Comparison of resting and total energy expenditure in peritoneal dialysis patients and body composition measured by dual energy X ray absorptiometry (DXA)

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short title resting and total energy expenditure in peritoneal dialysis patients

key words peritoneal dialysis resting energy expenditure total energy expenditure total body water body surface area Kt/Vurea

word count		
	abstract	250
	body	1344
	figures	2
	tables	1
	references	10

Funding grant -British Renal Society, Dr El-Kateb was awarded an International Society for Nephrology fellowship
No author has any conflict of interest

Abstract

Background/Objective

Under basal resting conditions muscle metabolism is reduced, whereas metabolism increases with physical activity. We wished to determine whether there was an association between resting energy expenditure (REE) and total energy expenditure (TEE) in peritoneal dialysis (PD) patients and lean body mass (LBM).

Subjects/Methods

We determined REE and TEE by recently validated equations using doubly labelled isotopic water, and LBM by dual energy X-ray absorptiometry (DXA) scanning.

Results

We studied 87 patients, 50 male (57.4%), 25 diabetic (28.7%), mean age 60.3±17.6 years, with a median PD treatment of 11.4 (4.7-29.5) months. The mean weight was 70.1±17.7 kg with a REE of 1509±245 kcal/day and TEE 1947±378 kcal/day. REE was associated with body size; (weight r=0.78, BMI r=0.72), and body composition (LBM r=0.77, lean body mass index (LBMI) r=0.76, r=0.62), all p<0.001. For TEE, there was an association with weight r=0.58, BMI r=0.49, and body composition (LBM r=0.64, LBMI (r=0.54), all p<0.001. We compared LBMI measured by DXA and that estimated by the Boer equation using anthropomorphic measurements, which overestimated and underestimated LBM for smaller patients and heavier patients respectively.

Conclusions

Muscle metabolism is reduced at rest, and increases with physical activity. Whereas previous reports based on REE did not show any association with LBM, we found an association between both REE and TEE, using a recently validated equation derived from dialysis patients, and LBM measured by DXA scanning. Estimation of muscle mass from anthropomorphic measurements systematically overestimated lean body mass for small patients and conversely underestimated for heavier patients.

Introduction

More than 300,000 patients with chronic kidney disease stage 5 (CKD5d) are now treated by peritoneal dialysis (PD) worldwide. The current paradigm is to assess PD by measuring urea clearance. However prospective studies have failed to demonstrate that increasing urea clearance is associated with greater patient survival [1]. An alternative suggestion is that the amount of dialysis a PD patient requires would depend upon their metabolic activity, as urea is generated as a by-product of cellular nitrogen metabolism [2]. Metabolic activity comprises both resting metabolic rate and that secondary to physical activity. Many studies concentrated on measuring resting energy expenditure (REE) [3], but this excludes activity energy expenditure (AEE), and so under estimates total energy expenditure (TEE).

We recently validated an assessment of TEE, and REE in dialysis patients using a patient self-reported questionnaire and double isotopic labelled water [4]. To determine whether there was an association between body composition and energy expenditure we compared TEE and REE with body composition measured by dual energy X-ray absorptiometry (DXA) scanning.

Patients and methods

Adult patients with chronic kidney disease under the care of the Royal Free Hospital treated by PD were recruited when attending for outpatient assessments of peritoneal dialysis adequacy. Corresponding spent dialysate effluent and serum samples were analysed by standard methods, and weekly dialysis dose calculated as Kt/Vurea . Nitrogen protein accumulate rate was estimated using the Bergström equation, and normalised for body weight (nPNA) g/kg.

DXA scanning was performed in a standardised manner, with all patients draining out peritoneal dialysate. Patients were then asked to empty the bladder, and scanning was then performed with patients wearing a paper gown (Hologic QDR 400, Malborough, USA) [5,6]. Lean body mass (LBM) and fat mass was measured by DEXA scanning, and lean body mass index (LBMI) calculated by LBM divided by height squared. In addition LBM was estimated using the Boer equation based on anthropomorphic measurements (Appendix)

Physical activity data was obtained through the validated Recent Physical Activity Questionnaire (RPAQ) [4]. The RPAQ collects information about activities performed at home, work and leisure time and also the time spent on each activity in the preceding 4 weeks. The RPAQ has been validated against doubly labelled water technique in general population [4], and has been shown to be a reliable tool for estimation of energy expenditure in patients with chronic kidney disease [7]. Physical activity data was determined by each reported activity being assigned a Metabolic Equivalent of Task (MET) value according to the Compendium of Physical Activities [8]. The equations for calculating Resting Energy Expenditure (REE) and Total Energy Expenditure (TTE) are described in the Appendix, along with the Boer equation for estimating lean body mass from anthropomorphic measurements.

Patient comorbidity was determined using the Stoke-Davies co-morbidity grading, and normalised nitrogen protein equivalent appearance rate (nPNA) calculated from total 24 hour urea removal.

Ethical approval was granted by the UK National Research Ethics Committee - Essex and the study was registered in UK Clinical Research Network (CRN) Portfolio number 14018. All patients provided written informed consent in keeping with the declaration of Helsinki.

Statistical analysis

Statistical analysis was by paired analysis, students' t tests, or Wilcoxon pair analysis, with appropriate correction for multiple testing, Pearson or Spearman's correlation (GraphPad Prism version 6.0, San Diego, USA), and Bland Altman comparison (Analyse-It version 3.0, Leeds, UK). Data are presented as mean ± standard deviation, median (inter quartile range), or mean and 95% confidence limits (CL), or as a percentage.

