Energy expenditure in response to energy intake and physical activity

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Background

Energy balance can be maintained by adapting intake to expenditure and vice versa

Key variables are food intake and physical activity

Objectives

Does a change in intake affect activity?

Does a change in activity affect intake?

Model

Total = basal + diet + activity expenditure

TEE = BEE + DEE + AEE

DEE = 0.1 EI (energy intake)

1 kg weight change = 75% FM + 25% FFM

Overeating and physical activity

<table>
<thead>
<tr>
<th>Reference</th>
<th>Subjects</th>
<th>Overfeeding</th>
<th>PA_basal</th>
<th>PA_dark</th>
<th>PA_light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roberts et al.</td>
<td>6 males, normal weight</td>
<td>3 weeks + 2 60</td>
<td>1.03±0.13</td>
<td>1.45±0.02</td>
<td></td>
</tr>
<tr>
<td>Drexler et al.</td>
<td>3 males, 10% bodyweight</td>
<td>6 weeks, 10% baseline</td>
<td>1.4±0.22</td>
<td>1.4±0.25</td>
<td></td>
</tr>
<tr>
<td>Weseloh et al.</td>
<td>4 females, normal weight</td>
<td>3 weeks, 30% baseline</td>
<td>1.4±0.12</td>
<td>1.4±0.05</td>
<td></td>
</tr>
<tr>
<td>Jensen et al.</td>
<td>6 females, normal weight</td>
<td>3 weeks, 100% baseline</td>
<td>1.7±0.18</td>
<td>1.7±0.31</td>
<td></td>
</tr>
</tbody>
</table>

* Significantly different from baseline (p<0.05).
* Physical activity: light: subjects worked out; moderate and light, moderate: activity expenditure as a multiple of resting energy expenditure.

Discussion

Overeating increases total energy expenditure with ~10% due to:

- Increased diet induced energy expenditure
- Storage cost of excess nutrients

No effect when overfeeding is lower than twice maintenance requirement

Discussion

Undereating decreases total energy expenditure with ~20% due to:

- Decreased basal energy expenditure
- Decreased diet induced energy expenditure
- A reduction of activity energy expenditure

Exercise training increases energy expenditure, especially in younger subjects with ad libitum intake

Exercise training hardly affects body weight, through a compensatory increase of intake

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Exercise training and body weight

<table>
<thead>
<tr>
<th>Reference</th>
<th>Subjects</th>
<th>Training mode</th>
<th>EE Expenditure</th>
<th>E Body</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brighten et al. (1984)</td>
<td>2 females, 3 males, normal weight</td>
<td>jogging for 8 weeks</td>
<td>+1.2a</td>
<td>-0.7a</td>
<td></td>
</tr>
<tr>
<td>Shi et al. (1992)</td>
<td>10 boys, obese</td>
<td>cycling for 4 weeks</td>
<td>+2.9b</td>
<td>+0.2c</td>
<td></td>
</tr>
<tr>
<td>Westerterp et al. (1996)</td>
<td>6 females, 8 males, normal weight</td>
<td>jogging for 40 weeks</td>
<td>+2.3***</td>
<td>-0.9**</td>
<td></td>
</tr>
<tr>
<td>Visscher et al. (1967)</td>
<td>12 males, normal weight</td>
<td>weight training for 12 weeks</td>
<td>+0.8**</td>
<td>-1.1***</td>
<td></td>
</tr>
</tbody>
</table>

Exercise induces increased energy intake

**P<0.05, ***P<0.01, ****P<0.001, for significant differences with baseline, #, not statistically significant
Discussion

A change to a more sedentary routine does not induce an equivalent reduction of energy intake

Physically active subjects have an increased risk of fattening

Conclusions

• Overeating does not affect physical activity
• Undereating decreases habitual physical activity

• Exercise induced energy expenditure is compensated by increased intake
• A more sedentary lifestyle does not induce an equivalent reduction of intake

Discussion

The asymmetric activity response has important consequences for the regulation of energy balance

Resting metabolic rate

Overeating and undereating induce changes in diet induced energy expenditure, being on average 10% of intake

Additionally, basal metabolic rate is affected by undereating
Measured versus predicted SMR

SMR reduction is sustained as long as weight loss is maintained

Discussion
Eating less induces a reduction of REE
Eating more does not induce an increase in REE
The asymmetric response has consequences for the regulation of energy balance

Simulation
From energy equilibrium in reference man:
Increasing intake 750 kJ/d induces a weight increase of 1 kg in 40 days
Decreasing intake 750 kJ/d induces a weight decrease of 1 kg in 55 days

Discussion
It takes 40 days to gain 1 kg and more than 55 days to lose that kg again with a 750 kJ/d intake manipulation as eating less reduces REE and AEE

Conclusions
It is easier to gain than to lose weight
Preventing weight gain by eating less is most effective