Resting energy expenditure measured longitudinally following hip fracture compared to predictive equations: is an injury adjustment required?

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The present study measuring resting energy expenditure (REE; kJ/d) longitudinally using indirect calorimetry in six elderly women aged ≥70 years following surgery for hip fracture, describes changes over time (days 10, 42 and 84 post-injury) and compares measured values to those calculated from routinely applied predictive equations. REE was compared to REE predicted using the Harris Benedict and Schofield equations, with and without accounting for the theoretical increase in energy expenditure of 35% secondary to physiological stress of injury and surgery. Mean (95% CI) measured REE (kJ/d) was 4704 (4354, 5054), 4090 (3719, 4461) and 4145 (3908, 4382) for days 10, 42 and 84, respectively. A time effect was observed for measured REE, P<0.003. Without adjusting for stress the mean difference and 95% limits of agreement for measured and predicted REE (kJ/kg per d) for the Harris Benedict equation were 1 (−9, 12), 10 (2, 18) and 9 (1, 17) for days 10, 42 and 84, respectively. The mean difference and 95% limits of agreement for measured and predicted REE (kJ/kg per d) for the Schofield equation without adjusting for stress were 8 (−3, 19), 16 (6, 26) and 16 (10, 22) for days 10, 42 and 84, respectively. After adjusting for stress, REE predicted from the Harris Benedict or Schofield equations overestimated measured REE by between 38 and 69%. Energy expenditure following fracture is poorly understood. Our data suggest REE was relatively elevated early in recovery but declined during the first 6 weeks. Using the Harris Benedict or Schofield equations adjusted for stress may lead to overestimation of REE in the clinical setting. Further work is required to evaluate total energy expenditure before recommendations can be made to alter current practice for calculating theoretical total energy requirements of hip fracture patients.

Energy metabolism: Nutrition: Orthopaedics: Rehabilitation

Hip fractures are a major public health problem with the consequences including impaired mobility and function (Marottoli et al. 1992), admission to residential care (Melton, 2003) and premature mortality (Johnell et al. 2004) at the individual level and increased burden on finite health resources at the community level (Haentjens et al. 2001). By the year 2025 the number of osteoporotic hip fractures is conservatively estimated to increase to 2.6 million world-wide, approximately double the current incidence (Gullberg et al. 1997).

Poor nutritional status is a risk factor for osteoporosis (Bonnour et al. 2001). Furthermore, protein-energy malnutrition is prevalent (Bastow et al. 1983; Patterson et al. 1992; Ponzer et al. 1999) and has been associated with poorer outcomes amongst older adults who break their hip (Foster et al. 1990; Sullivan et al. 1990). Nutrition interventions for hip fracture aftercare have been found to have some benefits including reduced length of total hospital stay (Delmi et al. 1990), reduced length of stay of rehabilitation (Schuricht et al. 1998) and reduced complications (Delmi et al. 1990; Tkatch et al. 1992; Bean et al. 1994). A Cochrane systematic review suggested that the overall quality of evidence in this area, however, is still not strong enough to support routine oral nutritional support for hip fracture aftercare (Avenell & Handoll, 2005).

One of the main limitations of studies evaluating the effect of oral nutritional supplements following hip fracture is the lack of attention to the provision of an adequate amount of energy and protein to address the deficits associated with pre-existing malnutrition (Avenell & Handoll, 2005), injury and surgical stress, and inadequate intakes during recovery (Delmi et al. 1990; Brown & Seabrook, 1992; Lumbers et al. 2001). Energy expenditure in older adults generally and specifically following surgery for hip fracture is poorly understood and estimates of supplement needs are based on limited evidence. Indeed most oral nutritional supplement trials in hip fracture patients prescribe a standard volume based on a convenient number of packs or tins rather than individual nutritional needs (Avenell & Handoll, 2005). Predictive equations such as the Harris Benedict (developed using healthy younger adults; Harris & Benedict, 1919) and Schofield (developed using small samples, n 38 women, n 50 men, aged >60 years; Schofield, 1985) equations with a factor of 1.35 applied for the stress associated with the injury and surgery (Long et al. 1979) are commonly used in the clinical setting (Reeves & Capra, 2003a). To calculate total energy expenditure and hence total energy requirements, these values are adjusted further to account for the theoretical cost of physical activity.
and, if deemed necessary, weight gain (Reeves & Capra, 2003a). Whether this method of estimation of total energy requirements is accurate, whether the stress factors applied are necessary and if so, for how long, remains relatively unknown.

