

Section 1

Trends and determinants of obesity in women of reproductive age

Chapter

1

Demography of obesity

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Introduction

According to the World Health Organization (WHO), overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health [1]. Overweight and obesity are usually diagnosed when weight normalized for height, or body mass index (BMI: weight in kilograms divided by the square of the height in meters, kg/m²), exceeds a defined threshold. In 1995, the WHO proposed a BMI classification for adults as a form of diagnosing excess adiposity [2]. According to this classification, individuals are considered overweight when their BMI is ≥25; those between 25 and 29.9 are designated as pre-obese and they are classified as obese when their BMI reaches or exceeds 30 kg/m² (Table 1.1). Many authors also use the term “overweight” to designate pre-obese individuals (BMI 25–29.9), which gives rise to some confusion, unless the specific range of BMI is specified. Although BMI does not directly measure the percentage of body fat, it offers a more accurate assessment of excess adiposity than weight alone. Due to its simplicity, BMI categorization is the preferred obesity measurement for clinicians, public health specialists, and researchers, and is currently used worldwide to track adult overweight and obesity prevalence [3].

Although BMI categorization is widely used, it has several limitations. The proposed BMI classification is age and gender independent and it may not reflect the same degree of adiposity in different populations, due to different body proportions in different ethnicities. Therefore, since the health risks associated with increasing BMI are continuous, the interpretation of BMI gradings in relation to risk may differ for different populations. Due to a growing debate in recent years on the need to develop different BMI cut-off points for different ethnic groups, the WHO convened

Table 1.1 The international classification of adult underweight, overweight, and obesity according to BMI: recommended reporting categories according to the WHO

Main classifications	Main categories	BMI (kg/m ²)	
		Additional categories	Additional classifications
Underweight	<18.5	<16.0	Severe underweight
		16.0–16.9	Moderate underweight
		17.0–18.4	Mild underweight
Normal	18.5–24.9	18.5–22.9	Normal I
		23.0–24.9	Normal II
Overweight ^a	≥25.0	–	–
Pre-obese ^a	≥25.0–29.9	25.0–27.4	Pre-obese I
		27.5–29.9	Pre-obese II
Obese	≥30.0	–	–
Class I obesity	30.0–34.9	30.0–32.4	Mild class I obesity
		32.5–34.9	Moderate class I obesity
Class II obesity	35.0–39.9	35.0–37.4	Mild class II obesity
		37.5–39.9	Moderate class II obesity
Class III obesity	≥40.0	–	–

Source: adapted from WHO, 1995 [2], WHO 2000 [1], and WHO 2004 [4].
^a In the USA, BMI 25.0–25.99 is often termed “overweight.”

an expert consultation on BMI in Asian populations [4] to address this issue. Despite evidence that Asian individuals may be at higher than average risk at BMIs lower than the existing WHO cut-off point for overweight (25 kg/m²), the experts observed that there is a large heterogeneity among the ideal cut-off points for

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different Asian populations. Therefore, the panel maintained the recommendation that the current WHO BMI cut-off points should be retained as the international classification. However, they also suggested that the cut-off points of 23.0, 27.5, 32.5, and 37.5 kg/m² are to be added as points for public health action, to create different risk level subcategories within each current category (see Table 1.1). The WHO therefore recommends that countries should use all categories in Table 1.1 for reporting purposes.

To facilitate international comparisons and provide a global perspective on nutritional transition, the WHO created a database that provides survey information on adult BMI from almost one hundred countries covering approximately 80% of the world's adult population [3]. This database, available at <http://apps.who.int/bmi/index.jsp>, serves as an early warning system for the rapidly rising prevalence of obesity in adults worldwide.

The global race of obesity

Obesity is a chronic multifactorial disease caused by genetic, environmental, and behavioral factors that leads to serious health consequences. When compared to non-obese individuals with similar characteristics, obese adults are at significantly higher risk for cardiovascular and metabolic morbidity, osteoarthritis, cancer, and mental disease, as well as overall mortality [5–9]. Besides the many individual physical and emotional costs of this disease, obesity also has important direct and indirect financial costs for government and society [10,11]. As the number of obese individuals in a population increases, the demands placed on the health resources of that population also increase [12,13].

