Appetite control, Food Choice and Physical Activity - Implications for Energy Balance and Weight Control

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Energy Balance and Active Living: Perspectives on Obesity Prevention

Health Promotion Board Singapore
Challenges

• How to prevent overconsumption?
• How to reduce sedentariness; Promote physical activity?

• What is the impact of physical activity on appetite control?
• Does exercise induce compensation?

• How does exercise influence energy balance?
• Does exercise help weight loss (weight control) or is it futile?
Obesogenic Environment

• Promotes overconsumption

• Deters physical activity
Obesogenic Environment

• A note on overconsumption...........It’s not just about food.
• We overconsume all material goods on the planet.
• We have too many.....................and too much of everything!
• Food consumption is just a specific aspect of general over-consumption

The role of behaviour in energy balance

Energy Intake

100% behaviour

40-45% CHO
12-15% Protein
>40% Fat

20 – 40% behaviour

Effect of behaviour on behaviour but routed through physiology

Physical Activity

20-40% DIT
10%

BMR

50-70%
Some interesting facts about human food choice (has implications for interventions)

• We are OMNIVORES (not herbivores or carnivores)
• This means that our food repertoire is huge
• What to eat requires decisions
• But, what we eat is not heavily pre-programmed biologically (has to be flexible)
• Determined by culture, geography, climate, religion.
• Within a culture large variety of individual eating patterns
• Range of food choice influenced by palatability (taste).
Increasing fatness weakens appetite control

Increasing fatness deters people from doing physical activity
Systematic reviews

• Cochrane review: ‘exercise has a positive effect on body weight and cardiovascular risk factors in people with overweight and obesity, particularly when combined with a diet (Shaw et al, 2006)

• ...for people starting an exercise programme, this leads to ‘a negative energy balance and a remarkably consistent loss of body fat in relation to the net cost of exercise training’ (Elder and Roberts, 2007).

Summary statements not spectacular, but they are positive
INTERACTION BETWEEN PHYSICAL ACTIVITY, APPETITE and BODY WEIGHT

SPECIAL COMMUNICATIONS

Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults

Position Stand

This pronouncement was written for the American College of Sports Medicine by Joseph E. Donnelly, Ed.D. (Chair); Steven N. Blair, PED; John M. Jakicic, Ph.D.; Melinda M. Manore, Ph.D., R.D.; Janet W. Rankin, Ph.D.; and Bryan K. Smith, Ph.D.
INTERACTION BETWEEN AMOUNT OF PHYSICAL ACTIVITY and BODY WEIGHT

Figure 3. Percentage weight loss by physical activity categories (minutes per week) (n=170).

Figure 4. Percentage weight loss by physical activity categories (kilocalories per week) (n=170).

(Jakicic, 2008)
Adipose tissue

Signals from GI tract

Influence from FFM and RMR

Hedonic inputs

SATIETY CASCADE

Meal timing
Meal size
Energy expenditure
Reproductive competence

Hypothalamus

Visfatin
Adiponectin

Leptin

Glutamic acid (aspartate and glutamate)

PYY3-36
OXM

GLP-1

GIP

PP
Amylin

Pancreas

Incretin action

Chemosensors

Vagal afferents

Simple model of appetite control

Modified after Badman and Flier, Science 2005
Satiety Cascade

Blundell, Rogers and Hill, 1987)
The Satiety Cascade

FOOD

Sensory
Cognitive
Post-ingestive
Post-absorptive

Early
Late

Satiation

Glucose - Insulin - Ghrelin - CCK - GLP1 - PYY

Hunger Fullness
8000 kcal per 1 kg body weight rule - incorrect
The importance of energy expenditure for energy intake (appetite control)

Fast food and sedentary lifestyle: a combination that leads to obesity\(^1,2\)

*David R Jacobs Jr*

Late Henry L Taylor favored a model that linked energy intake to energy expenditure in a J-shaped curve (personal communication, late 1970s). The first part of his concept was that energy intake is in exact homeostasis with energy expenditure under conditions of high energy expenditure. The second part was that there is a failure of homeostasis in a sedentary lifestyle because of its accompanying low energy expenditure. He postulated that body signals go awry in sedentary lifestyles; when a person does no physical work, the body will not recognize that it is being overfed. Sedentary persons may lose the innate ability to compensate for inactivity by reducing their eating. Neither Bes-
CLASSIC STUDY OF JEAN MAYER IN 1950s