There have been four small studies (Jallut et al. 1990; Campillo et al. 1992; Nelson et al. 1995; Paillaud et al. 2000) that have reported resting energy expenditure (REE) of hip fracture patients as measured by indirect calorimetry, two of which included longitudinal data. All reported that energy expenditure predicted by equations underestimated measured energy expenditure (range 8–30 %) and recommended that clinicians account for this by increasing the energy density or volume of the intervention. However, it appears that the REE values predicted by the various equations in these studies were not adjusted for physiological stress of surgery and trauma related to the injury, as is commonly recommended (Mahan & Escott-Stump, 2000; Thomas, 2002; Bales & Ritchie, 2004; Todorovic & Micklewright, 2004). Inaccurate estimation of REE potentially leads to provision of inadequate nutritional support with compromised outcomes or excess supplement volume with poor adherence, wastage and undue pressure on this vulnerable group of patients.

The aim of the present study was to measure REE longitudinally in a sample of elderly women following surgery for hip fracture, to describe changes over time and to compare these values to those predicted by routinely applied predictive equations.

**Methods**

**Recruitment of participants**

Admissions to the rehabilitation wards at Repatriation General Hospital (RGH) in Southern Adelaide, Australia were monitored between April and November 2003. All females (≥ 70 years) admitted to RGH within 7 d of hip fracture surgery were potential participants. For inclusion, participants had to reside independently within 20 km of RGH, be medically stable, have no diagnoses of cognitive impairment and not be taking medication affecting energy metabolism. Participants were excluded if they were smokers or had abnormal thyroid function as defined by thyroid stimulating hormone outside of acceptable limits (0.50–4.50 mIU/l). RGH Research and Ethics Committee approved the protocol and all participants provided written informed consent.

**Procedures**

Measurements were performed on days 10, 42 and 84 following surgery. Day 10 was selected as the earliest possible time for measurement of REE without compromising the rate of recruitment as our previous work had indicated rehabilitation admission was at a median of 10 d. Days 42 and 84 were chosen to coincide with timing of outcome assessments in a randomised controlled trial currently under way in our unit. Whilst on the rehabilitation ward (day 10) participants were measured at the bed-side at 07.00 hours following an overnight fast. Measurements on days 42 and 84 were performed at the RGH trial centre with participants transported from home to arrive by 07.00 hours, again after an overnight fast. Participants were instructed to avoid physical activity on the day before and morning of measurement.

REE was measured by a portable open-circuit calorimeter (GEM; NutrEn Technology Ltd, Cheshire, UK). Participants lay in a supine position and measurement of O₂ consumption and CO₂ production were taken every 30 s for 30 min after 10 min acclimatisation. Standard gases and atmospheric air were used for calibration. The measurement precision of the GEM was verified in three ways. Firstly, calibration values for a sample of eighteen subjects (not involved in the current study) were forwarded to the manufacturer who provided confirmation that the GEM was functioning correctly. Secondly, ten staff and family members were measured in triplicate within 2 h (under the same conditions as the study participants) to enable an assessment of the intra-class correlation coefficient. The intra-class correlation coefficient (two-way mixed model) was 0.98, indicating < 2 % measurement error. Finally, monthly whole-system calibration data collected for the duration of the study were assessed. Mean observed RQ was 1.8 % (95 %CI 0.8, 2.7) below the theoretical value, a CV of 1.5 %.