The concept that obesity is a public health problem emerged in the second half of the twentieth century, as the prevalence of this condition started to increase in parallel with industrial development. The global nature of the obesity epidemic was officially recognized by the WHO in the late 1990s [1]. The current situation is described as a global pandemic (“globesity”) that affects five of the six continents, sparing only sub-Saharan Africa. According to the latest WHO data [14], obesity has more than doubled since 1980 and in 2008 there were an estimated 1.5 billion overweight adults (BMI ≥ 25) in the world.

The prevalence of obesity is rising all over the world and is now recognized as an important public health problem that affects all age groups and both genders.

The global obesity pandemic is increasing at an alarming rate in both developed and developing countries and is considered one of the most important public health challenges of the twenty-first century.

Obesity in developing countries

Currently, 65% of the world's population lives in countries where overweight and obesity kill more people than underweight [15]. This includes all high-income and most middle-income countries. Although developed regions of the world have a higher prevalence of overweight and obesity [16] and the highest body mass indexes [17], the developing world faces a larger absolute burden because of larger population sizes [18,19].

There is a popular but erroneous belief that obesity is a problem of affluent societies and rich nations. This concept was generated in the early twentieth century, when most populations in which obesity became a public health problem were in the developed world, primarily the United States and Europe. In more recent decades, available data show that the most dramatic increases in obesity are occurring in developing countries such as Mexico, China, and Thailand [20].

In most developing countries, the prevalence of obesity is lower in rural compared to urban areas [20,21]. Rural inhabitants tend to eat traditional diets that are high in grains, fruits, and vegetables; when they move to the cities, they increasingly adopt a “Western-type” diet, high in fat and refined sugars. Rapid urbanization, accompanied by a significant reduction in fertility, aging of the population, receding famine patterns, and a marked increase in sedentary behavior, are the primary determinants for the explosive rise in obesity in developing countries. Obesity and all these factors, together with an increase in the consumption of tobacco and alcohol and stress-related ailments, contribute to the rising prevalence of non-communicable chronic diseases in these settings [22].

In the developing world, this nutrition transition is occurring more rapidly than previously seen in higher income countries that went through the same process [17,22]. It is difficult to assess obesity trends in developing countries because of the lack of nationally representative longitudinal data on BMI. Most of the available information in these countries comes from isolated cross-sectional surveys that used different sampling techniques and therefore are not necessarily representative of the country's population at the time of the survey. Despite these methodological limitations, the

existing evidence indicates an unequivocal increase in the prevalence of obesity in most low- and middle-income countries starting in the late 1990s [23,24]. According to the few existing longitudinal studies, and to several cross-sectional surveys, the relative increase in the prevalence of obesity in middle-income countries has ranged from 30% to 100% over the past two decades [25]. In developing countries where data are available, the annual rate of increase in the prevalence of adult overweight is approximately 1% [17].

The rapidity of the changes in developing countries is such that a double burden of disease often co-exists: hunger and obesity can occur simultaneously in the same country, a phenomenon known as the nutrition paradox [26]. This paradox can occur not only in different geographical regions of a country, but within the same family. In low-income areas on the outskirts of many large cities in countries such as China, Brazil, and Indonesia, hungry children and obese adults often share the same household [27].

Yet, in many developing nations, the burden of overnutrition is greater than that of undernutrition [21]. In fact, the latest surveys indicate that over half of the adults are overweight and obese in many developing countries throughout the world [3].

Although increase in the prevalence of obesity is a population-wide phenomenon in most developing countries, there are substantial disparities between and within countries, especially when different ethnic and socioeconomic strata are analyzed. Initially, as happened in the rich nations of the world, obesity affected mostly the higher socioeconomic strata of the

population in developing countries. However, more recently there has been a shift in prevalence from the higher to the lower socioeconomic level. For example, while in 1989 a national survey in Brazil reported that obesity was more prevalent in adults of higher socioeconomic status, ten years later the highest prevalence of obesity was observed among the lower socioeconomic status respondents [24].

The problem of obesity in developing nations is dramatic not only due to population size, but also to the proportionally smaller investments in public health programs in many of these countries. Additionally, due to technical, cultural, and political factors, health authorities in developing nations frequently employ their limited resources in less cost-effective interventions.

