Health & Fitness Journal

of Canada

Volume 11 May 30, 2018 Number 2

NARRATIVE REVIEW

Obesity in 2018. Do we have an epidemic, and if so what caused it?

Roy J. Shephard[1]

Abstract

Objective: To document the existence, nature and course of the "obesity epidemic," and to explore secular correlates that appear to have played a part in its causation. ***Methods:*** Analysis of relevant literature through the data bases of PUBMED and Google Scholar to March 2018, supplemented by material held in the author's personal files. ***Results:*** There is good evidence of an epidemic in the sense that obesity has become widely prevalent in many countries over the past 3 decades; in particular, there has been an increase in the proportion of grossly obese individuals. Obesity showed its first increase in North America and Western Europe, but the epidemic has spread progressively to developing countries, with the increased prevalence of obesity being seen first in urban areas. In western countries, the proportion of obese individuals rose markedly in the 1980s, and now appears to be reaching a plateau, although from the viewpoint of health, the obese fraction of the population remains undesirably large. Commonly supposed causes of the epidemic include secular changes in the amount and type of food ingested, and a progressive decrease of habitual physical activity, but there could also be influences from a wide variety of other social and environmental changes, some of which match the obesity epidemic in terms of their timing. Discrimination among these potential causes remains important to the design of appropriate tactics to combat the epidemic. ***Conclusions.*** Weight for height ratios and skin-fold thicknesses have increased substantially in many countries over the past 2-3 decades, and an associated decrease of lean tissue has masked the full extent of an adverse secular change in body composition. A decrease of habitual physical activity, an increased intake of sucrose and associated over-eating are likely primary causes, but a multitude of other demographic, social and environmental changes could also have played a contributory role. A clarification of causation remains difficult because of the small magnitude of the daily energy imbalance leading to obesity, but nevertheless a determination of aetiology remains important to the design of appropriate future preventive efforts. **Health & Fitness Journal of Canada 2018;11(2):53-112.**

Keywords: Adiposity; Body mass; Diet; Physical activity. Secular change.

From [1]Faculty of Kinesiology & Physical Education, University of Toronto, Toronto, ON, Canada. Email: royjshep@shaw.ca

Introduction

Both the popular media and scientific journals have devoted much space to discussions of an "obesity epidemic" in recent years. The present narrative review considers whether we are indeed faced with an "obesity epidemic," and if so what has been its time course and what is its current extent. It also looks at various secular correlates as possible causes of the phenomenon, with a view to designing appropriate preventive tactics.

Are we faced by an obesity epidemic?

Are we faced by an obesity epidemic? In seeking an answer to this question, we will look at historical perceptions of an epidemic and dictionary definitions of the term before considering more recent popular and scientific pronouncements on the existence of an obesity epidemic.

Historical perceptions of epidemics. Historical perceptions of what constitutes an epidemic go back at least to the Middle Ages, when the European population was decimated by the Bubonic Plague. Mediaeval scholars clearly recognized that the terrifying phenomenon of the Black Death was in some way introduced by travelers arriving from foreign lands. Guards were placed on strategic mountain passes, and 40 days of quarantine were required of all newcomers- time that was spent in an isolated camp far outside the city limits, or (in the case of England) on derelict ships moored off-shore in the Thames estuary. More recently, North America has observed similar precautions, holding immigrants in strict quarantine on isolated islands such as Ellis Island in New York State, and Grosse Isle in the St. Lawrence estuary (Shephard, 2015).

The historical perception of an epidemic thus carries with it the ideas of a clinical condition that is highly contagious and potentially fatal, but that the danger to the life of both the affected individual and his or her personal contacts resolves over a period of a few weeks. Neither of these concepts fits particularly well with the current world problem of a growing prevalence of obesity.

Dictionary definitions of the word "epidemic." Some authors, while admitting that there has been an increase of average body mass in many of the world's populations over recent decades, have queried use of the term "epidemic" to describe this phenomenon. They have argued that such a designation would imply a sudden and exponential increase in the proportion of the population who are obese, whereas in fact changes have been more subtle, with little evidence of contagion (Campos et al., 2006); some, indeed have suggested the phenomenon hardly warrants the concern that it has aroused in many epidemiologists.

Can popular dictionaries resolve this debate? The Oxford English Dictionary (OED) indicates that the word epidemic was first used in England in the year 1603 (Simpson and Weiner, 2001). In that era, the term was applied to a disease that was prevalent among a people or community at a special time, and was produced by some special causes not generally present in the affected locality. It proved a particularly apt descriptor of the Great Plague that ravaged London in 1665. However, by the year 1745, a second meaning of epidemic, that of “widely prevalent" or "universal," had also become generally accepted.

Noah Webster (Harris and Sturges Allen, 1927) had a similar, population-based, primary definition of the term: "*Common to, or affecting at the same time a large number of a community*" "*applied to a disease, which spreading widely, attacks many people at the same time*," with a secondary meaning of "*spreading widely*" or "*generally prevailing*."

More recently, the New Gould Medical Dictionary (Jones et al., 1949) proposed as its definition: "a*n unusual prevalence of a disease; normally affecting large numbers, or spreading over a wide area*." The Senior Dictionary of Canadian English (Avis et al., 1967) suggested "*a rapid spreading of a disease that many people have at the same time*," while for Wikipedia there currently remains the connotation of an infectious disease: "*the rapid spread of infectious disease to a large number of people in a given population within a short period of time, usually two weeks or less*." Wikipedia speaks of the alternatives of a common source outbreak and a propagated outbreak, neither of which is applicable to obesity; further, it lists 12 possible modes of transmission, none of which are relevant to the excessive accumulation of body fat.

Thus, in strict etymological terms, the ideas of an infection that is spread over a few weeks and a condition with a short duration do not jibe well with our current understanding of the obesity epidemic. The primary OED definition does not necessarily imply either an exponential increase in prevalence of the condition or a risk that currently health individuals will be affected. However, the alternative definition of a problem that is becoming "widely prevalent" seems appropriate to describe the situation where a growing proportion of the population in many countries are becoming obese.