DRAWS ATTENTION TO THE IMPLICATIONS FOR FOOD INTAKE OF BEING IN AN ACTIVE OR SEDENTARY STATE

Mayer, Roy and Mitra 1954
### REACTIV Programme: Comparing active and sedentary young adults

<table>
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<th>Mean</th>
<th>SD</th>
<th>P</th>
</tr>
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<td><strong>BMI (kg/m2)</strong></td>
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<tr>
<td>A</td>
<td>22.8</td>
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<tr>
<td>SED</td>
<td>22.9</td>
<td>2.3</td>
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<tr>
<td><strong>%FM</strong></td>
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<td><strong>FM (kg)</strong></td>
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<td>0.008</td>
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<tr>
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<td>7.9</td>
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<td><strong>FFM (kg)</strong></td>
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<td>71.0</td>
<td>8.7</td>
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<td>SED</td>
<td>59.9</td>
<td>3.4</td>
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<td><strong>RMR (kcal)</strong></td>
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<td>A</td>
<td>2050.1</td>
<td>264.9</td>
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<tr>
<td>SED</td>
<td>1764.9</td>
<td>219.2</td>
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**Experimental Platform: Psychobiological Systems Approach**

| Environment   | • Obesogenic  
|               | • Nutrition and **Energy density**  
| Behaviour     | • **Energy Intake**  
|               | • Physical activity  
| Psychology    | • **Appetite sensations**  
|               | • Hedonics  
| Physiology    | • **Energy expenditure**  
|               | • Gut peptides  
|               | • **Body composition**  
| Metabolism    | • **Resting metabolic rate**  
|               | • **Substrate oxidation**  
| Genetics      | • Allelic variation  
|               | • **Polymorphisms**  
| Time          | • **Adaptive capacity of system**  
|               | • **Durability of phenomena**  

**Strength of the systems approach lies in its capacity to integrate variables that otherwise would be isolated from each other.**

**Research Investigations follow a series of clinical trials**
12 week aerobic exercise program

- 5 exercise sessions per week
  - ~ 500 kcal per session
  - 70% HR max
  - Overweight/obese Ss: mean BMI 31.7: mean age = 43

- **PA Supervised and measured**

- Food intake measured objectively in intensive Probe Days

- Evaluate relationship between variables in the sedentary state (week 0) and after a period increased energy expenditure (week 12)
Take people from a sedentary to an active state

Study Procedure

Probe Day 1
High Fat Exposure

Probe Day 2
Low Fat Exposure

Probe Day 3
Low Fat

Probe Day 4
High Fat

Probe Day 5
High Fat

Probe Day 6
Low Fat

Subjects:
Main group
• Overwt & obese
• 12 wk exercise

12 week aerobic exercise

Multilevel analysis
• Total within-day energy intake (probe days)
• Appetite sensations
• Hedonics: food liking and implicit wanting
• Eating behaviour traits
• GI biomarkers (wk0 & 12)
• Resting metabolism and substrate oxidation
• Body composition (FM and FFM)
## RESULTS: Body Composition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Week 0</th>
<th>Week 12</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Body Mass (kg)</strong></td>
<td>90.9 ± 12.1</td>
<td>87.6 ± 12.4</td>
<td>-3.3 *</td>
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<tr>
<td><strong>Absolute Fat Mass (kg)</strong></td>
<td>31.9 ± 9.4</td>
<td>28.6 ± 9.8</td>
<td>-3.3 *</td>
</tr>
<tr>
<td><strong>Fat Mass (%)</strong></td>
<td>34.8 ± 7.8</td>
<td>31.9 ± 8.4</td>
<td>-2.1 *</td>
</tr>
<tr>
<td><strong>Waist Circumf (cm)</strong></td>
<td>101.5 12.4</td>
<td>96.5 11.8</td>
<td>-5.0 *</td>
</tr>
<tr>
<td><strong>Lean Mass (kg)</strong></td>
<td>59.2 ± 9.5</td>
<td>59.2 ± 10.7</td>
<td>0.0 ± 2.8</td>
</tr>
</tbody>
</table>

*Significant difference between week 0 & week 12 (P< 0.01)
Individual Variation in BW & FM Following 12 Weeks of Exercise

Range
Body Mass (kg): -14.7 to +2.0 kg
Fat mass (kg): -10.3 to +2.6 kg

(King et al IJO 2008; AJCN 2009)
• The average is an abstraction. Reality is variation.

