Environmental Factors Influencing Obesity

Updated: November 24, 2010

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THE OBESITY EPIDEMIC

Obesity is a global public health problem that plagues 400 million persons worldwide. The gravity of the dramatic rise in obesity and its consequences on health and quality of life cannot be overemphasized. In the United States, obesity is associated with more preventable deaths than any single factor other than cigarette smoking. Most of this associated mortality is mediate through major chronic diseases related to obesity, such as cardiovascular disease (mainly heart disease and stroke), diabetes, and cancer.

With an unexplained and escalating prevalence over the past three decades, obesity has features of an *epidemic* , an outbreak of disease that spreads more quickly and more extensively than would normally be expected. Since 1980, the prevalence of obesity has doubled among American adults (from 15% to over 34%) and tripled among youth, 2 through 19 years of age (from 5.5% to 16.9%). Although the trend of increasing obesity is seen across all ethnic/racial, socioeconomic, and educational groups, there are disparities in certain segments of the population. For example, obesity is more prevalent among non-Hispanic black women (49.6%) and Mexican-American women (45.1%) than non-Hispanic white women (33.0%). These distinct rates among people with shared backgrounds are consistent with both heritable and cultural factors, but certainly shape health burdens within these specific groups.

DEFINING OBESITY

Obesity is defined as a measure of Body Mass Index (BMI) – a ratio of weight to height that is calculated by the following formula:

BMI = weight (kg) ÷ height (m)

For adults, BMIs in the range of 18.5 to 24.9 are considered to be healthy – and associated with the lowest risk of mortality and morbidity. Overweight is defined as a BMI of 25.0 to 29.9 and

obesity is defined as a BMI of at least 30, with 3 sub-categories (Class 1, Class 2, and Class 3) that are associated with increasing risk of serious health consequences (Table 1). For children and adolescents aged 2-19 years, BMI is calculated by the same formula as for adults, but values are interpreted based on age- and sex-specific growth charts developed by the CDC. A healthy BMI is considered to be equal to or greater than the 5 percentile, but less than the 85 percentile for children of the same sex and age. Overweight is defined as a BMI greater than or equal to the 85 percentile and less than the 95 percentile; while obesity is defined as a BMI greater than or equal to the 95 percentile. While BMI is a commonly used guide to identifying obesity, it is not a precise measure of body composition; therefore, the use of BMI may lead to inaccurate estimates of body fatness and misidentification of obese individuals.

Table 1. Classification of Overweight and Obesity by BMI, Waist Circumference, and Associated Disease Risk*

BMI (kg/m)		Obesity Class	Disease Risk* (Relative to Normal Weight and Waist Circumference)	
			Men ≤ 40 in (≤ 102 cm) Women ≤ 35 in (≤ 88 cm)	> 40 in (> 102 cm) > 35 in (> 88 cm)
Underweight	< 18.5	—-	—-	
Normal†	18.5-24.9	—-	—-	
Overweight	25.0-29.9	Increased	High	
Obesity	30.0-34.9	I	High	Very High
35.0-39.9	II	Very High	Very High	
Extreme Obesity	≥ 40	III	Extremely High	Extremely High

*Disease risk for type 2 diabetes, hypertension, and CVD

† Increased waist circumference can also be a marker for increased risk even in person of normal weight.

Source: National Institutes of Health. *Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults (NIH Publication No. 98-4083)* . Bethesda, MD: Author; 1998.

BODY WEIGHT REGULATION

The causes of obesity are *multifactorial* in the vast majority of cases. In the simplest conception, obesity develops when energy intake exceeds energy expenditure over time; excess energy is stored in adipose tissue, and chronic excess leads to greater adiposity. For example, ingesting 3500 calories beyond energy expended will result in one pound of weight gain, mostly as triglycerides stored in adipocytes. Therefore, an individual who consumes 100 excess calories per day would gain more than 10 pounds per year. Considering that 100 calories represents a small amount of food (e.g., 1 medium apple or 1 tablespoon of margarine), and that most adults maintain their body weight within fairly narrow limits, it is clear that there are highly precise

physiological mechanisms that match energy intake and energy expenditure. However, it is also apparent that these compensatory mechanisms are not adequate to maintain energy balance completely, and that they have become increasingly inadequate over the last 3 decades.