Weight for all participants was measured using calibrated digital scales (Seca Mobila 812; Seca Corporation, Columbia, MD, USA) and knee height using a portable sliding knee height caliper (Ross Laboratories, Columbus, OH, USA). Height was estimated using a standard equation (Chumlea et al., 1985) and estimated BMI (kg/m²) was calculated. The Mini Nutritional Assessment (MNA) was administered to all participants on day 10. The MNA is an eighteen-item nutrition screening tool including measurements of anthropometry and questions relating to dietary intake and health (Guigoz et al., 1994). The MNA has been reported to be a valid and reliable tool to determine nutritional status in older adults across a variety of care settings (Guigoz et al., 1994; Chumlea et al., 1999; Bleda et al., 2002; Persson et al., 2002). A score ≥ 24 classifies individuals as well nourished, 17–23.5 as at risk of malnutrition and < 17 as malnourished (Guigoz et al., 1994).

**Statistical analyses**

Kolmogorov-Smirnov Z tests for normality demonstrated data distributions were not significantly different from normal and hence parametric tests were performed. For change in weight, REE and RQ (days 10, 42 and 84), general linear model repeated measures ANOVA were performed (Crowder & Hand, 1990). To determine change for all pair-wise comparisons, post hoc Bonferroni correction was applied. Estimated REE was calculated (Harris & Benedict, 1919; Schofield, 1985) and adjusted for physiological stress of injury and surgery (Long et al., 1979). To compare measured and predicted REE, the mean difference and 95 % limits of agreement were calculated (Bland & Altman, 1986) and a onesample t test was performed to test whether the mean difference was significantly different to zero. All analyses were conducted using the SPSS for Windows statistical package, version 11.0.0 (SPSS Inc., Chicago, IL, USA).

**Results**

The median (95 % CI) length of stay in rehabilitation for the participants was 16 (13, 23) d. At day 10 the mean (95 % CI) age of the six participants was 85 (78, 91) years. Mean (95 % CI) estimated BMI at day 10 was 26 (23, 30) kg/m² (Table 1). According to the MNA, four participants were classified as well nourished and two at risk of malnutrition (Table 1). Individual and mean (95 % CI) body weight (kg) for each participant is presented in Table 1 for days 10, 42 and 84. Individual and mean (95 % CI) measured REE (kJ/d; kJ/kg per d) for each participant is presented in Table 2 for days 10, 42 and 84. There was a significant
three calorimetric measurements: $0.9 (0.8, 1.0)$ on day 10, $0.9$ for stress, REE predicted by the Harris Benedict and Schofield equations overestimated measured REE in the order of $3–15\%$ for each participant at days 10, 42 and 84, with and without adjusting for stress, REE predicted from the Harris Benedict equation or Schofield equation without adjusting for stress were $8 (-3, 19)$ day 10, $16 (6, 26)$ day 42 and $9 (1, 17)$ day 84. After adjusting for stress, REE agreement for measured and predicted REE (kJ/kg per d) for the similar (Table 2).

Harris Benedict equation were $1(-9, 12)$ day 10, $10 (2, 18)$ day 42 and $9 (1, 17)$ day 84. The mean difference and $95\%$ limits of agreeing that the mixture of fuel oxidised on all three occasions was decrease in measured REE (kJ/d) over time, $P<0.01$ (post hoc Bonferroni days $10–42 P<0.001$, days $42–84 P>0.05$, days $10–84 P=0.02$); weight, $P<0.01$ (post hoc Bonferroni $P<0.05$ for all pair-wise comparisons); and measured REE (kJ/kg per d), $P=0.02$ (post hoc Bonferroni days $10–42 P<0.01$, days $42–84 P>0.05$, days $10–84 P>0.05$).

No change in mean (95 % CI) RQ was observed between the three calorimetric measurements: $0.9 (0.8, 1.0)$ on day 10, $0.9 (0.8, 1.1)$ on day 42 and $1.0 (0.9, 1.0)$ on day 84 ($P>0.05$), indicating that the mixture of fuel oxidised on all three occasions was similar (Table 2).

