibility and are prone to overestimating the measured REE in adult CKD patients.

When focusing on HD, it has been shown that the REE (assessed by indirect calorimetry) of adult HD patients was similar to that of gender- and age-matched healthy individuals.[9] Nevertheless, if one considers the changes in body composition that occur with aging, such as the progressive reduction in lean body mass,[10] the REE of elderly individuals may be diminished, regardless of the dialysis procedure. Altogether, it is possible that the predictive equations, which were developed for healthy and mostly adult persons, might not be able to capture the lower REE found in elderly individuals and an error of overestimation can be expected when REE is estimated using equations on elderly patients on HD. This highlights the need to study the accuracy of prediction equations to estimate the REE in elderly HD patients. With this rationale, the aim of this study was to evaluate the agreement between the REE obtained by indirect calorimetry and the prediction equations of Harris & Benedict, Schofield and WHO in elderly patients on HD.

2. Materials and methods

2.1. Patients

A total of 72 elderly subjects were included in the present study. The sample was comprised of 57 HD patients, in addition to 15 elderly individuals with normal renal function from an elderly cohort involved in research on frailty in elderly Brazilians (Rede de Pesquisa Fragilidade em Idosos Brasileiros – Seção Rio de Janeiro, FIBRA-RJ).[11] The cutoff to define elderly individuals can vary among countries. In Brazil, elderly individuals are those aged 60 years or more, as established by the Ministry of Health.[12] Therefore, were included patients older than 60 years. Other inclusion criteria comprised being on HD for at least three months and dialyzing 3.5–4 h thrice a week. Institutionalized patients, those in wheelchairs, with amputated limbs, signs of cognitive impairment, acute infection, cancer, acquired immunodeficiency syndrome, liver disease, degenerative disease and hypo- or hyperthyroidism were not included in the study. The presence of comorbidities was recorded from the medical records. Out of the 57 patients on HD, a subgroup of 30 patients (HD subgroup) was matched by gender and age (±2 years) with 15 elderly individuals with normal renal function (elderly control group), matched as 2 HD patients for 1 elderly individual from the control group. The inclusion criteria for the control group were age >60 years old and normal renal function. The same exclusion criteria described for the HD patients were adopted for the elderly control group.

The Local Research Ethical Committee from the Rio de Janeiro State University and from Federal University of São Paulo approved this project and all participants provided written informed consent before their inclusion in the study.

2.2. Study design and protocol

This is a cross-sectional study. After signing the informed consent, all participants were scheduled for measurements of REE (indirect calorimetry), body composition (dual-energy X-ray absorptiometry, DXA – GE Medical Systems Lunar®, Madison, Wisconsin, USA), 7 point subjective global assessment (SGA)[13] and food intake assessment (three-day food record). For the HD patients, the DXA and REE assessments were performed on the midweek interdialytic day in the morning (8:00 am). Blood was drawn before the dialysis session and body weight and height were measured after the dialysis session. For the elderly control group, REE and DXA were performed on the same day after an overnight fast early in the morning (8:00 am). Blood was drawn on a different day than the REE and body composition measurements.

In order to confirm the findings obtained for the primary cohort of elderly HD patients, the REE was compared to the prediction equations in the subgroup of elderly HD patients and in the elderly control group.

2.3. Laboratory data

Serum creatinine, urea (pre- and post-dialysis), albumin, high-sensitivity C-reactive protein ($_{hs}$CRP), parathyroid hormone (PTH), thyroid-stimulating hormone (TSH) and free thyroxine (T4) were measured in the HD patients. Urea Kt/V was calculated according to Daugirda's formula on a midweek dialysis day.[14] In the elderly control group, measurements of serum creatinine, TSH and T4 were performed. Renal function was assessed by the validated CKD-EPI MDRD equation,[15] which calculates the glomerular filtration rate (GFR).

CKD-EPI MDRD equation[15]: $141 \times \min(\mathrm{Scr}/\kappa, 1)^{\alpha} \times \max(\mathrm{Scr}/\kappa, 1)^{-1.209} \times 0.993^{\mathrm{age}} \times 1.018$ (if female) $\times 1.159$ (if black), where κ is 0.7 for females and 0.9 for males. $^{\alpha}$ is −0.329 for females and −0.411 for males, min indicates the minimum of Scr/κ or 1, and max indicates the maximum of Scr/κ or 1.

None of the individuals from the elderly control group had CKD, according to the criteria proposed by the Kidney Disease Improving Global Outcomes (KDIGO).[16]

2.4. Resting energy expenditure

The REE was measured by indirect calorimetry using an open circuit ventilated computerized metabolic system (Vmax series 29n; SensorMedics Corp; Yorba Linda, CA, USA). All subjects had been instructed to maintain their regular medication, to refrain from any unusual physical activity (playing sports, lifting weights, jogging, walking, etc.) for 24 h prior to the test and to maintain their usual sleep schedule the night before the REE measurement. They were admitted to the laboratory at 8:00 am after an overnight fast of 12 h. After resting for 30 min in a recumbent position, subjects breathed for 30 minutes through a clear plastic canopy placed over their heads in a quiet, dimly light thermoneutral room. They were instructed to avoid hyperventilation, fidgeting or falling asleep during the test. Oxygen consumption and carbon dioxide production were measured and the mean of the last 20 min was used to calculate the REE according to Weir's equation.[17] The predicted