Results

We studied 87 patients, 50 male (57.4%), 25 diabetic (28.7%), mean age 60.3±17.6 years, with a median duration of peritoneal dialysis 11.4 (4.7-29.5) months. The mean weight was 70.1±17.7 kg with a median co-morbidity grade of 1 (0-1). The mean REE was 1509±245 kcal/day and TEE 1947±378 kcal/day,

Male patients were heavier than females, but this was not significant due to the wide variation in weights, and body mass index (BMI) was similar (table 1). Whereas male PD patients had significantly greater lean body mass, both measured by DEXA and estimated by the Boer equation, female patients had greater body fat mass. Patient co-morbidity, serum albumin and CRP and dialysis adequacy, as assessed by weekly Kt/Vurea were similar between the sexes. Similarly assessment of dietary protein intake was similar. Male patients had higher haemoglobin, but after correcting for multiple statistical testing this difference was no longer significant. Male patients had a greater REE but not TEE (table 1).

On univariate analysis, REE was associated with body size; (weight $r=0.78$, BMI $r=0.72$, both $p<0.001$), and body composition (lean mass (DXA) $r=0.77$, lean body mass Boer $r=0.81$, lean body mass index (DXA) $r=0.76$, lean body mass index (Boer) $r=0.62$, fat mass $r=0.56$, all $p<0.001$). Similarly for TEE, there was an association with body size; (weight $r=0.58$, BMI $r=0.49$, both $p<0.001$), and body composition (lean mass (DXA) (Figure 1), lean body mass Boer r=0.60, lean body mass index (DXA) (r=0.54), lean body mass index (Boer) r=0.40, all p<0.001 and fat mass r=0.35, p=0.001). There was no association between percentage body fat and either REE or TEE (r=0.07and r=-0.04, p>0.05) respectively. Separating the cohort by gender, then there was a positive correlation between fat mass and REE (males r=0.53, women r=0.73, p<0.000), and also between TEE and lean body mass index (Figure 1).

Although there was a significant correlation between lean body mass and lean body mass index between that measured by DXA, and that estimated by the Boer equation (r=0.8, r=0.66, p<0.001 respectively), on Bland Altman comparison, the estimation by the Boer equation systematically over estimated lean body mass and index for smaller patients, and then under-estimated lean body mass and index for heavier patients (Figure 2).

Discussion

Traditionally the amount of dialysis delivered to patients with end stage kidney failure is based on urea clearance adjusted for total body water volume. However as uraemic toxins are generated by cellular metabolism, and in particular it has been suggested that the amount of dialysis required for patients should be based on metabolic rate [2]. Studies to-date have concentrated on resting metabolic rate [3], but this ignores physical activity, and as such under estimates TTE. We therefore set out to determine both REE and TEE using equations based on patient self-reported physical activity questionnaire, which has been validated using doubly labelled isotopic water [4].

Muscle activity is reduced when at rest, and as such basal metabolic rate may not reflect muscle mass. Similarly as physical inactivity leads to loss of muscle we wished to determine whether there was an association between muscle mass and both REE and TEE. We found that there was a positive association for both REE and TEE and both muscle mass, and muscle mass index whether measured by DXA scanning, or estimated by the Boer equation. The correlations between REE and TEE were statistically greater for lean body mass, than for fat mass, BMI or weight, and there was no association with percentage body fat. Correlations with TEE and REE were stronger for lean body mass for men, and for fat mass with women, respectively. Previous studies which have concentrated on either measuring basal metabolic rate or maximal exercise capacity in peritoneal dialysis patients failed to demonstrate an association between REE and muscle mass [9,10]. As such these studies were unable to estimate TEE, whereas our equation estimating both REE and TEE demonstrates a strong association with lean body mass and index.

Although there was a strong association between lean body mass and lean body mass index measured by DEXA scanning and that estimated by the Boer equation using anthropomorphic measurements, the Boer equation systematically over-estimated lean body mass and index for smaller patients and then under-estimated lean body mass and index for heavier patients. As such, for this group of peritoneal dialysis patients then measurement of lean body mass with DEXA scanning is to be preferred than estimating muscle mass by anthropomorphic based equations. Understanding the relationship between body composition and energy expenditure is important as patients with greater energy expenditure generate more waste products of metabolism , and as such require greater clearances by dialysis.

The authors have no conflict of interest
None of the data contained in this report has been previously published in whole or part form

Funding grant British Renal Society
Dr El-Kateb was awarded a scholarship by the International Society of Nephrology

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Figure 1:correlation between lean body mass index measured by dual electron X ray absorption (DEXA) and total energy expenditure (TEE). (males r = 0.62, p<0.001 and females r= 0.45, p<0.001).

Figure 2: Bland Altman analysis of lean body mass index measured using dual electron X-ray absorption (DEXA) and lean body mass calculated by the Boer equation. Mean bias 1.5 kg/m^2 (95% confidence limits -2. to 5.4 kg/m^2).

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Appendix

Resting Energy Expenditure (REE) was estimated from a newer novel predictive equation which was derived and validated in a cohort of HD patients [4].

$$REE = -2.497 * Age(years) * Factor_{age} + 0.011 * Height^{2.023}(cm) + 83.573 * Weight^{0.6291}(kg) + 68.171 * Factor_{sex}$$

where Factor age is 0 if age <65 and 1 if ≥65 and Factor sex is 0 if female and 1 if male

Physical activity data - Each reported activity was assigned a Metabolic Equivalent of Task (MET) value as per the Compendium of Physical Activities [4]. Sleep time per day was assumed to be 8 hours and any unreported time during the day was assumed as the time performing light activities at home. A Mean daily MET value was calculated.

Total Energy Expenditure (TEE) was estimated from the following equation.

$$TEE = REE * Mean\ Daily\ MET$$

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Boer equation

Lean body mass (male) = (0.407 x Weight kg) + (0.267 x height cm) -19.2

Lean body mass (female) = (0.252 x Weight kg) + (0.473 x height cm) -48.3