Female and maternal obesity

According to WHO data, of the 1.5 billion individuals with BMI ≥25 in 2008, nearly 300 million of these were obese women (BMI ≥30) [14]. Generally, in any population, men will have higher rates of overweight, while women will have higher rates of obesity [3]. Table 1.2 and Figure 1.1 present the prevalence of pre-obese and obese women in the world according to the latest available data.

Although the increasing prevalence of obesity among women of childbearing age is part of the larger worldwide epidemic, its consequences can be particularly devastating. As described in the later chapters of this book, the problems related to female obesity start in adolescence with amenorrhoea and dysovulation

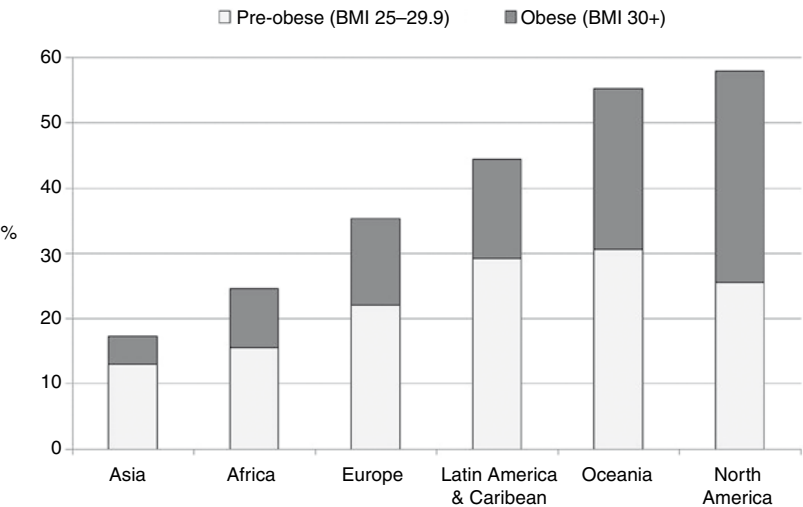


Figure 1.1. Prevalence of overweight women in the world.

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Table 1.2 Regional distribution of female overweight

Region/ sub-region	Coverage of estimates (%)	Women with BMI 25.0–29.9 (%)	Women with BMI ≥30 (%)	Women with BMI ≥25 (%)
Africa	85.3	15.6	9.0	24.6
Eastern Africa	93.7	93.0	2.8	12.1
Middle Africa	84.5	11.3	3.5	14.8
Northern Africa	54.0	29.6	28.8	58.4
Southern Africa	96.6	28.9	25.0	53.8
Western Africa	98.7	14.8	5.4	20.2
Asia	92.9	13.1	4.2	17.3
Eastern Asia	88.3	15.4	3.4	18.8
Central Asia	100.0	15.2	5.9	21.0
Southern Asia	98.4	8.6	2.7	11.3
Southeastern Asia	91.4	15.2	4.5	19.7
Western Asia	86.7	28.6	21.4	50.0
Europe	98.4	22.1	13.2	35.2
Eastern Europe	96.7	24.5	16.8	41.3
Northern Europe	99.8	29.7	18.7	48.4
Southern Europe	99.6	20.8	8.1	28.9
Western Europe	99.7	14.9	8.4	23.3
Latin America and the Caribbean	91.9	29.2	15.2	44.3
Caribbean	81.4	22.3	8.5	30.8
Central America	96.8	35.6	25.7	61.3
South America	91.0	27.1	11.3	38.4
North America	100.0	25.6	32.3	57.8
Canada	100.0	26.1	16.9	43.0
USA	100.0	25.5	34.0	59.5
Oceania	79.3	30.6	24.6	55.2
Australia/New Zealand	100.0	30.7	24.3	55.0
Melanesia	19.1	31.4	25.1	56.6
Polynesia	63.5	22.8	44.3	67.1

Sources: latest Demographic and Health Surveys are available at www.measuredhs.com/ [39] or WHO database on BMI, available at www.who.int/bmi/index.jsp [3].

and continue throughout the reproductive period. Although there are no data available for a global assessment of obesity levels in pregnant women, this issue can be framed within the global weight increase among the female population. More women are entering pregnancy with excess weight, exposing them and their unborn child to increased risks of adverse gestational and perinatal outcomes, as well as long-term risks.