In actuality, the regulation of energy balance is quite complex and influenced by numerous genetic and environmental factors. Maintenance of body energy stores is critical for survival, and has undoubtedly been under strong selective pressure throughout mammalian evolution. The adaptive capacity of humans to store and lose fat during times of overfeeding and underfeeding has a strong genetic basis. It is estimated that genes may be responsible for up to two-thirds of variation in BMI among individuals. Evidence from a multitude of studies, particularly monozygotic twin studies provides strong support for the impact of genetics on individual differences in body weight and adiposity. Researchers continue to identify specific genetic links to obesity and some of the great gains in modern science have been the understanding of the intricate molecular pathways dictating energy balance. However, overall current understanding of the genetic and molecular mechanisms governing body weight regulation in humans is still elementary.

IMPACT OF THE ENVIRONMENT

An interplay of genetics and the environment is central to the regulation of energy balance, and thus body weight. Although the genetic influences on body weight have received considerable attention in recent years, the marked increase in the prevalence of obesity over the past 30 years, a relatively short period of time, is most likely is due to recent environmental changes. Thus, a gene-environment interaction is likely in which individuals, particularly those who are genetically susceptible, are at risk for developing obesity in an environment that facilitates high energy intake and low energy expenditure. In fact, *obesogenic* is a term that has been coined to describe a permissive environment that both promotes food intake and discourages physical activity. With an abundance of convenient, palatable, energy-dense foods and increasingly fewer demands for physical activity in usual lifestyles, the contemporary environment enables the energy balance to be tipped in favor of weight gain.

DIET

Over the past 50 years in the United States, the per capita availability of energy has increased steadily, with the greatest increase occurring in tandem with the rising prevalence of obesity. Likewise, trends in the consumption of specific nutrients or foods have also paralleled the rise in obesity. Therefore, the macronutrient content of the diet (i.e., carbohydrate, protein and fat), energy density, sugar-sweetened beverages, and portion size have been implicated as important drivers of the obesity trend. Many studies in this area are observational or cross-sectional designs that suggest associations between dietary factors and obesity, but cannot determine causation. Rigorous, long-term investigations are needed to provide evidence for the causative role of specific dietary components in the development of obesity.

Macronutrients

According to National Health and Nutrition Examination Survey (NHANES) data, the intake of carbohydrate has increased significantly from 42.4% to 49% of total energy intake for men, and from 45.4% to 51.6% for women, while fat intake has decreased significantly from 36.9% to 32.8% for men, and from 36.1% to 32.8% for women. This shift in nutrient intake occurred along with the increase in energy intake and obesity among Americans. So it's not surprising that an interest in managing weight through modification of the macronutrient profile has surged among researchers, healthcare practitioners, and industry. Current weight loss diets are quite diverse, ranging from Ornish's very low-fat, high-carbohydrate diet to Atkins' very low-carbohydrate, high-fat diet with a multitude of regimens between these two extremes. The alleged benefits of these diets (i.e., improved body weight, body composition, and overall health) are often attributed to the relative distribution of macronutrients. While moderately low-fat, high-carbohydrate diets have been endorsed by many health organizations, diets that are restricted in carbohydrate and higher in protein are also quite popular.

Past studies investigated the effects of diets with varied macronutrient content on energy intake and body weight over short periods of time in controlled settings. More recently, longer-term randomized clinical trials have examined the effects of diets with varying amounts of protein, carbohydrate, and fat. A meta-analysis of these studies showed that low-carbohydrate, high-protein, nonenergy-restricted diets are advantageous for weight loss compared with energy-restricted, low-fat diets after 6 months, but the diets are associated with similar weight loss after 12 months. Additional RCTs have concurred that lower carbohydrate, higher protein diets are associated with similar, or superior benefits for weight loss, body composition, and cardiovascular risk factors, when compared with low fat diets after 12 months or longer.