Without adjusting for stress the mean difference and 95 % limits of agreement for measured and predicted REE (kJ/kg per d) for the Harris Benedict equation were $(-9, 12)$ day 10, $10 (2, 18)$ day 42 and $9 (1, 17)$ day 84. The mean difference and 95 % limits of agreement for measured and predicted REE (kJ/kg per d) for the Schofield equation without adjusting for stress were $(-3, 19)$ day 10, $16 (6, 26)$ day 42 and $16 (10, 22)$ day 84. After adjusting for stress, REE predicted from the Harris Benedict equation or Schofield equation overestimated measured REE by between 38 and 69 %.

Table 3 presents the ratio of predicted REE by measured REE for each participant at days 10, 42 and 84, with and without adjustment for stress of injury and surgery. Without adjusting for stress, REE predicted by the Harris Benedict and Schofield equations overestimated measured REE in the order of $3–15\%$ and $11–25\%$, respectively. Adjusting for stress increased the overestimation of the predictive equations to $38–57\%$ for Harris Benedict and $50–69\%$ for Schofield.

**Discussion**

We found that REE predicted by equations commonly used in the clinical setting overestimated measured REE of elderly females following hip fracture by up to $25\%$ and that REE decreases between day 10 and 42 but is comparatively stable from day 42 to day 84. Whilst the present data do not shed light on the precise timing of the catabolic response our data suggest that adjustments to predictions of energy expenditure to account for the physiological stress of injury and surgery may be unnecessary 10 d or more after the injury.

Numerous clinical nutrition texts (Mahan & Escott-Stump, 2000; Thomas, 2002; Bales & Ritchie, 2004; Todorovic & Micklewright, 2004) recommend the Harris Benedict and Schofield equations for estimating the REE of healthy adults. The validity of these recommendations, however, has recently been questioned given the age of the data used in formulating the predictive equations, the small sample size overall and particularly in the older age groups, and the poor predictive value at the individual level (Reeves & Capra, 2003a). Studies comparing predicted REE using the Harris Benedict equations with measured REE in

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**Table 1.** Nutritional status of six elderly females (≥70 years) 10, 42 and 84 d following hip fracture*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>MNA</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>Weight change (%), day 10–42†</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>Weight change (%), day 42–84‡</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>Weight change (%), day 10–84§</th>
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<tr>
<td>Mean‡</td>
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<td>26</td>
<td>25</td>
<td>62</td>
<td>25</td>
<td>-5</td>
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<td>26</td>
<td>3</td>
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<td>23, 28</td>
<td>51, 72</td>
<td>22, 28</td>
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<td>-4, -1</td>
<td>-4, -1</td>
</tr>
</tbody>
</table>

MNA, Mini Nutritional Assessment (maximum score 30; score of 24 + indicates well nourished).

† Weight change calculated as: (weight at day 42 – weight at day 10)/weight at day 10 and converted to % by multiplying by 100.

‡ Weight change calculated as: (weight at day 84 – weight at day 42)/weight at day 42 and converted to % by multiplying by 100.

§ See this page for statistical differences.

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**Table 2.** Resting energy expenditure (REE; kJ/d; kJ/kg per d) and respiratory quotient (RQ) for six elderly females (≥70 years) 10, 42 and 84 d following hip fracture*

<table>
<thead>
<tr>
<th>Subject</th>
<th>RQ</th>
<th>REE (kJ/d)</th>
<th>REE (kJ/kg per d)</th>
<th>RQ</th>
<th>REE (kJ/d)</th>
<th>REE (kJ/kg per d)</th>
<th>RQ</th>
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<td>3620</td>
<td>70</td>
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<td>3885</td>
<td>75</td>
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<td>2</td>
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<td>3</td>
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<td>3738</td>
<td>72</td>
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<td>4028</td>
<td>76</td>
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<td>5183</td>
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<td>4498</td>
<td>80</td>
<td>1</td>
<td>4175</td>
<td>72</td>
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<tr>
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<td>4717</td>
<td>70</td>
<td>0.9</td>
<td>4070</td>
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<td>0.9</td>
<td>4372</td>
<td>65</td>
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<td>4213</td>
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<td>54</td>
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<tr>
<td>Mean‡</td>
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<td>4704</td>
<td>74</td>
<td>0.9</td>
<td>4090</td>
<td>67</td>
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<td>67</td>
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<tr>
<td>95 % CI</td>
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<td>4354, 5054</td>
<td>63, 84</td>
<td>0.8, 1.0</td>
<td>3719, 4461</td>
<td>59, 76</td>
<td>0.9, 1.0</td>
<td>3908, 4382</td>
<td>57, 76</td>
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</tbody>
</table>

