Food and Physical Activity Environments

An Energy Balance Approach for Research and Practice

Christina D. Economos, PhD, Daniel P. Hatfield, PhD, Abby C. King, PhD, Guadalupe X. Ayala, PhD, MPH, Mary Ann Pentz, PhD

Increases in the prevalence of overweight and obesity are a function of chronic, population-level energy imbalance, whereby energy intakes exceed energy expenditures. Although sometimes viewed in isolation, energy intakes and expenditures in fact exist in a dynamic interplay: energy intakes may influence energy expenditures and vice versa. Obesogenic environments that promote positive energy balance play a central role in the obesity epidemic, and reducing obesity prevalence will require re-engineering environments to promote both healthy eating and physical activity. There may be untapped synergies in addressing both sides of the energy balance equation in environmentally focused obesity interventions, yet food/beverage and physical activity environments are often addressed separately. The field needs design, evaluation, and analytic methods that support this approach. This paper provides a rationale for an energy balance approach and reviews and describes research and practitioner work that has taken this approach to obesity prevention at the environmental and policy levels. Future directions in research, practice, and policy include moving obesity prevention toward a systems approach that brings both nutrition and physical activity into interdisciplinary training, funding mechanisms, and clinical and policy recommendations/guidelines.

(Am J Prev Med 2015;48(5):620–629)

Overview

Recent increases in the prevalence of obesity in the U.S. (>33% of adults and 17% of youth)[1] and worldwide[2] are the result of widespread, chronic energy imbalance—that is, higher energy intakes (EI) relative to energy expenditures (EE). Such widespread energy imbalance is linked to environmental factors that influence EIs and EEs at the population level.[3] Some evidence suggests that there are advantages to taking an integrated approach to understanding and intervening in food/beverage and physical activity environments. A small number of studies, including two large community-based trials in the U.S. and Australia,[4,5] have taken such an integrated approach, altering the environment at multiple levels (including schools, homes, and communities) and successfully reducing excess weight gain in children. School-based approaches that target both diet and physical activity hold promise for childhood obesity prevention compared to the alternative of treating adult obesity through lifestyle changes. However, in environmentally focused research and practice efforts, diet ("energy in") and physical activity ("energy out") are often addressed separately. The objectives of this paper are to link the concept of energy balance to environmental correlates of obesity and discuss opportunities when taking an energy balance approach to environmentally oriented obesity prevention work.

Introduction to Energy Balance

The first law of thermodynamics, that energy can neither be created nor destroyed, dictates that, in humans, EIs must either be expended or else stored. EIs are a function of both volume and energy density of consumed foods and beverages, whereas total EEs are mostly attributable to basal metabolic rate (BMR) and physical activity. BMR includes the energy required for normal metabolic processes while a body is at rest; it increases proportionately to body mass, particularly lean mass.[6] Physical activity expenditures, energy required for movement produced by skeletal muscles, is the most modifiable

From the Friedman School of Nutrition Science and Policy (Economos, Hatfield), Tufts University, Boston, Massachusetts; Health Research and Policy Department and the Stanford Prevention Research Center (King), Department of Medicine, Stanford University School of Medicine, Stanford; San Diego State University and the Institute for Behavioral and Community Health (Ayala), San Diego; and the Keck School of Medicine (Pentz), University of Southern California, Los Angeles, California

Address correspondence to: Christina D. Economos, PhD, Tufts University, 150 Harrison Ave., Boston MA 02111. E-mail: christina.economos@tufts.edu.

0749-3797/$36.00

http://dx.doi.org/10.1016/j.amepre.2014.12.007

component of EEs; its value depends on volume of activity and energy cost of that activity.[7]

Changes in body weight depend on the difference between EE and EI: weight gain occurs when EI exceeds EE and the difference is stored (about 60%–80% as fat), and weight loss occurs when EE exceeds EI and stored mass (likewise approximately 60%–80% fat) is used to make up the gap.[8] There are several important sources of variability in energy balance dynamics over the life course. For example, during childhood and adolescence, energy needs increase because of the energy cost of growth and development, as well as increases in BMR and physical activity expenditures associated with increased body mass. Later in life, aging adults typically experience gradual losses in lean mass, thus reducing energy needs.