Diets with varying levels of fat, particularly monounsaturated fats (MUFA) have also been a topic of interest. High-MUFA diets typical of the Mediterranean region emphasize the consumption of vegetables, fruits, whole grains, legumes, nuts, and specific oils (e.g. olive oil, canola oil), and limit the intake of saturated fats from meat, poultry, and dairy products. Many short-term studies compared the effects of high-MUFA diets with those of high-carbohydrate, lower-fat diets. More recent randomized, controlled trials examined the effects of Mediterranean diets on multiple outcomes, including body weight for at least one year. Results suggest that high-MUFA diets may improve weight, blood pressure, plasma lipids, and insulin sensitivity at least as well as lower fat diets. In addition, the greater acceptability and palatability of high-MUFA diets may enhance adherence.

The Institute of Medicine currently recommends that 45-65% of total energy should be derived from carbohydrate, 10-35% of total energy from protein, and 20-35% of total energy from fat. These guidelines allow for an array of diets with varying macronutrient content. Until there is adequate evidence for specific macronutrient combinations outside the recommended ranges, a variety of diets with moderate amounts of macronutrients can be tailored to individual needs and preferences.

Energy densit

Energy density is defined as the amount of energy in a given volume of food. Foods that contain a lot of water, such as fruits and vegetables tend to be low in energy density, while other foods

such as butter or ice cream are higher in energy density. In other words, a highly energy-dense food is packed with calories, while the same volume of a lower energy-dense food has fewer calories. Studies have shown that the energy density of a diet directly impacts energy intake, independent of macronutrient content. Studies by Rolls and colleagues have shown approximately 20% reduction in daily energy intake when meals lower in energy density are consumed, compared to higher energy-dense meals. Moreover, energy density and portion size together have an additive effect on energy intake, without compensation for the higher energy intake by eating less at the subsequent meal. The potential contribution of energy density to weight regulation was investigated in a clinical trial in which subjects were randomly assigned to energy-restricted diets that included 1-2 servings of foods equal in energy but different in energy density. After one year, the lower energy-density group (with 2 servings of soup daily) had 50% greater weight loss than the group that consumed higher energy-density foods. Therefore, large portions of energy-dense foods (e.g., French fries and pizza) are likely to result in excessive energy intake, and subsequent weight gain.

Sugar-sweetened beverages

According to the NHANES data, the mean intake of added sugars is over 22 teaspoons (355 calories) per day, with sugar-sweetened beverages (e.g., soft drinks, fruit drinks, lemonade, and iced tea) being the chief source of added sugars. Furthermore, over 50% of the increase in caloric intake over the past three decades is attributed to beverages, mainly sugar-sweetened beverages. Due to the potential contribution of added sugars to caloric excess, the American Heart Association has issued the recommendation that most women should consume no more than 100 calories per day from added sugars, and men should consume no more than 150 calories per day from added sugars.

In a recent systematic review of 30 cross-sectional, prospective cohort, and experimental studies, the authors concluded that the prevailing evidence supports a positive association between increased consumption of sugar-sweetened beverages and weight gain and obesity in children and adults. Study findings suggest that sweetened beverages, with their low satiety value, are not associated with an adequate decrease in energy at subsequent meals, resulting in excess energy intake and weight gain. Small sample sizes, short study duration, lack of repeated measures, and multiple confounders (e.g., other lifestyle habits) have plagued many past studies; therefore, well-designed trials are needed to confirm the link between sugar-sweetened beverages and long-term weight gain, as well as the physiologic mechanisms that account for this association.