Popular opinions about an obesity epidemic. A press release from the World Health Organization (WHO) in 2003 noted that it had already begun warning policy makers about a growing prevalence of obesity during the mid 1990s, and that it had responded by organizing a series of expert and technical consultations, together with public awareness campaigns in an attempt to sensitize policy makers, private sector partners, medical professionals, and the general public to this problem (World Health Organization, 2003). The WHO pointed to what had become a global epidemic of overweight and obesity, affecting virtually all age and socioeconomic groups and threatening to overwhelm health services with obesity-related diseases. Already, in 1995, there were an estimated 200 million obese adults worldwide and 18 million children under the age of five were classified as overweight. As of 2000, the number of obese adults had risen to over 300 million. Moreover, and contrary to conventional wisdom, the obesity epidemic was not restricted to industrialized societies. In developing countries, also, over 115 million people already suffered from obesity-related problems.

A subsequent WHO fact sheet suggested that the worldwide prevalence of obesity had doubled between 1980 and 2014, and that by 2014 41 million children under the age of 5 years had become overweight or obese (World Health Organization, 2014).

The U.S. Centers for Disease Control and Prevention released a popular video and Podcast in July of 2011 (Centers for Disease Control and Prevention, 2011). The opening statement of this presentation contained an equally grim warning, as Dr. Patricia Dietz noted: "*Obesity costs this country about $150 billion a year, or almost 10 percent of the national medical budget. Approximately one in three adults and one in six children are obese. Obesity is epidemic in the United States today and a major cause of death, attributable to heart disease, cancer, and diabetes*." She indicated that the problem reflected complicated secular changes in an environment, "*where food is more readily available and opportunities for physical activity are lacking*."

In 2016, the American Heart Association (AHA) posted a public information bulletin entitled "*Understanding the Obesity Epidemic*" (American Heart Association, 2016a). This document opened with the assertion "*Obesity — everyone knows it's bad and that it's everywhere. Nearly 78 million adults and 13 million children in the United States deal with the health and emotional effects of obesity every day. The solution to their problem sounds deceptively simple — take in fewer calories a day, while cranking up the calorie-burning process with regular exercise.*" In the same year the AHA also posted a statement (American Heart Association, 2016b) responding to a World Health Organization report entitled

"*Ending Childhood Obesity*." The AHA argued the need "*to aggressively address the childhood obesity epidemic using every recommendation possible. Children should be surrounded by healthy food and drinks and opportunities to play and be active.*"

The popular web-site Web-MD (Smith, 2016) suggested that "*One of the biggest health stories of the year has been the rise in obesity among both adults and children in the U.S. while obesity may not be the Black Death, it is a severe public health crisis...at the rate we're going, obesity-related diabetes alone will break the bank of our healthcare system.*"

Thus, recent popular opinion in the U.S. and elsewhere in the world has been unanimous in its concern about a growing epidemic of obesity among all ages of the general population, a problem of sufficient magnitude that it now threatens to overwhelm medical services.

Scientific opinions. The idea that there has been a recent "obesity epidemic" finds many strong proponents among the scientific community. In 2003, a joint statement from the Food and Agriculture Organization and the WHO proclaimed that "*almost all countries (high income and low income alike) are experiencing an obesity epidemic...*" (Deurenberg-Yap and Sediell, 2003). Moreover, it asserted that in affluent countries, "*obesity is not only common in the middle-aged, but is becoming increasingly prevalent among younger adults and children*."

In 2013, the International Obesity Task Force, organized by the International Association for the Study of Obesity, estimated that at least 1.1 billion of the world's population were now overweight, with 312 million of these being obese (GBD Obesity Collaboration, 2014). The same year, the World Health Organization (WHO) presented even more alarming figures, estimating that by 2014 a total of 1.9 Billion adults > 18 years of age were overweight, and a further 600 million were obese (World Health Organization, 2014).

Technical concerns. From the foregoing, there can be little dispute that in recent years there has been an alarming increase in the proportion of the world population who are classed as overweight or obese. Nevertheless, some technical concerns limit the interpretation of absolute numbers and percentages.

One immediate issue, undoubtedly contributing to the growing proportion of Americans who became classed as obese during the late 1990s was a downward shift in what was regarded as an acceptable BMI for American citizens, from 27.8 to 25 kg/m^2. This 1998 move by the U.S. National Institutes of Health (Pi-Sunyer, 1998) was designed to bring the U.S. definition of an excessive body mass in line with the international standards set by the WHO (Mitchell et al., 2011) (Table 1); with one bureaucratic pen-stroke, the CDC immediately classed an additional 25 million Americans as obese. However, this shifting of the goal posts for an acceptable body composition in the U.S. does not affect the figures for prevalence as shown in the present review; here, the upper limit of a "normal" BMI has been set consistently at the now internationally accepted level of 24.9 kg/m^2.

Table 1: Current internationally accepted definitions of "overweight" and "obesity."

Category	BMI range (kg/m^2)	Male waist circumference (cm)	Female waist circumference (cm)
Underweight	<18.5		
Normal	18.5-24.9	<102	<88
Overweight	25.0-29.9	>102	>88
Obesity Class 1	30.0-34.9		
Obesity Class II	35.0-39.9		
Obesity Class III	>40.0		

In considering the proportion of obese individuals in any given population, we should also emphasize that most investigators have focused simply on body mass/height ratios, particularly the BMI. In theory, an increase of body mass could reflect an accumulation of fat, muscle or fluid, although in most people high values arise from an accumulation of body fat. More seriously, the data used in calculating BMIs have often been obtained from self-reports, and because body mass is systematically under-reported, particularly by individuals who are at the upper end of the distribution curve, recent increases in the prevalence of obesity and severe obesity are likely to have been under-estimated (Rowland, 1990). Canadian data illustrate the magnitude of this problem. In 2005, the prevalence of obesity in Canada was estimated at 15.5% on the basis of self-reports of standing height and body mass, but it rose to 24.2% when it was based upon measured data (Katzmarzyk, 2009; Paccaud et al., 2001).