• Important message: effects of exercise vary from person to person

• Blastland and Dilnot (2005) The Tiger that isn’t.
• Silver (2012) The Science of Prediction
• Blastland and Siegenhalter (2013) The Norm Chronicles
Daily Energy Intake

* NR have a significant increase in EI (Wk0 – Wk12; p<0.005)
HUNGER IS AN IMPORTANT SENSATION – A RISK FACTOR FOR EATING

HUNGER IS A BIOMARKER OF THE INTENTION OR WILLINGNESS TO EAT
Daily Hunger (AUC)

**NR have a significant increase in hunger (P = 0.002)**
But how does exercise affect meal to meal control?

• What is called post-prandial satiety.

• This can be measure by the use of the ‘Satiety Quotient’ (SQ)

• Suppression of hunger after a meal – in relation to the calories consumed.
12 weeks of exercise increases satiety in both susceptible and resistant individuals

Increase in satiety is independent of changes in body weight
FIGURE 1—Changes in anthropometric variables from week 0 to week 12 for overweight and obese males and females (mean ± SEM).

Caudwell et al, MSSE 2013.
Influence from FFM and RMR

Adipose tissue

Signals from GI tract
Post-prandial Satiety (measured by Satiety Quotient)

Responders

Non Responders

Responders - Wk0 vs Wk12

Non Responders - wk0 vs Wk12

GLP-1

Fasting GLP-1 levels (ng/l)

Week 0

Week 12

**

PYY

Fasting PYY levels (ng/l)

Week 0

Week 12

**

CCK

Fasting CCK levels (pmol/l)

Week 0

Week 12

**
Changes in health markers are **independent** of changes in body weight.
The power of energy density

PASSIVE OVERCONSUMPTION

- High ED foods increase meal size
- High ED foods increase food intake by ~ 30% or 800 kcal
- High RMR increases meal size

Caudwell et al AJCN 2013, 97: 7 - 14
To control Energy Balance (and therefore obesity) you need to control **BOTH** energy expenditure (physical activity level) **AND** energy intake (food consumption).

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th></th>
<th>Men</th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Week 0</td>
<td>Week 12</td>
<td>Week 0</td>
<td>Week 12</td>
</tr>
<tr>
<td>Resting metabolic rate (MJ/d)</td>
<td>6.59 ± 1.12</td>
<td>6.53 ± 0.68</td>
<td>8.09 ± 1.08</td>
<td>8.13 ± 1.03</td>
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<tr>
<td>HED meal size (MJ)</td>
<td>6.35 ± 224</td>
<td>5.55 ± 2.29</td>
<td>8.46 ± 2.46</td>
<td>9.40 ± 3.53</td>
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<tr>
<td>LED meal size (MJ)</td>
<td>4.18 ± 1.64</td>
<td>3.74 ± 1.52</td>
<td>5.70 ± 1.71</td>
<td>5.50 ± 1.79</td>
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<tr>
<td>HED daily EI (MJ)</td>
<td>13.19 ± 2.93</td>
<td>12.77 ± 2.84</td>
<td>15.69 ± 3.04</td>
<td>16.63 ± 2.81</td>
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<tr>
<td>LED daily EI (MJ)</td>
<td>9.49 ± 2.00</td>
<td>9.04 ± 1.61</td>
<td>11.84 ± 1.89</td>
<td>11.24 ± 1.91</td>
</tr>
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</table>

**EI:RMR ratio of 1.9 for high energy dense diet**

Caudwell et al AJCN 2013, 97: 7 - 14
Regulated zone

Non-regulated zone

Increasing physical activity improves satiety signalling.

Becoming sedentary does not downregulate food intake.

Favours increase in body fat.

Improves body composition.

Blundell, 2011 Nut Bull
BioPsychology: Energy Balance and Appetite Regulation Group

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