It is commonly assumed that a fixed reduction in EI will be linearly associated with changes in weight over time—for example, that reducing EI by 100 kcals/day over 35 days will lead to a net negative 3,500-kcal contribution to energy balance and, in turn, 1 fewer pound of body weight gain compared with no changes in EI.[7] However, energy costs of BMR and physical activity decrease as weight decreases, so associations between changes in EI and changes in energy balance are in fact non-linear[7] and EI may need to be increasingly reduced over time to sustain a consistent rate of weight loss.[9]

For overweight/obese individuals who are losing weight, increasing physical activity lessens the extent to which EI must be reduced and may therefore increase the likelihood that weight loss will be maintained.[10] However, the rate at which weight loss occurs may decrease as individuals approach normal body weight. One way to characterize how EI, EE, and current weight status could achieve energy balance in the same individual is depicted in Figure 1 as a "sweet spot." As long as EI and EE remain within the box, energy balance is achieved and obesity is conceivably averted. The flexibility of operating within the box, instead of reducing daily EI or increasing EE by a fixed amount, recognizes that energy balance can be achieved in diverse ways, which may vary depending on the environmental contexts in which behaviors are enacted.

For obesity prevention, reducing total positive energy balance by about 100 kcals/day in adults[11] and by about 150 calories/day in children[12]—the so-called "energy gap"—may avert most excess weight gain at the population level. Closing the energy gap may in principle be achieved through reduced EI, increased EE, or a combination of both. However, it is important to note that dietary and physical activity behaviors strongly influence each other and therefore cannot be viewed in isolation.[7] For example, increases in physical activity tend to be accompanied by increased hunger and, in turn, increased caloric intakes.[13] Therefore, efforts to reduce positive energy balance through physical activity alone may be ineffective if environments promote overconsumption in response to hunger cues. Conversely, some evidence suggests that people engaging in high levels of physical activity may be most capable of regulating EI to match energy needs,[7] whereas those engaging in very low levels of physical activity demonstrate impaired regulation of caloric intakes.[14] Thus, efforts to promote appropriate caloric intakes may be most successful if complemented by efforts to increase EE by increasing activity.

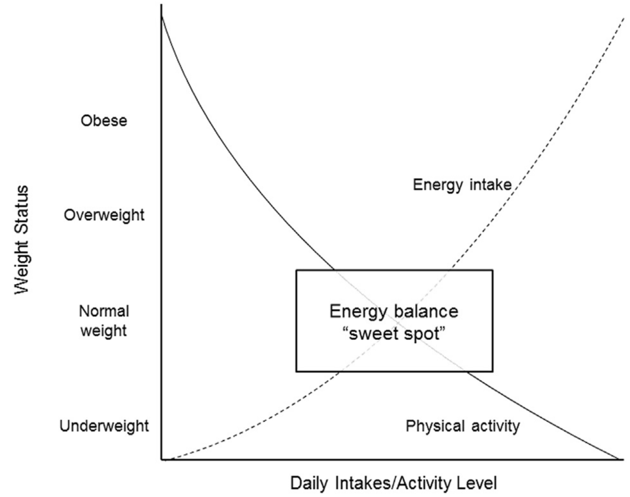

Figure 1. The energy balance "sweet spot."

Obesogenic Environments

Globally, increases in the prevalence of obesity tend to follow inter-related economic, social, and environmental shifts that affect both sides of the energy balance equation. Economic development generally increases total food availability, particularly of energy-dense products, such as added sugars, refined grains, and animal-based foods.[15] Concomitant reductions in EE are typically attributable to declines in levels of household work, occupational physical activity, and active transportation, trends related in part to increased access to labor-saving technologies.[16] In the U.S., rises in obesity prevalence since the 1970s coincided with pronounced increases in EI and decreases in EE, attributable in large part to changes in the food/beverage and physical activity environments. One study[17] using nationally representative data sets found that U.S. adults consumed an average of 1,803 kcals/day in 1977–1978, 1,949 kcals/day in 1989–1991, 2,145 kcals/day in 1994–1998, and 2,374 kcals/day in 2003–2006. These increases were driven by a combination of Americans' consumption of more