* For details of procedures, see p. 977.

† See this page for statistical differences.

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For statistical differences.
healthy adults suggest the equation consistently overestimates energy expenditure by between 5 and 14 % (Daly et al. 1985; Owen et al. 1986, 1987; Foster et al. 1988; Mifflin et al. 1990; Case et al. 1997). In contrast, the Schofield equation has been shown to both overestimate (McNeil et al. 1987; Shah et al. 1988) and underestimate (Lawrence et al. 1988; Luhrmann & Neuhaeuser, 2004) measured energy expenditure. In addition, it is commonly recommended that estimates of total energy expenditure account for physical activity, physiological stress and required weight gain yet the data to support these correction factors are not well established.

Despite these limitations, the Harris Benedict, Schofield and other similar equations often form the basis for prediction of energy expenditure of acutely ill patients in clinical practice (Reeves & Capra, 2003b). In hip fracture patients, four studies have evaluated the difference between REE estimated using predictive equations and measured RIE via indirect calorimetry. Three of these studies have reported that the equations significantly underestimate measured RIE by between 8 and 20 % (Jallut et al. 1990; Nelson et al. 1995; Paillaud et al. 2000) whilst one study suggests that using the predictive equations of Owen et al. (1986, 1987) can either over- or underestimate RIE by 30 % (Campillo et al. 1992). Direct comparisons between literature findings and the findings of the present study are complicated given the variation in timing of the RIE measurement (days 3, 8/9, 21, 51, 81), the range of predictive equations used for comparison (Harris & Benedict, 1919; FAO/WHO/UNU, 1985; Owen et al. 1986, 1987) and the lack of detail regarding the use of correction factors to adjust for physiological stress related to injury and surgery (Long et al. 1979).

Of the two studies using the Harris Benedict equation for comparison with measured RIE (Nelson et al. 1995; Paillaud et al. 2000), only Paillaud et al. (2000) performed measurements longitudinally at similar intervals post-fracture and used an indirect calorimeter that calculates RIE using the same equation as that used in the present study (de Weir, 1949). Paillaud et al. (2000) reported RIE of fifteen hip fracture patients (mean age 86 years) on approximately days 21, 51 and 81 following surgery and found that on average these patients expended at rest 4700, 4500 and 4600 kJ, respectively, approximately 10 % higher than RIE measured in the present study on days 42 and 84. Based on the measured values of Paillaud et al. (2000), the Harris Benedict equation was found to underestimate measured RIE by 9 %, 5 % and 7 % for days 21, 51 and 81, respectively, whilst in the present study the Harris Benedict equation was found to overestimate measured RIE by 3 % at day 10 and 15 % at days 42 and 84 post-fracture. Participants in the present study were heavier than those in the Paillaud et al. (2000) study (mean 62 kg vs. 48 kg day 42/51 and 64 kg v. 50 kg day 84/81), possibly contributing to the differences observed.

