The Development of a Prediction Equation to Estimate Resting Metabolic Rate in Healthy, College-aged Students

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Abstract
Our purpose was 1) to measure resting metabolic rate (RMR) in apparently healthy, college age (18-26 yr) students, n=30 (18 women, 12 men), 2) compare measured RMR to estimated values, and 3) to derive a new predictive equation for RMR using body composition. Each subject completed a 30-min RMR test with a portable metabolic analyzer and performed hydrodensitometry to obtain an estimate of body composition. Steady-state VO2 measurements from the last 5-min of each test were extrapolated over 24 hr to determine kcal/day. Age, weight, body fat%, and RMR (mean ± SD) for females was 21±8.0 yr, 62.0±6.1 kg, 23.5±8.8 %, and 1318±202 kcal/day, and for males was 22±6.8 yr, 85.1±16.3 kg, 18.7±7.3%, and 1878±218 kcal/day, respectively. Multiple regression analysis to predict RMR from gender (G) and lean body mass (LBM) resulted in the following model (R²=0.711):

\[
\text{RMR (kcal/day)} = 781.3 + 313.6(G) + 11.4(LBM)
\]

Figure 1. Hydrostatic Weighing Procedure for Body Fat %

Methods

Subjects
18 UWEC students from Biology 354 Physiological Nutrition and 12 student volunteers.

Procedures

Resting Metabolic Rate: All subjects reported to the lab between 6 and 8am having fasted overnight. Subjects were placed in a sitting chair for 30 minutes to return to a resting metabolic condition. Data (O2 uptake, CO2 production, Respiratory Quotient) were collected for 15 minutes using a Cosmed K4BE portable metabolic analyzer with an 18mm turbine. (see picture 2). The first 5 minutes data were discarded and the remaining 10 minutes averaged. Calories expended were calculated from the O2 uptake and the RQ and expressed for a 24-hour period (kcal/day)

Body Composition: Height and weight were measured using standard scales. BMI was calculated as weight in kg height in m². Body density was determined via hydrostatic weighing (see picture 1). Body fat% was calculated from standard equations using body density, and then lean body mass calculated as total body mass minus fat mass.

Statistical analyses

All statistical procedures were completed using SPSS statistical software (Version 16.0). Pearson’s r was calculated to determine the correlation between predicted and measured RMR values. The standard error of the estimate (SEE) was calculated to determine the accuracy of the predicted VO2 versus the measured VO2. The probability of making a Type I error was set at p≤0.05 for all statistical analyses.

Results

Descriptive data are shown in Table 1, for all subjects combined as well as averaged by gender. Measured RMR ranged in our subjects from 850kcal/day to 2172kcal/day. Using the Harris-Benedict equation, RMR was overestimated in 28 of 30 subjects. The combined average overestimation was about 140 kcal/day.

New Predictive Equation

Multiple regression analysis was used to develop a prediction equation for RMR using the following combination of lean body mass and gender as independent variables (R²=0.711):

\[
\text{RMR (kcal/day)} = 781.3 + 313.6(G) + 11.4(LBM)
\]

where G = gender (0 for women or 1 for men) and LBM = lean body mass (kg).

The SEE for the prediction of RMR was 193 kcal/day. The correlation coefficient between predicted RMR and measured RMR values was significant (r = 0.91, p<0.05). Mean difference between predicted RMR and measured RMR values ranged only 3 kcal/day (p<0.05).

Table 1. Physical and metabolic characteristics of participants. (mean ± SD)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Woman (n=18)</th>
<th>Man (n=12)</th>
<th>Combined (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>21.7±0.8</td>
<td>22.4±1.8</td>
<td>22.0±1.3</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168.1±5.8</td>
<td>179.8±6.7</td>
<td>172.7±8.4</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>62.0±6.1</td>
<td>85.1±16.3</td>
<td>72.1±16.0</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.0±2.1</td>
<td>26.2±3.7</td>
<td>23.6±3.5</td>
</tr>
<tr>
<td>Lean Body Mass (kg)</td>
<td>47.2±5.5</td>
<td>68.9±10.1</td>
<td>55.9±13.2</td>
</tr>
<tr>
<td>Estimated RMR (kcal/day)*</td>
<td>1456±65</td>
<td>2072±232</td>
<td>1685±322</td>
</tr>
<tr>
<td>Measured RMR (kcal/day)</td>
<td>1318±202</td>
<td>1878±218</td>
<td>1542±346</td>
</tr>
<tr>
<td>Body Fat Percentage</td>
<td>23.5±8.8</td>
<td>18.2±7.3</td>
<td>21.4±8.6</td>
</tr>
</tbody>
</table>

*Harris-Benedict Equation, circa 1919

Conclusions and Recommendations

- The old, but still widely used Harris-Benedict equation overestimated our subjects daily caloric expenditure by about 140 kcal. This could help explain why few people who carefully monitor their calories in and out are still gaining weight.

- Measurement of RMR via oxygen uptake is preferred to estimates when caloric balance needs to be closely calculated.

- When measurement of RMR is not possible, but body composition can be assessed, our proposed equation for predicting RMR should be more accurate for college-age individuals.

- This equation can be used by health and fitness professionals to provide accurately RMR when oxygen uptake cannot be measured but body composition can be. This information can be used to design safe and effective energy balance programs for fat loss and maintenance.

References


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