Portion size

As the rate of obesity has escalated, portion sizes of most foods and beverages in the marketplace have increased, with some products' current portion size being five times the original size. Thus, larger portion sizes with their higher energy content have been implicated as contributors to the obesity trend. Short-term trials of both children and adults have provided evidence that energy intake increases as portion size increases. Interestingly, subjects reported similar ratings of hunger and fullness after meals with small portions and those with large

portions, even though they consumed significantly different amounts of energy. Although these studies provide evidence for the influence of portion size on energy intake at a single meal, the impact on body weight may be minimized if persons compensate by consuming less energy at the next meal. So Rolls and colleagues examined the effect of larger portions (twice the size of standard portions) of all foods over a 2-day period. Results showed a 26% increase in energy intake on both days in spite of reports of feeling fuller. Even though evidence indicates that portion size can influence energy intake over several meals, further studies are needed to demonstrate the effect of larger portions on energy intake and body weight over a longer period of time, as well as the physiological mechanisms responsible for the apparent insensitivity to hunger and satiety signals when large portions of food are served.

PHYSICAL ACTIVITY

The global trend of increasing technology, automation, motorized transportation and sedentary occupations contributes to a comfortable lifestyle that requires minimal physical activity. While once essential for survival, regular physical activity is optional in our modern, low energy-demanding environment. The vast health benefits of physical activity include decreased mortality and reduced risk for several chronic diseases, including cardiovascular disease, type 2 diabetes, cancer, and osteoporosis. The 2008 Physical Activity Guidelines for Americans recommend *at least* 150 minutes per week of moderate-intensity aerobic activity (walking briskly, biking, water aerobics) or 75 minutes per week of vigorous-intensity aerobic activity (jogging, jumping rope, swimming laps), in addition to muscle-strengthening activities (sit-ups, weight-lifting) twice per week for adults. Yet, less than half of Americans report that they engage in the recommended amount of physical activity.

In addition to its role in health promotion and disease prevention, physical activity is regarded as a means of body weight regulation. While the contribution of physical activity to energy expenditure is acknowledged, the amount and intensity of activity necessary for loss and maintenance of weight is uncertain. Results of cross-sectional studies, prospective studies, and randomized controlled trials (RCTs) demonstrated an inverse relationship between physical activity and body weight and/or BMI, with evidence for a dose-response relationship. Study findings indicated that moderately intense physical activity (e.g., walking at a pace of 4 miles per hour) for 30 to 60 minutes per day on at least 5 days per week is sufficient to maintain body weight (i.e., less than 3% change in body weight). However, for clinically meaningful weight loss (i.e., at least 5% loss of initial body weight), a higher dose and intensity of physical activity may be needed. A recent review of 41 RCTs concurred that only a marginal amount of weight loss is achieved with physical activity alone for overweight or obese adults; however, weight loss increases significantly when dietary interventions are combined with regular physical activity.

In regard to maintaining lost weight, a greater amount and intensity of physical activity may be needed to prevent regain than to prevent weight gain. Data from the National Weight Control Registry (i.e., persons who have maintained at least a 30-pound weight loss for one year or longer) indicated that the amount of activity is variable among the registrants, implying that there may be individual-specific determinants of activity requirements for weight loss maintenance.

Regular aerobic physical activity also is associated with positive changes in body composition, including loss of total and abdominal fat. Visceral (i.e., abdominal) fat is an independent risk factor for several morbidities, including cardiovascular disease and diabetes. Results of RCTs indicate that moderate to high intensity exercise effectively reduces abdominal fat in overweight and obese subjects, particularly when imaging methods are used to measure changes in body composition. McTiernan and colleagues found modest loss of abdominal fat (6-8%) associated with 60 minutes or more of moderate-to-vigorous aerobic physical activity on 6 days per week . In the Studies of Targeted Risk Reduction Interventions through Defined Exercise (STRRIDE) among middle-aged persons, a 7% reduction in abdominal fat was achieved with intense activity, equivalent to jogging approximately 20 miles per week for 8 months.