The overestimation is exacerbated if predicted RIE is adjusted for physiological stress, as is commonly recommended (Rolandi & Ullrich, 1994; Reeves & Capra, 2003b). In the present study, the adjustment for stress (35 %; Long et al. 1979) results in RIE predicted by the Harris Benedict equation overestimating measured RIE by 38 % at day 10 post-injury (this increasing to over 50 % if considered at days 42 and 84). The hip fracture literature (Jallut et al. 1990; Campillo et al. 1992; Nelson et al. 1995; Paillaud et al. 2000) is not explicit in reporting whether the predicted RIE includes an adjustment for stress. If we assume not then when RIE data predicted by the Harris Benedict equation in the Paillaud et al. (2000) study are adjusted for stress, predicted RIE overestimates measured RIE by 26 %, 30 % and 28 % at days 21, 51 and 81 post-fracture, respectively. This has important implications for clinical practice as overestimating RIE, the largest contribution to total energy expenditure, may lead to an unnecessarily high prescription of nutritional supplements, place unrealistic expectations on patients, reduce adherence, increase wastage and in some patients result in overfeeding which may compromise health outcomes (Reeves & Capra, 2003a). These implications, however, need to be confirmed by measurement of total energy expenditure. In addition, surplus nutritional supplements may be indicated to prevent weight loss of unknown aetiology early in recovery.

### Table 3. Ratio of predicted resting energy expenditure to measured resting energy expenditure (pREE/mREE) for six elderly females (≥70 years) 10, 42 and 84 d following hip fracture*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Day 10</th>
<th>Day 42</th>
<th>Day 84</th>
<th>Day 10</th>
<th>Day 42</th>
<th>Day 84</th>
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<td></td>
<td>(1.43)</td>
<td>(1.62)</td>
<td>(1.76)</td>
<td>(1.54)</td>
<td>(1.75)</td>
<td>(1.88)</td>
</tr>
<tr>
<td>Mean</td>
<td>1.03</td>
<td>1.15</td>
<td>1.15</td>
<td>1.11</td>
<td>1.25</td>
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</tr>
<tr>
<td></td>
<td>(1.38)</td>
<td>(1.55)</td>
<td>(1.57)</td>
<td>(1.50)</td>
<td>(1.69)</td>
<td>(1.68)</td>
</tr>
<tr>
<td>95 % CI</td>
<td>0.95-1.11</td>
<td>1.08-1.22</td>
<td>1.06-1.24</td>
<td>1.03-1.20</td>
<td>1.16-1.34</td>
<td>1.16-1.33</td>
</tr>
<tr>
<td></td>
<td>(1.28-1.49)</td>
<td>(1.45-1.65)</td>
<td>(1.45-1.69)</td>
<td>(1.38-1.62)</td>
<td>(1.57-1.80)</td>
<td>(1.57-1.80)</td>
</tr>
</tbody>
</table>

* For details of procedures, see p. 977. Values in parentheses are adjusted for a trauma factor of 1.35 (Long et al. 1979).
†‡pREE predicted using equation proposed by Harris & Benedict (1919).
The effect of the bias towards overestimation of REE found in the present study is most evident when considering the findings in relation to the impact on a nutrition support protocol. For example, the Schofield equation estimates unadjusted REE of a 50 kg female (aged >60 years) to be 4655 kJ/d and energy intake of older females following hip fracture is reported as 4200 kJ (Older et al. 1980). The shortfall between estimated total energy expenditure and intake is commonly used as the basis for determining volume of nutritional supplement required, in this case an additional 455 kJ/d would need to be met through 110 ml of 1 kcal/ml oral supplement or equivalent to achieve resting requirements, more if REE is adjusted to account for other components of total energy expenditure such as physical activity. According to the findings of the present study, and using the limits of agreement data, REE predicted at day 10 following injury using the unadjusted Schofield equation could be an underestimate of actual REE (by up to 254 kJ/d) or an overestimate of actual REE (by up to 1297 kJ/d). This has implications for clinical decision making and optimal health outcomes given that nutrition support may be deemed either unnecessary or may result in overfeeding (an extra 1297 kJ/d = 310 ml of 1 kcal/ml oral supplement per day = three times the volume using literature estimates). If corrections are made to predicted REE to account for stress then the potential for overfeeding is increased even further, with volumes almost tripling for the same example. It is important to recognise that total energy expenditure was not measured in the present study and that without accurate measurement using techniques such as doubly labelled water, total energy requirements will continue to be calculated using values that may be inappropriate. Adjusting measured and predicted REE in the earlier example to account for physical activity using available theoretical values or prevention of weight loss does not alter the findings described in the example.

