Energy Balance: You can’t do just one thing.

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Disclosure

I have received financial and other benefits from the following entities: the Frontiers Foundation; The Federal Trade Commission; and numerous additional government, non-profit and for-profit (including publishing, food, beverage, and pharmaceutical companies) organizations with interests in obesity, nutrition, and health.
Outline

1. The Concept of Energy Balance.
2. Passive Compensation
3. Active Compensation – General
4. Active Compensation in Response to Physical Activity manipulation
5. Active Compensation after Intake Manipulation
6. Active Compensation after Other Manipulations
7. Allostatic vs Homeostatic Adaptation
8. For whom and under which circumstances?
9. Conclusions
"You cannot do only one thing." ~ Garrett Hardin

For every action, there is an equal and opposite reaction.
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The Fallacy of Static Energetic Predictions

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Failure to Consider Energy Balance as an Adaptive System

Examples: Consider these unstated and completely opposite implicit assumptions:

Reduce Restaurant Dining – Implicit Assumption is undercompensation.

Eat Breakfast Everyday – Implicit assumption is overcompensation.


Kral et al. 2011
Available Models Account for Passive Compensation, Under the Assumption of No Active Compensation

- NIDDK Body Weight Simulator: http://bwsimulator.niddk.nih.gov/

- Pennington Multi Subject Weight Change Predictor: http://www.pbrc.edu/research-and-faculty/calculators/mswcp/
Pediatric Public Health Intervention Calculator Uses Model that Assumes no Active Compensation

Biological Organisms Are Adaptive Systems

A model that accounts for the fully adaptive system of energy balance will account for both passive and active compensation.

Free-living Compensation Model Project

- Free-living adults with at least one objective measure of $\geq 80\%$ compliance
- Studies $N=31$, 40 treatment arms adjusted for control effects
- Diet ($n=4$), Exercise ($n=15$), Overfeeding ($n=9$)
High agreement between “no active compensation” prediction models, $r = .98$
Observed versus “no active compensation” prediction
Observed versus no active compensation prediction
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Compensating during exercise regimen by increased EI, not decreased EE

- **Sample:** 54 middle-aged men with sedentary lifestyles (BMI: 28±3)

- **Methods:** Used synchronized accelerometry and heart rate to observe prescribed and non-prescribed PAEE during an 18-week exercise intervention, plus 2 week “detraining period”

- **Results:** No significant decrease in non-prescribed PAEE to compensate for prescribed PAEE

- **Conclusion:** Losing less weight than predicted by PAEE likely a result of increased energy intake (both groups were allowed to eat *ad libitum*)

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**Figure 1.** Physical activity energy expenditure (PAEE) throughout the study, no exercise group vs. prescribed exercise.
Metabolic and Behavioral Compensatory Responses to Exercise Interventions

Potential Methods of Compensation

Increased Energy Intake

Decreased Duration of non-exercise Energy Expenditure

Energy Intake increases in compensators with intensity of exercise. No exercise (Nex), moderate (Mex), and heavy (Hex), adapted from Stubbs et al. (2004)

Duration of non-exercise physical activity during a walking weight loss trial. Before the trial (PRE), non-walking days (INT-NW), walking days (INT-W), and after the trial (POST), adapted from Colley et al. (2005)

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How about Primates?

A rapidly occurring compensatory decrease in physical activity counteracts diet-induced weight loss in female monkeys.

“18 adult ovariectomized female monkeys were placed on a low-fat diet, and available calories were reduced by 30% compared with baseline consumption for 1 mo. Surprisingly, there was not significant weight loss.”

Projection of Effects in a Non-Adaptive System

Observed Effect in Single-Event Randomized Study (142 kcal deficit).

Erroneously predicted 1 year weight loss with 3500 kcal rule = (142*365)/3500 = 14.8 lbs.

Projected effect in of a 142 daily deficit assuming no adaptation = 4.9 lbs at 1 year.


http://www.pbrc.edu/research-and-faculty/calculators/weight-loss-predictor/
Short-Term Studies Are Insufficient: Example - Learned Compensation in Humans

Learned Caloric Adjustment of Human Intake

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Laboratoire de Neurobiologie de la Nutrition E.P.H.E., Université Paris 6

JOSEPH HOSSENLOPP
Ecole Nationale des Sciences de l’Industrie Alimentaire

*Appetite, 1989, 12, 95–103*
Metabolic and Behavioral Compensations in Response to Caloric Restriction (CR)

- **Subjects**: 48 (36.8 ± 1 y), overweight (BMI: 27.8 ± 0.7) participants randomized into 1 of 4 groups: Control, CR+Exercise (12.5%↓ EI+12.5%↑ EE), CR (25%↓ EI), and Low-Calorie Diet (LCD, 15% weight reduction and maintenance)

- **Results**: CR, LCD, and CR/LCD groups had significantly different TDEE from baseline at M3, and CR/LCD at M6; CR+EX did not have significantly different TDEE after intervention

- **Conclusion**: CR causes a “metabolic adaptation” by decreasing TDEE, but not when combined with EX as in the CR+EX group

TDEE for each group at M3 and M6. * indicates TDEE is significantly different from baseline measurement (TDEE corrected for sedentary energy expenditure). CR and LCD combined to obtain sufficient power at M6.

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Lovejoy et al.

Consumption of a controlled low-fat diet containing olestra for 9 months improves health risk factors in conjunction with weight loss in obese men: the Ole' Study.

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Fig. 2. Food intake and body weight as functions of duration of exercise in normal adult rats.


See also:


**FIGURE 12-5** Body weight gain in various arctic expeditions lasting between 3 and 12 months.
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Results indicate that simply reading about physical activity leads participants to compensate by serving themselves more snacks.

...we have consumer camp ...At one of these, we said, “We’re through for the day but dinner isn’t ready yet so we’re going to take a one-mile walk around Beebe Lake.” The students who set the pace told them that it was either an exercise walk or a scenic walk.

... And it was an easy walk but the same pace and distance in both cases.

When they got back, they were given dinner, and they ended up eating more calories if they had been on the exercise walk. And most of the increase was from dessert. The exercise group estimated that they had burned more calories, and they ended up eating more calories.

http://ht.ly/5WJCV

Design: In a randomized, counterbalanced design, 11 active male participants completed 3 experimental trials in a fasted state: exercise in the heat (36°C), exercise in a neutral temperature (25°C), and a resting control (25°C). The exercise trials consisted of treadmill running for 40 min at 70% $\dot{V}O_2$peak. After each trial, participants were presented with a buffet-type breakfast of precisely known quantity and nutrient composition, which they could consume ad libitum.
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Because we cannot yet predict long-term changes in integrated energy balance from short-term studies of single components of energy balance, in research to determine efficacy and effectiveness (as opposed to studying potential mechanisms and promising approaches), we:

<table>
<thead>
<tr>
<th>Do Not Need</th>
<th>Need</th>
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<tbody>
<tr>
<td>• Surrogate or Intermediary Endpoints</td>
<td>• Ultimate Endpoints (e.g., weight, body composition)</td>
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<tr>
<td>• Weak non-randomized designs</td>
<td>• RCTs (or at minimum quasi-experiments)</td>
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<td>• Short-term studies</td>
<td>• Long-term studies</td>
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“...let us take this path through the woods...”

~ Jean-Jacques Rousseau