While many studies have investigated the acute and chronic effects of physical activity, very little research has addressed the physiological effects of physical *inactivity* for prolonged periods of time. Studies have shown a positive relationship between television viewing and obesity in adults, with increasing relative risk of obesity from 2-5 hours per week to over 40 hours per week of television watching. Whether obesity is the result of low energy expenditure, prolonged inactivity, or increased snack consumption is still unknown.

A recent review noted that epidemiological studies have linked sitting time and non-exercise physical activity with rates of obesity, cardiovascular disease, type 2 diabetes, and metabolic syndrome. Existing though limited data suggest that physical inactivity may be accompanied by specific cellular changes, such as suppression of lipoprotein lipase activity. Beyond its direct effect on energy expenditure, inactivity's impact on specific clinical outcomes and cellular responses are yet to be determined.

STRATEGIES FOR MODIFYING DIET, PHYSICAL ACTIVITY, AND THE ENVIRONMENT

Obesity treatment should be viewed as a chronic, ongoing process that requires the implementation of multiple strategies. The initial weight loss goal should be set realistically at 10% reduction in body weight over 6 months of treatment. This level of weight loss is associated with improvement in related co-morbidities, such as hypertension, dyslipidemia, and insulin insensitivity. After achieving the initial goal, practitioners should emphasize the importance of maintaining the reduced weight via sustained therapy. If the patient wants to continue to lose weight, further weight loss goals may be considered with an adjustment of treatment (i.e., further decrease in energy intake and/or increase in energy expenditure).

On an individual level, practitioners and patients must understand the factors that are contributing to the patient's obesity before choosing a treatment strategy. According to the "BEST Treatment" assessment developed by Wadden and Phelan, biological, environmental, social/psychological, and timing factors should be considered when selecting a treatment method. In other words, the following information should be discussed: family history, weight history, energy/nutrient intake, eating patterns, physical activity, relationships, social support, and time/motivation/ability for treatment. Based on the patient's profile, the treatment plan can be individualized for optimal weight management. The most effective weight management

interventions use a combined approach of diet, physical activity, and behavior modification. Principles of behavioral treatment are based on the notion that (1) behaviors can be relearned or altered and (2) behaviors can be changed by modifying the environmental cues (antecedents) and reinforcers (consequences) of the behavior. Common behavioral strategies used in conjunction with diet and physical activity components include stimulus control, goal-setting, self-monitoring (keeping track of weight, dietary intake, and activity), problem solving, contingency management, cognitive restructuring, social support, and relapse prevention.

Program duration may vary, but a recent review showed that shorter programs (less than 6 months) have higher failure rates than longer ones. Extended programs with weekly or biweekly sessions beyond 6 months are associated with improved maintenance of weight loss and continued adherence to recommended eating and exercise behaviors. Furthermore, long-term maintenance of weight loss is enhanced by contact with health professionals who can provide ongoing support.

Most interventions target behavior change at the individual level, delivering information via group sessions or one-on-one counseling. Yet multifaceted approaches that reach beyond educational tactics to include behavioral and social strategies, as well as environmental and policy changes may be needed to support individuals' efforts to adopt and sustain healthy lifestyle habits over time.

Dietary component

Diet is the cornerstone of obesity treatment. In fact, diet alone and with the addition of exercise and/or behavior therapy is associated with significant weight loss and improvement in health outcomes. Moderate restriction of calories for gradual weight loss is endorsed by most health care organizations. Based on the individual's energy needs, a diet plan is devised to create an energy deficit of 500 – 1000 kcal/day, with the goal of losing 1-2 pounds per week. Although very low calorie diets (i.e., less than 800 kcal/day) may be used with medical monitoring for rapid weight loss, most diet plans recommend 800-1500 kcalories per day to ensure delivery of the essential nutrients.