In terms of secular change, even if it were to be shown that the average BMI had remained relatively constant over the past several decades, the typical person could have reduced habitual physical activity and thus replaced a considerable amount of his or her lean tissue by fat during this period. Thus, an analysis of BMIs could underestimate the secular trend to an accumulation of body fat. The potential importance of this issue is well illustrated by data for Inuit living in the community of Igloolik (Nunavut), where a substantial acculturation to a sedentary, western lifestyle occurred between the years 1970 and 1990 (Shephard and Rode, 1996). The BMI of the Inuit showed little change over these two decades, but nevertheless, subcutaneous fat thickness increased by an average of 37% in the men and 22% in the women (Table 2), as lean tissue was replaced by fat.

In the usual situation, where the analyzed data have been collected from repeated National surveys, one final technical issue is whether any observed trends to an increase of body mass reflect an overall secular change or whether they are the consequence of a cohort effect.

Historical trends in body mass and obesity in selected countries. There are now many statistics illustrating historical trends to increases in body mass and the prevalence of obesity in various communities around the world. Unfortunately, the data often cover only a few years, and figures have not always been collected by consistent techniques. We will look at findings for adults living in the United States, Canada, Australia, and some European, Asian and Latin-American countries, and will consider more briefly the information on children.

Table 2: Changes in body mass index (BMI) and thicknesses of the triceps skin-fold in Igloolik Inuit as they underwent a progressive acculturation to a sedentary, western lifestyle over the period 1970-1990 (based on data of Shephard and Rode, 1996).

Age group (yr)	Men				Women			
	1970		1990		1970		1990	
	BMI (kg/m^2)	Skin-fold (mm)	BMI (kg/m^2)	Skin-fold (mm)	BMI (kg/m^2)	Skin-fold (mm)	BMI (kg/m^2)	Skin-fold (mm)
20-29	24.3	5.5	23.8	7.1	23.2	8.5	23.1	12.0
30-39	24.9	6.3	25.8	8.4	23.9	9.2	25.4	13.5
40-49	25.3	5.4	26.9	10.1	23.7	7.0	27.9	16.4
50-59	25.8	7.9	26.4	8.6	27.5	19.0	24.0	11.2
Average, all ages	25.1	6.3	25.7	8.6	25.3	10.9	25.1	13.3

Historical pattern of body mass in U.S. adults. In the U.S., evidence of a secular trend to a progressive increase in average BMI is confirmed by observations on waist circumferences and skin-fold thicknesses, with these adverse changes being particularly marked in minority segments of the population.

Trends in body mass index. A substantial proportion of men and older women were classed as overweight in relation to standing height back at least as far as 1960. Indeed, some investigators have traced the obesity epidemic as far back as 100 years; although the rate of increase in the average body mass has accelerated over the last 3 decades. By 1998, many of the population weighed 3-5 kg more than they had a decade earlier (Flegalet al., 1998). Moreover, the proportion of those who were classed as overweight had not increased dramatically between surveys conducted in 1960-64 and 1988-94, but in contrast there had been a substantial rise in the proportion of those who were rated as obese. Comparing across successive NHANES studies, increased numbers of obese were first seen in 1976-80, and this trend became more marked in 1988/94 (Table 3). It was accompanied by a growing rightward skewing of the body mass distribution curve; average individuals showed only small gains of body mass (Flegal et al., 1998; Flegal and Troiano, 2000), but there was a much

Table 3: Changes in the percentage of individuals rated as overweight and obese in the U.S. between 1960-62 and 2011-2012, based on data from the National Health and Examination Survey (1960-62), and a series of National Health and Nutrition Examination Surveys (1971-74; 1976-80; 1988-94).

Years	Men				Women			
	Age 20-29 yr		Age 60-69 yr		Age 20-29 yr		Age 60-69 yr	
	Overweight	Obese	Overweight	Obese	Overweight	Obese	Overweight	Obese
1960-62	30.8%	9.0%	45.1%	7.8%	10.9%	6.1%	35.5%	27.2%
1971-74	30.6%	8.1%	45.3%	10.3%	15.0%	8.2%	34.0%	23.9%
1976-80	28.8%	8.1%	43.9%	12.5%	16.0%	8.9%	38.8%	22.1%
1988-94	30.6%	12.5%	45.4%	24.8%	18.5%	22.0%	32.8%	29.8%

greater rise of body mass in the heaviest individuals. Between 1990 and 2000, the overall prevalence of Class 3 obesity (those with a BMI > 40kg/m^2) among U.S. adults increased from 0.8% to 2.2%. Moreover, the increase was seen in both sexes and at all ages, irrespective of the individual's smoking category, and the problem was over-represented in minority groups. By 2000, grade 3 obesity affected 6% of black women and 3.4% of those who had not completed high school (Freedman et al., 2002).

Hopes that the increase in average BMI might have reached a plateau by the time of the third NHANES survey (Campos et al., 2006) were crushed as data were analyzed for 1999-2000 and beyond. The average prevalence of obesity among U.S. adults increased from 23% in 1988-94 to 30% in 1999-2000 (Centers for Disease Control and Prevention, 2000), 34.3% in 2005-2006, 35.7% in 2009-2010, and 37.9% in 2013-2014 (National Center for Health, 2016). In the latest data set (2013-2014), the prevalence of obesity was 32.3% in young adults, 40.2% in middle aged people and 37.0% in the elderly, with slightly higher average figures for women (38.3%) than for men (34.3%) (Flegal et al., 2016).

Trends in circumference data. As might be expected, the secular trend to increases of BMI in Americans has been mirrored by a progressive augmentation of waist circumferences over the past 25 years. However, there have been suggestions that increases in abdominal circumference and thus abdominal obesity may provide the best measure of the associated changes in health risks (Sharma, 2002).

Between 1988-94 and 2003-2004, NHANES data showed average waist girths increasing from 96 to more than 100 cm in men, and from 89 cm to 93 cm in women, with the proportion of "high" values rising from 30 to 41% of the male sample, and from 47 to >60% of females (Katzmarzyk, 2009; Li et al., 2007). Circumference increases of 2 cm in men and 4 cm in women were documented between the 1999-2000 and 2011-2012 cycles of the NHANES surveys; in the men, this change was approximately what would have been predicted from increases of BMI over the same period, but in the women the gain was even larger than would have been predicted from the increase in BMI (Freedman and Ford, 2015), implying that measurements of BMI may be under-estimating the growing health risk from the accumulation of abdominal fat (Walls et al., 2011). In children, 74% of the increase of waist circumference in boys and 50% of that in girls could also be explained in terms of the increase in BMI at a given age (Freedman et al., 2015).