A body of evidence indicates that obesity in pregnancy is associated with increased risk for several clinical and obstetric complications, such as gestational diabetes, pre-eclampsia, preterm delivery, or fetal macrosomia [28–32]. Additionally, as detailed in Chapters 9 to 11 in Section 3, several longitudinal studies report that individuals exposed to maternal obesity during fetal life are at increased risks of

Table 1.3 Countries with the highest prevalence of female obesity and pre-obesity

Country	% female population with BMI >30
American Samoa	80
Nauru	78
Tokelau	68
Kiribati	59
French Polynesia	44
Saudi Arabia	44
Egypt	40
Iraq	38
Panama	36
Seychelles	35

Country	% female population with BMI 25.0–29.9
Mexico	37
Germany	36
Turkey	34
Portugal	34
Malta	34
United Kingdom	34
Panama	33
Colombia	33
Kuwait	33
Chile	33

Source: available at www.who.int/bmi/index.jsp [3].

becoming overweight or obese children and adults themselves [33], thus perpetuating the vicious cycle of obesity and creating an intergeneration effect.

Female obesity in developing countries is becoming very prevalent. In fact, the most recent data available on the WHO Global Database on BMI indicate that all ten countries with the highest prevalence of obese women are developing countries [3], as can be seen in Table 1.3. The striking representation of Polynesian islands in this list may be the result of genetic susceptibility fueled by geographical isolation and inbreeding, allied with environmental factors. Women of low socioeconomic status living in developing countries are at especially high risk for obesity [23,34,35].

Paradoxically, as a country’s gross national product increases, the burden of obesity in that country tends to

shift toward the lower socioeconomic groups. Thus, the increasing economic prosperity seen in many developing countries over the last decades may be contributing to the obesity epidemic among women of the lowest socioeconomic status in these nations. Moreover, the shift of obesity toward women of lower socioeconomic status apparently occurs at an earlier stage of economic development than it does for men [23,35].

Economic development is significantly related to a faster increase in the prevalence of overweight for women of lower socioeconomic strata and this relation varies by income inequality [36]. In the 1980s, the WHO initiated a ten-year study in 26 countries to monitor trends and determinants of cardiovascular disease, including obesity [37]. According to the data collected from over 50 million participants included in this study, there was a significant inverse association between educational level, used as a proxy for socioeconomic level, and BMI for women in almost all populations. Women with low education had higher BMIs than those with higher education. Additionally, the authors reported an increasing difference in BMI between educational levels over a ten-year period.

In developed as well as in developing countries, female obesity is clearly a problem associated with social class. However, it is also a problem related to income inequality: the prevalence of female obesity is higher in countries with the largest differences between the incomes of the rich and the poor [38]. In developing countries, the combination of rising national economies, persistent income inequalities, and increased “Westernization,” will most likely lead to sustained increases of female obesity in the future.

As the number of women who are obese at the start of pregnancy continues to escalate worldwide, there is an urgent need to invest more resources on studies that analyze the determinants of this trend and that test population interventions to help curb this phenomenon.

Conclusion

In contrast to malnutrition and infectious diseases, which have always dominated the attention of public health specialists and organizations, the causes and consequences of obesity have only recently achieved global recognition. In fact, the WHO describes obesity as one of the most blatantly visible, yet most neglected, public-health problems that threatens to overwhelm both more and less developed countries [1].

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With the increase in sedentary lifestyles and the availability and consumption of energy-dense foods, the incidence of obesity among women is rising globally. Health providers are expected to care for a growing number of obese reproductive-age women in the coming decades. Simultaneously, more and more women will enter pregnancy with higher BMIs, which will expose them and their unborn child to higher immediate and long-term risks.

The high and continuously accelerating rate of obesity among women living in developing countries is one of the darkest facets of this worldwide problem, since it involves an immense population and affects predominantly those in the lower socioeconomic strata. There is an urgent need for investments and studies on obesity in reproductive-age women, focused on understanding the determinants of this problem and the development of effective interventions to curb this trend while there is still time.