The current recommendations for macronutrient composition allow for a variety of diets with differing levels of carbohydrate, protein, and fat. Diets moderately increased in protein and modestly restricted in carbohydrate and fat, particularly saturated fat, may provide beneficial outcomes in terms of improved satiety, body composition, blood lipid profile, and insulin sensitivity. Likewise, higher-fat diets such as Mediterranean-type diets that emphasize mono-unsaturated fats (e.g., olive oil, avocados, nuts) may improve weight and cardiovascular and diabetic risk factors at least as well as lower fat diets. Thus, calorie-controlled diets can be tailored in their carbohydrate, protein, and fat content according to individuals' food preferences, which in turn may enhance long-term adherence, weight, and health outcomes.

In addition to formulating a calorie-controlled diet plan, programs to modify dietary habits typically include education about calories, nutrients, portion sizes, and healthy cooking techniques, as well as healthy restaurant selections. Based on the evidence presented earlier in

this chapter, the overarching strategy for devising a calorie-controlled diet is to include healthful, nutrient-dense foods in moderation. Instead of energy-dense foods, such as desserts, candies, and deep-fried foods, choose foods that are low in energy density (e.g., fruits and vegetables) as snacks and meal accompaniments for increased satiety with fewer calories. Be cognizant of the portion sizes of foods and beverages and steer clear of the “supersizing” and “value meals” trends that promote huge portions of energy-dense foods and sugar-sweetened beverages, and increased energy intake.

Physical activity component

Physical activity interventions aim to increase energy expenditure by reducing sedentary behaviors and promoting physically active lifestyles. Physical activity is encouraged through programmed exercise (i.e., structured activities such as walking or biking) or lifestyle exercise (i.e., increased activities throughout the day such as stair climbing). Both types of exercise have been shown to be equally effective for maintaining weight loss. For sedentary, obese individuals, physical activity should be initiated at a slow pace for short periods of time and gradually increased in intensity and time.

In a systematic review of 253 interventions, the Task Force on Community Preventive Services categorized interventions as: 1) informational approaches to change knowledge and attitudes about the benefits, barriers, and opportunities for physical activity, 2) behavioral and social approaches to increase behavior management skills and to create social environments that facilitate behavioral change, and 3) environmental and policy approaches to change physical and organizational environments. Within these categories, the Task Force recommended the following intervention strategies based on evidence of effectiveness for increasing physical activity: point-of-decision prompts, community-wide campaigns, school-based physical education, social support interventions, individually adapted health behavior change programs, and access to places for physical activities combined with informational activities. These strategies can be incorporated into existing or new interventions, depending on the goals, resources, infrastructure, and social environment of the organization or practitioner. For instance, practitioners may tailor behavior change programs to patients’ needs and preferences; organizations may enhance social support by creating walking programs in which individuals are paired to encourage participation; schools and worksites may develop walking trails or provide exercise equipment, and then promote their use via point-of-decision prompts.

INSTITUTIONALIZING CHANGE

There are no simple solutions to the problem of obesity. The prevention and treatment of obesity require commitment and collaboration of countless stakeholders at the individual, community, national and global levels. For long-lasting changes in our obesogenic environment, health care professionals, government agencies, the private sector, and community members must consider the prevention of obesity to be a high priority in both developed and developing countries. National initiatives that include programs, polices, and built environments should be implemented to make healthy foods and physical activity accessible for all persons. Federal agricultural policies are needed to promote the development, marketing, and intake of healthy

foods via pricing strategies or subsidies. Lastly, environmental changes in schools, worksites, and communities (e.g., increased access to recreational activities and affordable food venues) are essential to support healthy lifestyle behaviors.

CONCLUSIONS

Diet and physical activity contribute to energy balance and weight control. Multi-strategy interventions that include educational, behavioral (e.g., problem solving, goal setting, and self-monitoring) and environmental approaches have been effective in promoting healthy lifestyle habits in the short-term. Unfortunately, there is little evidence for maintenance of these behaviors over long periods of time. So it is imperative that well-designed, large-scale trials be conducted to establish the long-term efficacy of specific strategies and delivery methods for the prevention and control of obesity in home, school, workplace, and healthcare settings . Effective interventions that promote sustainable healthy behaviors across a wide range of sectors may be the key to stalling and even reversing the current obesity trend.

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