Trends in skin-fold data. Secular trends to increases in skin-fold thicknesses (triceps + subscapular) were examined by Freeman et al. (2017). Among male participants in the NHANES surveys, the skin-fold data mirrored the changes seen in BMI and waist circumferences over the period from 1988-1994 to 2009-2010, but in women skin-folds showed no increase despite the augmentation of BMI, suggesting that in women sub-cutaneous fat, as determined by skin-fold data, may not provide a reliable index of changes in total body fat accumulation and associated health risks.

Groups particularly affected. All groups of the U.S. population have grown steadily heavier over the past few decades, irrespective of socio-economic group or ethnicity. Nevertheless, the problem has been particularly acute among women of African and Mexican ancestry, and in those with low incomes and low socio-economic status (Mitchell et al., 2011). Possibly, these groups tend to eat cheap foods that contain high levels of saturated fat and sugar and thus encourage over-eating (Cawley, 2004; Drewnowski and Specter, 2004). Possibly, also, these segments of the U.S. population live in environments that are less conducive to engaging in regular voluntary physical activity (Gordon-Larsen et al., 2006; Harper and Lynch, 2007).

Historical pattern of body mass data for Canadian adults. In Canada, representative population data on body build are available from 1953. In that year a height and weight survey was conducted (Pett and Ogilvie, 1956), in part over concerns that the Canadian population was becoming obese. Indeed, the investigators rated a substantial proportion of the 1953 sample as being overweight. Despite this assessment, the overall Canadian weight for height ratios showed their first significant increase of about 2% between the Nutrition Canada Survey of 1970-72 and the Canada Health Survey of 1978/79 (Katzmarzyk, 2002). Figures then increased by a further average of 5.1% in men and 4.9% in women to 2004, due mainly to an increase in the proportion of individuals who were rated as obese or grossly obese. Nevertheless, the interpretation of secular trends in the average body composition of Canadians is complicated by immigration, which (at a rate of almost 1% per year) has substantially altered the ethnic make-up of the Canadian population over the period under consideration.

Taking the data at their face value, Canada has shown a somewhat similar picture to the U.S. between 1970/72 and 2004, with a statistically significant decrease in the percentage of adults classed as having a healthy body mass, and a significant increase in the percentage of those categorized as obese (Table 4). Moreover, as in the U.S., there has been a particularly large increment in the percentages of people with morbid (Class II and Class III) obesity. Between 1970/72 and 2004 the morbidly obese increased from 2.3 to 5.1% of men and from 0.9 to 2.7% of women. Subsequent self-reported data have shown further increases in the total of those rated as either overweight or obese, from 49.3% in 2003 to 54.0% in 2007, although with little change thereafter.

Historical pattern of body mass data for Australian adults. A comparison of data for Australian adults between 1995 and 2011-2012 shows that there has been an overall increase in the prevalence of obesity from 19.1% to 27.2% over this time period. As in the U.S. and Canada, the largest increase has been in the heaviest

Table 4: Secular changes in reported prevalence of overweight and obesity in Canadian adults, based on the data of Nutrition Canada (1970-72), the Canada Health Survey (1978/79) and the Canadian Community Health Survey (2004).

Category	Men			Women		
	1970/72	1978/79	2004	1970/72	1978/79	2004
Underweight		1.4%	1.4%		3.5%	2.5%
Normal weight		44.3	33.6		52.5	44.1
Overweight	46.1	42.8	42.0	31.7	28.4	30.2
Obese	7.6	11.5	22.9	11.7	15.7	23.2

category, with respective 1.3-, 1.7- and 2.2-fold increases in prevalence of the 3 classes of obesity (Keating et al., 2015). Women contributed more than men to the growing totals of the obese. An analysis by the Australian government (Australian Institute of Health and Welfare, 2017) reached similar conclusions to Keating et al. (2015).

Looking at the population by birth cohort, in 2014-2015 the prevalence of obesity (based on BMI data) was 15.2% for those born in 1994-1997 compared with only 8% for the cohort that was born 2 decades earlier. Moreover, abdominal obesity (as assessed from circumference measurements) had increased in prevalence from 7.2% to 16.8% over the same interval.

Historical patterns of body mass data for Europe. Data showing historical patterns of obesity in Europe are less readily available than for North America. A comparison across 9 countries found that in 1998 the prevalence of obesity was lowest in Italy (6.6% of the population in women, 7.9% in men), rising to 11.8% and 14.0% for women and men in Spain. Moreover, the prevalence of obesity increased by 8.5% in both sexes from 1998 to 2001. The pattern of increasing body mass generally persisted in the OECD survey of 2015 (OECD, 2017), with populations reaching even higher body fat contents.

United Kingdom. By 2013, the United Kingdom had become the most obese nation in Europe (24.9% of the population being classed as obese). In comparison, the prevalence was 17.2% in Italy, with a world-wide average of 11.7%, figures of 8.7% for developing countries, 4.7% for Kenya, and 1.2% for Ethiopia (Food and Agricultural Organisation, 2013). In the latest measured data for England (in 2014, 26% of those aged >15 years were obese, and in 2015, 26.9%). These levels were exceeded only in one European country (Hungary, with 30.0% of the population rated as obese)(OECD, 2017; National Health Service, 2017).

Germany. In Germany, data are available from surveys conducted in 1998 and in 2008-2011 (Mensink et al., 2013). Although the BMI was initially undesirably high, it appears to have increased slightly further over this period, with the percentages of those rated as obese rising over the 10-12 year interval from 22.5% to 23.3% in women, and from 18.9% to 23.9% in men (OECD, 2017).