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Chapter

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Determinants of obesity

Cuilin Zhang and Frank B. Hu

Introduction

Obesity has become a global epidemic. The World Health Organization's (WHO) latest report [1] indicates that in 2008 approximately 1.5 billion adults 20 years or older worldwide were overweight, defined as having a body mass index (BMI) $\geq 25 \text{ kg/m}^2$ [1]. Of these, nearly 500 million were obese, BMI $\geq 30 \text{ kg/m}^2$, including 200 million males and nearly 300 million females. The numbers of those overweight and obese are projected to reach 2.3 billion and 700 million respectively by 2015 [1]. In the United States, the percentage of obese adults increased from 15% in the late 1970s to over 33% in 2007–2008, with the greatest increase among Mexican American women [2]. Similarly, in a number of developing countries such as China and India, where the Western lifestyle and diet are becoming more common, the prevalence of overnutrition, obesity, and obesity-related disorders is increasing rapidly. For instance, according to the WHO's Global Information Database, 45% of males and 32% of females aged 15 years or older in China were overweight, or an average of 38.5% of the 2010 population. This is a sharp increase from the 2002 estimate of 25% in China (27.5% of males and 22.7% of females) [3].

Women of reproductive age are no exception. Based on data from the National Health and Nutrition Examination Survey (NHANES) 2007–2008, US women of 20 to 39 years old are alarmingly heavy: 60% are overweight, 34% are obese, and 8% have a BMI $\geq 40 \text{ kg/m}^2$ (class III obesity) [4]. Moreover, a very high proportion of pregnant women, approximately 45%, were overweight or obese when becoming pregnant [5]. Furthermore, in the United States, the greatest increase in the prevalence of obesity in the past decade is among women aged 20 to 39 years, a jump from

28% during 1999–2000 to 34% during 2007–2008, as compared with a slight increase from 37.8% to 38.4% among women of 40 to 59 years old. Substantial increase in obesity burden among women at reproductive age was observed in other countries as well. For instance, in a nationally representative study of maternal obesity in England, UK, first trimester maternal obesity more than doubled from 7.6% in 1989 to 15.6% in 2007 ($p < 0.001$) [6]. In South Asian countries (Bangladesh, Nepal, and India), although the prevalence of underweight has remained high, the prevalence of overweight and obesity in women of reproductive age has increased substantially [7]. For example, between 1996 and 2006, in Bangladesh, the prevalence of overweight among women of 14 to 49 years old increased from 2.7% to 8.9%; in Nepal, from 1.6% to 10.1%; and in India, from 10.6% to 14.8%.

Obesity has adverse impacts on multiple aspects of the health of reproductive-age women. Obese women generally experience more difficulty in conceiving than lean women [8]. Among women who succeed in conceiving, pre-pregnancy BMI has long been known as a major determinant of adverse pregnancy outcomes [9]. For example, maternal obesity is strongly associated with an increased risk of a number of pregnancy complications for both women and their children, such as gestational diabetes [10], pre-eclampsia, macrosomia, premature deliveries, fetal injury during delivery, and intrauterine mortality [11,12]. Long-term adverse outcomes related to maternal obesity include chronic diseases, e.g., diabetes and cardiovascular disease, and certain cancers, premature death, and complications during the next pregnancy. See Chapter 8 for more details of these phenomena.

In view of the escalating burden of obesity among women of reproductive age and the detrimental

impacts of obesity on women's health overall, it becomes increasingly important to identify risk factors and determinants for obesity, in particular factors that may contribute to its prevention. Our aim for the present chapter is to provide readers with an overview of the determinants of obesity, in particular those relevant to women of reproductive age.