It is important to acknowledge that the hip fracture literature and the findings of the present study do suggest there is a catabolic response to stress but of much less magnitude than that proposed by Long et al. (1979). Our data also suggest that the catabolic response is resolved some time between days 10 and 42. The data from the Paillaud et al. (2000) study, the only other comparable longitudinal study of REE, also suggests that the catabolic response is resolved, possibly by day 21 post-fracture. It is possible that the stress factors applied in the clinical setting are inaccurate or inappropriately applied. The evidence supporting a 35% increase in energy expenditure following skeletal trauma was published by Long et al. (1979) who measured the energy expenditure of various clinical groups (e.g. elective surgery, skeletal trauma, sepsis, burns) using indirect calorimetry and found that energy expenditure increases correlated with severity of the insult. The patients (n not reported but likely to be <10, mean age not reported) contributing to the data for energy expenditure following skeletal trauma had suffered a motor vehicle or motor cycle accident and had multiple long bone fractures, contusions and lacerations. There were no data presented for patients admitted to hospital for surgical repair of a hip fracture, and therefore adjusting energy expenditure estimated by equations using a factor of 35 % is questionable. Furthermore, the Long et al. (1979) stress factors are frequently used with a variety of equations in clinical practice (Reeves & Capra, 2003b) although they were only developed by comparing measured REE using indirect calorimetry with predicted REE from the Harris Benedict equation (Long et al. 1979).

Strengths of the present study compared to the hip fracture literature include that we measured REE following an overnight fast, our sample consisted of only females, we adjusted our data for body weight and we compared measured REE to REE predicted by equations routinely used by clinicians. Our findings that predicted REE is higher than measured REE and that correction for stress is unfounded, however, should be interpreted with caution. Given the small sample size we may not have an accurate representation of the variability in energy expenditure for this clinical group. Tables 1 and 2 clearly demonstrate the large variability in data, likely contributed to by the small sample size. The small sample size also limits any sub-group analyses, for example evaluating differences in energy expenditure according to surgical procedure or determining differences according to nutritional status. For practical reasons we were unable to measure REE until day 10 and therefore we have no data on the period immediately following the injury and post-surgery. The measurements at days 42 and 84 required participants to travel from home to the trial centre on the morning of the measurement as the indirect calorimeter used was unable to be transported to the participants’ home due to its size, weight and fragile component. The impact of this change in setting on the measurement obtained is likely to have been in the direction of a decrease in REE in the home setting which would have led to a greater change over time and a greater overestimation of REE predicted by commonly applied equations. We are also unable to provide a precise description of when the possible catabolic effect ends as we did not undertake any measurements between days 10 and 42. Future research could overcome these limitations through recruitment occurring in trauma units, more frequent measurements being undertaken and measurement of total energy expenditure by use of doubly labelled water to evaluate the contribution of physical activity to total energy expenditure.

The present preliminary results suggest that measured REE is lower than that calculated using commonly used theoretical equations. Given that REE accounts for a substantial proportion of total energy expenditure, energy requirements calculated using these equations in the clinical setting may be overestimated. This overestimation may be even greater if a multiplier is applied to the calculated REE to theoretically account for a metabolic response to injury and surgery. The present results appear to provide no justification for use of an injury factor in theoretical calculations of energy requirements in hip fracture patients. Physical activity is an important component of total energy expenditure, but the relative contribution to energy requirements attributable to activity during rehabilitation after hip fracture is unknown. Additional longitudinal studies to quantify total energy expenditure and the relative contributions of REE, activity and metabolic responses during the post-operative and rehabilitation recovery phases following hip fracture are required to determine the usefulness of the current theoretical equations to predict individual energy requirements for use in the clinical setting.

Acknowledgements

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