France. In France, the prevalence of obesity was initially low relative to other European countries and it remained almost stable over the period from 1980 to 1991 (increasing from 6.4% to 6.5% in men, and from 6.3% to 7.0% in women)(Maillard et al., 1999). Subsequently, representative data for the reported heights and body masses of adults >18 years were obtained from 20,000 households in 1997, 2000, 2003 and 2006. These latter figures showed a progressive rise in the prevalence of obesity in both sexes over the 4 surveys (from 9% to 13% in men, and from 8% to 14% in women) (Charles et al., 2008).

Detailed analysis of the data shows that within each birth cohort, obesity increased with age, and that more recent birth cohorts had a greater prevalence of obesity than their predecessors. The greater susceptibility to obesity apparently began with the cohort born around 1960, at a time when economic conditions in France were improving rapidly (Diouf et al., 2010).

Italy. Italy has one of the lowest prevalences of obesity of European countries, at 8.5% in 2003 (Nationmaster, 2003) and rising only slightly to 9.8% in 2015 (OECD, 2017).

Scandinavia. The Scandinavian countries are often considered to be physically more active and healthier than other members of the European community. However, recent reports suggest that they have not been entirely spared from the obesity epidemic.

Norway. The Tromsø study examined 3541 Norwegian men and 4993 women four times over the period 1974-1994/5 (Jacobsen et al., 2001). Over this period, the age and sex-adjusted BMI increased by 1.0 kg/m^2 in men and 0.9 kg/m^2 in women over this period; a longitudinal analysis of data for those aged 20-49 years showed even larger increases (2.0 kg/m^2 in men, and 2.4 kg/m^2 in women). By 1994-1995, 9,5% of men and 11.5% of women were obese (Jacobsen et al., 2001).

A survey of literature for Norway as a whole (Ulset et al., 2007) showed that in men aged 40-45years, the prevalence of obesity rose steadily from 1964-65, reaching an average of 19.5% in 2000-2003. In women, the prevalence of obesity actually decreased from 1964-65 to 1984, before increasing steadily to an average of 20% in 2000-2003.

Finland. The health statistics of the OECD show that the percentage of self-reported obese Finns rose from 6.6% in 1978 to 15.9% in 2009 and 24.8% in 2015 (OECD, 2017). A regional report from Eastern Finland (Lahti-Koski et al., 2001) looked at the increase of BMI with aging. Among the women, the increase over a lifespan of 25 years (an average of 4.2 kg/m^2) remained constant across birth cohorts, but in the men an average increase of 3.3 kg/m^2 was greater for the younger cohorts.

Denmark. A survey in the Copenhagen area concluded that the prevalence of obesity had generally increased in recent decades, although the effect was very heterogeneous, with men showing gains in the 1970s and the 1990s, and women only during the 1990s, to reach respective prevalences of 12% and 11% in 1994 (Heitmann et al., 2003) and 14.9% in 2015 (OECD, 2017).

Another Danish study looked at the course of the obesity epidemic in boys aged 7-11 years and young men at the age of 19 years (Olsen et al. 2006). When plotted by year of birth, the surge in the prevalence of obesity was similar for the two population samples (in the early 1940s to mid-1950s and in the late 1960s), suggesting that some adverse event affected early development (possibly intra-uterine or neonatal) over these time periods.

Sweden. Four postal surveys of the population in mid-Sweden (Molarius et al., 2016) showed increases in the prevalence of obesity from 2000 to 2012. In women, the reported change was from 13% to 17%, and in men it was from 12% to 17%; however, the true final figure in both sexes was probably around 20%, after allowing for the self-reporting of data. Increases in the prevalence of obesity varied with educational attainment, being greatest for those reaching the middle level of education.

Historical pattern of body mass data for Asian Countries. The secular trend to an increase in body fat content now seems a world-wide phenomenon, affecting both developed and emerging nations, including people many parts of Asia. However, in a number of Asian countries, obesity of the urban population has substantially preceded that of those still living in poor and rural areas.

India. Data from India show that the present generation are much more obese than their predecessors. In 1998, the average prevalence of overweight was only 4%, and obesity was only seen in 0.5% of men and women (Prentice, 2006). However, by 2015 the prevalence of obesity had risen substantially, to 5.0% (OECD, 2017). Likewise, the combined prevalence of overweight and obesity amounted to 23.5% for urban adults in 1995, but by 2006 it had risen to 40.8% for urban and 19.5% for rural residents (Ramachandran and Snehalatha, 2010).

China. A meta-analysis based on nationally representative data (Wang et al., 2007) shows that over the decade 1992-2002, a growing material prosperity in China was accompanied by an increased prevalence of overweight and obesity. This trend affected both sexes and all age groups with combined figures for overweight plus obesity rising from 14.6 to 21.8% over the ten years. By 2002, 19.4% of the men and 22.2% of the women living in Beijing were classed as obese, although this remained mainly an urban problem; the overall prevalence of obesity across China was still only 7.0% in 2015 (OECD, 2017). Unfortunately, the situation seems destined to worsen, since there is now a rapid migration to urban centres, and a large segment of the Chinese population believes that an excess of body fat is an indication of health and prosperity (Wu, 2006).

Japan. The Japanese National Nutrition Survey of 2000 showed a much lower prevalence of overweight (24.5% in males, 17.8% in females) and obesity (2.3% in males, 3.4% in females) than in most western nations (Yoshike, et al., 2003). In 2015, the average prevalence of obesity in Japan was still only 3.7% (OECD, 2017).

Historical pattern of body mass for Latin-American countries. Many Latin American countries have seen a progressive transition from being underweight to overweight as economic conditions have improved over recent decades. The Ministry of Health in Brazil estimated the current percentages of obese individuals in South America at 17.9% for Brazil, 19.9% for Uruguay, 20.5% for Argentina, 22.8% for Paraguay, and 25.1% for Chile. In Brazil, the percentage of obese women increased from around 7% in 1975 to ~12.5% in 1997, while for men the corresponding figures were ~2.5 and ~6.5%. Figures for Chile were much higher (14.5 and 23% in women, and ~5.5 and ~15.5% in men) (Uauy et al., 2001).