Determinants of obesity

Diet and lifestyle factors

Diet

Obesity and weight gain usually result from the cumulative effects of a small daily positive-energy balance. Excessive caloric intake is a major driving force behind the escalating obesity epidemic worldwide, but diet quality has also been demonstrated to have an independent impact on the risk of obesity. Over the past few decades, numerous observational studies and clinical trials have investigated the role of dietary factors in weight control and obesity prevention. In general, the impact of major dietary factors such as macronutrient amounts (i.e., fat, protein, carbohydrate) on body fatness remains uncertain, with the existing literature suggesting that altering macronutrient composition itself is unlikely to have a substantial impact on long-term weight control [13]. Moreover, the effects of popular diets designed to promote weight loss remain controversial. Clearly, there is no magic diet or nutrient that offers weight control. Rather, many individual dietary factors exert a modest effect on body weight and, over time, the cumulative effects of small changes in daily energy balance lead to weight gain and obesity [13].

Although dietary fat has long been considered the main culprit behind obesity, large prospective studies [14,15] and long-term randomized clinical trials [16] do not support a major role of fat consumption, either total fat or types of fat including saturated, mono-unsaturated, and polyunsaturated fat, in weight loss and obesity prevention. By contrast, emerging evidence suggests that restricting carbohydrates and reducing glycemic load (GL) may improve weight control [17–19]. Investigations of diet in terms of specific foods, food groups, and dietary patterns have yielded more conclusive findings than focusing on individual nutrients. In general, these findings indicate that increasing consumption of plant-based foods such as whole grains, fruits, and vegetables is associated with

less weight gain over time [13,19]. On the other hand, there is substantial evidence that higher consumption of sugar-sweetened beverages (SSB) induces greater weight gain. Indeed, the consistent increase in SSB intake over the past three decades parallels the growth of the obesity epidemic [20]. Findings from a systematic review of 30 studies including large cross-sectional investigations, well-powered prospective cohort studies with long follow-up and repeated measures of diet and weight, as well as clinical trials provide strong evidence for an independent role of SSBs, particularly soda, in the promotion of weight gain and obesity [21].

In a recent prospective study [19] based on data from three large prospective cohorts of males and females aged 24 to 74 years at baseline, the Nurses' Health Study, the Nurses' Health Study II, and the Health Professionals Follow-up Study, Mozaffarian *et al.*, demonstrated that dietary quality, i.e., types of foods and beverages consumed, could have a strong impact on dietary quantity, i.e., the amount of food and total calories, and thus risk of long-term weight gain. Most of the foods that were significantly and positively associated with weight gain during each four-year follow-up period were those rich in refined carbohydrates or starch: for instance, sweets, desserts, and potato products (see Figure 2.1). By contrast, higher consumption of foods rich in fiber (for instance, vegetables, nuts, fruits, and whole grains) was associated with less weight gain. The inverse associations with weight gain could be because increasing the consumption of these foods reduced the intake of other foods to a greater extent, thereby decreasing the overall amount of energy consumed. Higher fiber content and slower digestion of these foods may also increase satiety, and their increased consumption would also displace other more highly processed foods in the diet, decreasing energy intake. Interestingly, in this study, greater yogurt consumption was also associated with less weight gain in both men and women, though the precise mechanisms underlying this association are unclear. Changes in colonic bacteria and the microbiome related to yogurt consumption might influence weight gain [22]. It is also possible that certain unmeasured factors that are highly correlated with yogurt consumption may minimize weight gain. For instance, individuals who increased their yogurt consumption may have other weight-influencing behaviors that were not measured in the study.

Most studies of dietary factors and obesity and weight control have been conducted in developed

