Overgewicht, het gevolg van te weinig beweging of teveel eten?

evidence from $^2$H$_2^{18}$O studies

Klaas R Westerterp

Human Biology, Maastricht University

**Synopsis**

Physical activity of modern humans is in line with wild terrestrial mammals

To prevent weight gain: reducing intake is more effective than increasing physical activity

**Outline**

Physical activity assessment

Physical activity in modern man

Training effects

Food intake and physical activity
**Energy expenditure**

Indirect calorimetry: measurement of oxygen consumption and/or carbon dioxide production

- Ventilated hood ->
- Respiration chamber <-
- Doubly labeled water ->

**Doubly labeled water**

*Maastricht protocol, Obes Res 3. SI: 49-58, 1995*

**Principle of $^{2}\text{H}^{18}\text{O}$ method for measurement of energy expenditure**

**Elimination curves $^{2}\text{H}$ and $^{18}\text{O}$**
Validation results $^{2}\text{H}_2^{18}\text{O}$

Non-significant difference with simultaneous chamber results

Reported intake, measured expenditure and body weight

Variation in AEE

PAL 1.2: AEE = 5%

PAL 2.5: AEE = 50%

Conclusions

Maintenance metabolism largest component

Activity energy expenditure most variable

Food intake measurement complicated by misreporting
**Physical activity in ‘modern’ man**

Physical activity energy expenditure has not declined since the 1980s and matches energy expenditure of wild mammals


---

**Design**

Assessment of activity energy expenditure with $^{2}{	ext{H}}_{2}^{18}{	ext{O}}$

Time trend analysis since 1985

Comparison with wild mammals

---

**Residual DEE-BEE**

---

**Significant increase of the DEE-BEE residual in time**

---
No significant change in PAL over time

Energy expenditure and weight

Conclusions

There is no indication that energy expenditure on physical activity or total energy expenditure have declined over the past decades.

Daily energy expenditure of modern humans is in line with the prediction from measurements of wild terrestrial mammals.

Exercise training and AEE

Conclusions

Exercise training can increase energy expenditure.

The effect is a function of food intake and age.

Training and body weight

<table>
<thead>
<tr>
<th>Activity</th>
<th>PAL before</th>
<th>PAL after</th>
<th>Δ Body mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>jogging (40wk)</td>
<td>1.68</td>
<td>2.13 **</td>
<td>- 1.0 *</td>
</tr>
<tr>
<td>weight training (18wk)</td>
<td>1.76</td>
<td>1.92 *</td>
<td>+ 0.1 ns</td>
</tr>
<tr>
<td>cycling (4wk)</td>
<td>1.77</td>
<td>2.04 *</td>
<td>+ 0.5 ns</td>
</tr>
</tbody>
</table>

ns non-significant, * p<0.05, ** p<0.01

Adapted from Kempen et al., Am J Clin Nutr 1995;62:722-9
Exercise, FFM and RMR

Energy intake and expenditure in elite athletes

Exercise, FFM and RMR in non-athletes

Training, body mass and SMR in non-athletes
Conclusions

Elite athletes have an increased FFM

Elite athletes have an increased FFM_{adj}. RMR

Exercise induces a reduced RMR when BM is not maintained

Under-eating and AEE

Energy saved by 24 weeks semi-starvation in the Minnesota Experiment

<table>
<thead>
<tr>
<th></th>
<th>(MJ/d) (%) of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMR</td>
<td>2.6 32</td>
</tr>
<tr>
<td>DEE</td>
<td>0.8 10</td>
</tr>
<tr>
<td>NEAT</td>
<td>4.7 58</td>
</tr>
<tr>
<td>Total</td>
<td>8.0 100</td>
</tr>
</tbody>
</table>

Main saving on energy expenditure from reduced AEE


Conclusions

A reduction in food intake decreases energy expenditure

Activity induced energy expenditure shows the largest decrease
**Moving less**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>27±5</td>
<td>39±8***</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>22.8±2.0</td>
<td>24.3±2.6**</td>
</tr>
<tr>
<td>Resting energy expenditure (REE, MJ/d)</td>
<td>6.76±0.98</td>
<td>6.84±1.00</td>
</tr>
<tr>
<td>Total energy expenditure (TEE, MJ/d)</td>
<td>12.19±1.82</td>
<td>11.95±1.77</td>
</tr>
<tr>
<td>Activity energy expenditure (0.9xTEE-REE, MJ/d) x</td>
<td>4.21±1.05</td>
<td>3.92±1.19*</td>
</tr>
<tr>
<td>Physical activity level (TEE/REE)</td>
<td>1.81±0.16</td>
<td>1.75±0.11**</td>
</tr>
</tbody>
</table>

*Calculation based on a fixed 10% of TEE for diet induced energy expenditure. * P<0.05; ** P<0.01; *** P<0.001 for difference with baseline (n=40).

**Weight change over 12 year**

**Conclusions**

Eating more does not result in moving more
Eating less results in moving less
Moving more results in eating more
Moving less is not compensated by an equivalent intake reduction