In Brazil, the earliest documented trend to obesity (1975-1989) excluded the rural population, But in more recent years (1989-1997) the rate of increase in obesity has been greatest among poor and rural families, particularly in men (Monteiro et al., 2000).

Overview for 200 countries. The NCD Risk Factor Collaboration has assembled data from 1698 studies on a total of 19.2 million people, providing a large volume of body mass data for the period 1975-2014. The global age-standardized BMI increased from an average of 21.7 kg/m^2 in 1975 to 24.2 kg/m^2 in men in 2014, and from 22.1 to 24.2 kg/m^2 in women, with the age standardized prevalence of obesity rising from 3.2% to 10.8% in men, and from 6.4% to 14.9% in women (NCD Risk Factor Collaboration, 2016).

Historical pattern of body mass data for children. Data from a number of countries points to the fact that in recent years, children have not escaped the obesity epidemic, although it is difficult to make direct comparisons with the increases in body mass of their parents.

United States. U.S. children have shown a growing prevalence of obesity over the past 3 decades, and by 2007-2008, the NHANES survey was reporting that the BMI of 17% of children between the ages of 2 and 19 years was lying at or above the 95th percentile on the CDC growth charts (Ogden et al. 2010). Childhood overweight and obesity usually portend adult obesity, and it is particularly disturbing from the viewpoint of future population health that there has been a substantial increase in the percentage of children who are now rated as either overweight or obese (Table 5). The trend has affected U.S. children of both sexes at all ages (Flegal and Troiano, 2000), and as in the adults, the largest increase in numbers appears to have been seen at the upper end of the weight distribution curve. Between 1980 and 2014, the percentage of children who were rated as obese increased from 7% to 17.5% in those aged 6-11 years, and from 5% t0 20.5% in those aged 12-19 years. However, overall figures for those aged 2-19 years suggest some moderation of the trend in more recent years, with figures rising from 13.9% in 1999-2000 to 17.2% in 2013-2014 (Johnson Foundation, 2014; National Center for Health Statistics, 2016).

Waist circumferences for American children have also increased substantially over the short period between 1999 and 2004. Respective values for boys and for girls were at ages 2-5 years 1.2 and 0.8 cm, at ages 6-11 years 2.6 and 3.0 cm, at ages 12-17 years 3.0 and 3.9 cm and at 18-19 years 5.3 and 6.2 cm (Li et al., 2006). A subsequent report showed some leveling off in this adverse trend, with waist circumferences and waist hip ratios remaining stable for most age categories of children from 2003-2004 to 2011-2012 (Xi et al., 2014).

As in adults, substantial under-estimates of the prevalence of obesity can arise from reliance upon reported values for body mass. In boys aged 12-17 years, the percentage who were rated as obese rose from 5 .7% to 11.1% when measured values were substituted for subjective reports, and in girls the increase was from 3.3 to 7.4% (Shields, 2004).

Table 5: Combined percentages of U.S. children rated as overweight (>85th percentile) and obese (> 95th percentile), based on their placement on normal height and weight growth charts. Data for 1964-70 (NHES) and 1988-1994 (NHANES III).

Age (yr)	Male		Female	
	1964-70	1988-94	1964-70	1988-94
6-8	3.4%	10.8%	4.1%	11.0%
9-11	4.6%	12.8%	4.9%	11.0%
12-14	4.7%	11.9%	4.4%	11.7%
15-17	4.2%	12.0%	5.1%	8.7%

Table 6: Prevalence of overweight and obesity among Canadian children aged 7-13 years, as reported by Tremblay et al. (2002) and the Canadian Community Health Survey.

Sex	Overweight				Obese			
	1981	1995-96+	2000-01+	2004*	1981	1995-96+	2000-01+	2004*
Male	8.6%	22.4%	20%	17.9%	2.0%	10.2%	9%	9.1%
Female	11.4%	17.7%	17%	18.3%	1.7%	8.9%	10%	7.2%

*Age 2-17 years
+Reported rather than measured values

Canada. Canadian data for children aged 7-13 years showed increases in the percentages of both overweight and obese individuals between 1981 and 2004 (Table 6). The main change apparently occurred quite rapidly between 1981 and 1995-1996, and indeed a more recent report has noted a small reversal of this trend. Thus, the prevalence of overweight plus obesity in children aged 3-19 years dropped from 31.0 to 27.6% over the period 2004 to 2013, although obesity remaining constant at around 13%.

Australia. When national data for Australian schoolchildren aged 10-11 years from 1985 were compared with findings on South Australian children in 1997, the average body mass had increased by 1.4-2.9 kg over the 12-year interval (Dollman et al., 1999). Moreover, waist circumference data collected in 2014-2015 (Australian Institute of Health and Welfare, 2017) showed substantial increases in the prevalence of obesity relative to two decades earlier (rising from 4.2% to 8.8% for the age group 2-5 years, from 23.9% to 30.8% at ages 10-13 years, and from 19.7% to 29.8% in those aged 14-17 years).

Europe. British children were evaluated at ages 4-5 and 10-11 years. In the younger group, obesity was relatively stable in recent years, with figures of 10% in 2006-2007 and 9% in 2013-2016, but in the older children the prevalence of obesity had risen from 17% to 20% over this interval (National Health Service, 2017); moreover, only 51% of mothers and 56% of fathers described obese children as being too heavy. The problem of growing obesity was most marked among those with low socio-economic status, and those with black ancestry, whereas it was lowest among those of Chinese origin.

In Germany, an interesting difference was reported between the former Eastern and Western halves of the country (Liese et al., 2006). Soon after reunification (1995-1996), the percentages of overweight children were 22.2% and 24.0% for Munich boys and girls, as compared with 14.2% and 15.2% for children in the much less wealthy East German city of Dresden.

In Sicily, the body mass of children aged 11-13 years was compared between 1999-2001 and 2009-2010 (Parrino et al., 2012). Over this period, the economic situation of Sicilians improved substantially. Probably for this reason, the prevalence of obesity increased from 7.9 to 13.7%, and excessive thinness decreased from 10.1 to 2.3%.