Section 1: Obesity in women of reproductive age

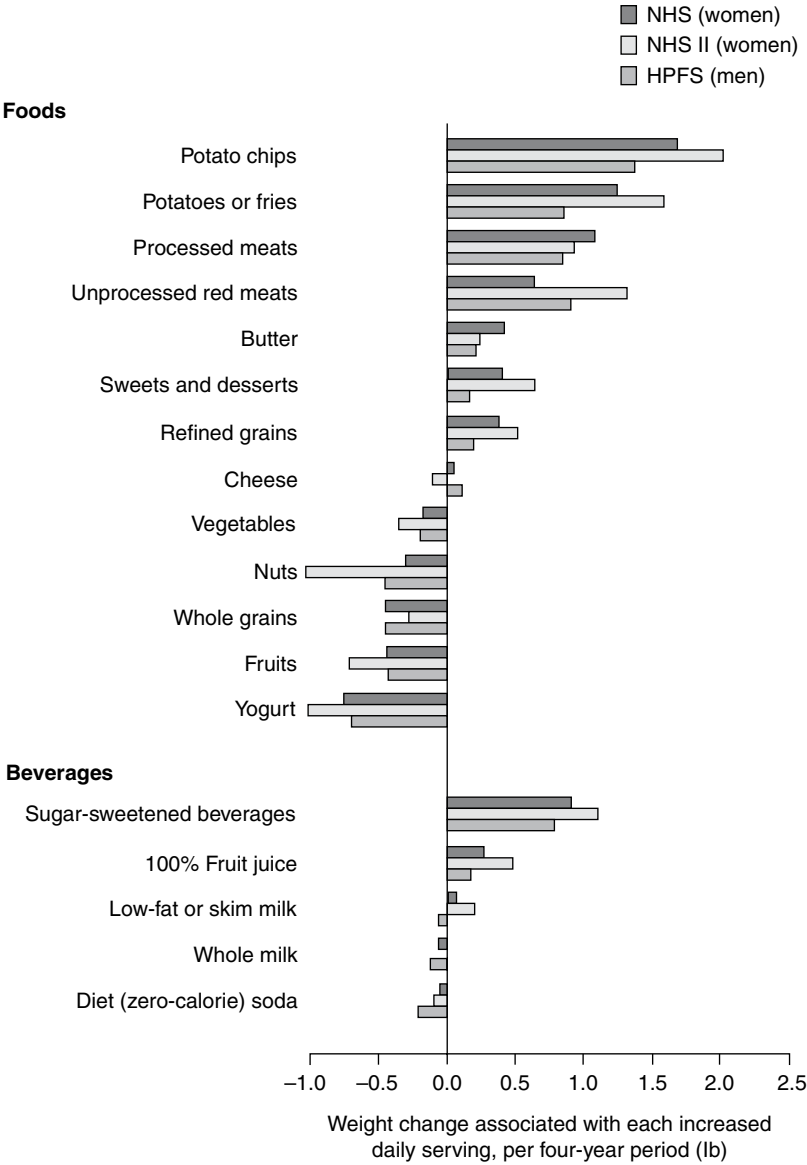


Figure 2.1. Associations between changes in food and beverage consumption and weight changes every four years, according to study cohort. Study participants included 50 422 women in the Nurses' Health Study (NHS), followed for 20 years (1986 to 2006); 47 898 women in the Nurses' Health Study II (NHS II), followed for 12 years (1991 to 2003); and 22 557 men in the Health Professionals Follow-up Study (HPFS), followed for 20 years (1986 to 2006). Weight changes are reported for each increase in the daily serving of the food or beverage; decreased intake would be associated with the inverse weight changes. There was little evidence of a significant interaction between diet and physical activity ($p > 0.10$ for the interaction in each cohort). All weight changes were adjusted simultaneously for age, baseline body mass index, sleep duration, and changes in smoking status, physical activity, television watching, alcohol use, and all of the dietary factors shown. The p value is less than 0.001 for all dietary factors with the exception of butter in the NHS II, cheese in the NHS and NHS II, low-fat or skim milk in the NHS and HPFS, diet soda in the NHS, and whole-fat milk in all three cohorts. Reproduced with permission from reference [19], © 2011, *New England Journal of Medicine*. (See figure in color plate section.)

countries. However, data from the developing world have begun to emerge. As discussed previously in the present chapter, in some developing countries such as China and India, where the Western lifestyle and diet are becoming more common, the prevalence of obesity and obesity-related disorders is increasing rapidly. Economic development and globalization have spurred nutritional transitions in these countries typically involving increased consumption of animal fat and energy-dense foods and SSBs, decreased consumption of fiber, and more frequent intake of fast foods, which are related to weight gain and obesity. At the same time,

a shift away from agricultural labor toward employment in manufacturing services has led to a dramatic decline in physical activity, the main determinant of variation in energy expenditure in the population [23]. The combination of excessive energy intake and drastically reduced energy expenditure is driving the increased obesity epidemic in these countries.

Physical activity and inactivity

In addition to diet, physical activity may play a pivotal role in maintaining energy balance and weight control. Numerous prospective studies have examined the