Summary. In North America, many middle-aged and older people have been overweight for at least 50 years. However, there is good evidence that over the past 2-3 decades the prevalence of frank obesity and particularly of morbid obesity has increased substantially, not only in North America, but also in many developed and emerging countries around the world. With a prevalence currently averaging at least 11% world-wide, and reaching over 20% in many countries, the problem of obesity certainly qualifies as an epidemic in the sense of now being "widely prevalent."

A review of 52 studies from 25 countries suggests that the continuing increase in the prevalence of obesity has moderated in many countries since 2000 (Rokholm et al. 2010). However, the stabilization of data is less evident among lower SES groups and in rural populations, and substantial overall increases are still occurring in some European and Asian countries as their economic situation improves. Any leveling off of the epidemic might offer some encouragement to those engaged in public health messaging. Nevertheless, this should not obscure the fact that the average body fat content remains unacceptably high for much of the world's population. This situation is prejudicial to the future health not only of those who are now adults but also that of the current generation of children and adolescents.

Time course of the obesity epidemic

It is plain from the previous section of this review that the obesity epidemic is now widespread, and that it began at differing times in various countries. It was first seen in the United States, and subsequently spread to Europe and other developed and developing countries. It also seems that the problem was first observed in middle-aged and older adults, but it has subsequently affected children, adolescents and younger adults. It remains difficult to establish precise time relationships when trying to correlate the obesity epidemic with secular changes in lifestyle and environment, in part because there is necessarily a lag-time between the appearance of such changes and the accumulation of significant amounts of body fat. Moreover, in many countries the collection of representative data on BMI, circumferences and skin-fold thicknesses on large population samples is a relatively recent phenomenon.

North America. It is clear that many older people in North America were already somewhat overweight, even 50 years ago. The new features of U.S. and Canadian data are (1) that during recent decades there has been a growing prevalence of frank obesity, particularly class II and class III morbid obesity (people with a BMI >35 kg/m^2), and (2) excessive fat accumulation has spread from middle-aged and elderly people to younger age groups.

Denmark. Data on the characteristics of military recruits provide some useful insights into secular trends for large and (in the case of compulsory military service) of representative population samples of young adults. Figures for young Danish men who joined the armed forces at the age of 18-19 years offer a 50-year perspective on secular trends in the prevalence of obesity in that country. Between 1930 and 1940, only about 0.1% of Danish recruits were classed as obese. The prevalence of obesity rose a little to 0.5% in 1950 and 0.7% in 1960 and 1970, but showed a sudden surge to 3.5%for recruits around 1980. The percentage of those who were rose further to > 6% in 2002, and continued to increase more slowly to about 7.5% in 2009 (Rokholm et al., 2010).

Sweden. Observations similar to the Danish data have been made on Swedish young men at the time of their military conscription. For the five-year periods from 1969-1974 to 2000-2005, the prevalence of moderate obesity (BMI > 30 kg/m^2) increased progressively from 0.8% to 3.8%, while morbid obesity (BMI > 35 kg/m^2) rose from 0.12% to 1.28% over the same time interval (Neovius et al., 2008). As in Denmark, the largest surge in the prevalence of obesity began in the 1980s (Table 7). However, the Swedish data through to 2000-2005 have shown no signs that the prevalence of obesity has yet reached a plateau.

Austria. Military records from Austria suggest a rather later onset of the obesity epidemic, with the largest increase in the proportion of fat recruits occurring during the early 1990s. Overweight and obesity showed respective prevalences of 13.0% and 2.6% in 1986/90, 14.0% and 3.7% in 1991/95, 15.2% and 5.0% in 1996-2000, and 15.5% and 5.8% in 2001-05 (Shober et al., 2007).

Britain. Britain offers data from 1980 to 2013 for both men and women aged > 16 years. In this population, there was initially a substantial proportion of overweight individuals, but this proportion remained relatively constant between 1980 and 2013. On the other hand, the prevalence of obesity doubled in both sexes between 1980 and 1993, apparently reaching a plateau beyond the year 2000 (Table 8) (National Health Service, 2014; Prentice and Jebb, 1995).

Table 7: Prevalence of moderate obesity (BMI > 30 kg/m^2) and morbid obesity (BMI > 35 kg/m^2) in Swedish male military recruits, from 1969-74 to 2000-2005 (based on data of Neovius et al. (2008)).

	1969-74	1974-79	1979-84	1984-89	1989-94	1994-99	2000-05
Moderate Obesity	0.83%	1.13%	1.26%	1.60%	1.96%	2.80%	3.80%
Morbid obesity	0.12%	0.19%	0.23%	0.35%	0.44%	0.72%	1.28%

Iran. Figures for Iran offer a perspective on the course of the obesity epidemic in a less developed country (Esteghamati et al., 2010). Overall, Iranian data showed some increase in the prevalence of overweight individuals between 1999 and 2007 (from 30.9% to 37.5% in men, and from 33.5% to 35.1% in women). There were larger gains in the prevalence of obesity (from 7.4% to 14.2% in men, and from 20.0% to 30.6% in women), but the most dramatic

Table 8: Secular trends in the prevalence of overweight and obesity for British men and women over the age of 16 years, based on the data of Prentice and Jebb (1995) and U.K. Health Surveys.

Year	Men		Women	
	Overweight (%)	Obese (%)	Overweight (%)	Obese (%)
1980	39	6	32	8
1993	44	13	32	16
1998	46	17	32	21
2003	43	22	33	23
2008	42	24	32	25
2013	41	26	33	24

phenomenon, seen also in many other developing nations, was a 4-fold difference in the proportion of obese individuals between urban and rural populations.

Children. Data for children in most countries have shown a steady increase of both height and body mass as their nutrition has improved over the past 100 years. But since 1980, there have also been increases of body mass relative to height, with particularly large increments at the upper end of the population distribution curve. Australian children also showed a 2 mm increase of average skin-fold thicknesses between 1975 and 1995 (Olds and Harten, 2001). However, as discussed above, in many countries such as Canada the trend to an increasing prevalence of obesity among children seems to have slowed or stopped during the 2000s.

Summary. In summary, middle-aged adults in developed countries have shown a substantial prevalence of overweight for many years. The new feature of the past several decades has been a substantial increase in the prevalence of obesity and in particular of morbid obesity among both adults and children. In many developed countries, the rapid increase of body fat content began around 1980, but the phenomenon spread to developing countries over the next 2 decades, with an additional time lag in rural communities. In some developed countries, the increase seemed to reach a plateau around 2000, but nevertheless the number of obese individuals remains undesirably high from the viewpoint of public health.

Correlates of the epidemic

The primary focus in this section of the review is upon temporal changes in the environment and such aspects of personal lifestyle as habitual physical activity and diet that have accompanied a progressive increase in the average body fat content of people throughout the world over the past 2-3 decades. Having looked at the extent of the obesity epidemic, and the likely timing of its onset, we will endeavour to pin down possible correlations with contemporary changes in environment and lifestyle. Does the time-course of the epidemic provide any clues as to dominant causal factors?

Many possible influences have been invoked (McAlister et al., 2009), with a particular stress upon changes in diet and habitual physical activity. Nutritionists have pointed to an increased availability of food, changes in its composition, incentives to eat more (particularly increased portion sizes), and altered patterns of intake, while physical educators have underlined reductions in daily energy expenditures (at work, in active transportation and in domestic tasks), together with reduced opportunities for and/or interest in active leisure pursuits. However, there are a host of other secular changes in the environment, culture and social attitudes that must also be considered (Table 9).

Availability of food. ***The pre-war years***. During the 1930s, massive unemployment and low wages led to a steep social divide in many of the world's developed nations. Poor people were obliged to spend as much as 70% of their weekly income on food, and the unemployed often lived largely on bread, jam and margarine, with some scraps of meat at weekends. Nutritional studies show that in Britain, the reported overall energy intake of poor people was only 88% that of the middle class (a difference of 0.66 MJ/day between the social classes), although at

Table 9: Potential causes underlying the secular trend to an increased prevalence of overweight and obesity in recent years.

- Increased availability of food (particularly in poor countries)
- Commercial incentives to eat to excess (e.g. larger portion sizes, increased content of refined sugar and/or salt)
- Reduced energy expenditures at work (mechanization and automation of industrial tasks, increased use of computers) and in schools (less class time allocated to sport and physical education)
- Reduced active transportation (e.g. universal ownership of cars, deterioration of the "built environment," increased working from home, children more frequently driven to school)
- Reduced energy expenditures at home (piped water, simplified heating, use of labour-saving devices and power tools)
- Reduced opportunities for and/or interest in active leisure (fewer home gardens, move to high-rise apartments in large cities; popularity of TV and computer games)
- Decreased prevalence of cigarette smoking
- Greater cultural acceptance of an obese body build
- Other miscellaneous causes

the same time the poor often had to engage in greater physical activity both at their place of work and in active transportation to and from work (Zweininger-Bergielowska, 2000).

Few of the lower class were overweight during the 1930s, although fat accumulation had already become an issue for some middle-class women, as witnessed by the popularity of commercial diet foods such as "*Ryvita*" and "*RyeBisk*" crackers (Figure 1), the "Grapefruit" diet for those who sought to look like film stars such as Jean Harlow and Greta Garbo (Williams, 2013), camomile and other herbal teas that promised slimness (de Garine, 2001), and a first generation of local and/or whole body vibrating machines that purported to remove excessive body fat (Chambers, 2013). In a 1941 essay discussing saucy seaside postcards ("*The art of Donald McGill*"), George Orwell maintained that the desire of the wealthy to maintain a youthful figure was one of the few remaining indicators of social class in Britain during the 1930s (Orwell, 1946).

Figure 1: Advertisement for RyeBisk slimming crackers, from around 1928.

Effects of World War II. During World War II, a rigid system of rationing drastically reduced the availability of sugar, butter and meat for everyone living in Britain. Daily energy needs were largely satisfied by an increased intake of potatoes and bread. By 1994, the official rationing allowance had fallen to 10 MJ/day, although additional food could be purchased in restaurants, factory canteens and schools, to an estimated total of 12.1 MJ/day (Table 10). At least in theory, there was a 27% reduction of energy available for the middle class and a 17% reduction for the poorer members of society (Zweininger-Bergielowska, 2000), although it is also possible that the change was smaller because consumers wasted less food during war-time. Despite the restriction of total food intake, daily

Table 10: Supplies of food available to British citizens in 1944, expressed as a percentage of prewar values (based on a report of the British Ministry of Food (1946).

Reduced	Increased
Butter, oils and fats 85%	Bread, flour and cereals 119%
Sugar 69%	Milk and milk products 127%
Meat and bacon 86%	Potatoes 160%
Poultry game and fish 76%	Vegetables 113%
Eggs and egg products 97%	
Fruit 73%	
Tea, coffee and cocoa 87%	

energy demands were increased for many people in wartime Britain. No petrol was provided for the operation of private motorized vehicles, reductions in bus and train services forced many commuters to walk to and from work, and leisure time was often spent trying to supplement the official dietary allowance by growing vegetables on a small garden plot. The average body mass of British adults apparently remained constant on this Spartan regimen. However, a series of adverse economic events led to a further 0.5 MJ/day reduction of British rations in 1946, and this was associated with some decrease in the average body mass of adult citizens (Zweininger-Bergielowska, 2000).

The food supply was much more stringently restricted in Nazi-occupied Europe than in Britain, and indeed many European city-dwellers faced near total starvation. During a 1944 rail strike intended to hamper German troop movements, Dutch citizens were forced to live on rations of 2.5 MJ/day. One of the inevitable effects of the "*Hungerwinter*" was foetal malnutrition; the period of wartime privation apparently had adverse health consequences when food again became plentiful; as adults, the affected individuals demonstrated an increased vulnerability to diabetes mellitus (Scholz, 2010).

Immediately following World War II, Germans subsisted on a diet of 5 MJ/day, with substantial decreases in their average body mass (Editor, British Medical Journal, 1979).

Post-war era. It is possible that there was some over-eating in Europe during the early 1950s, as the dietary constraints of the previous decade disappeared. Ancel Keys and his associates (Keys et al., 1950) noted such an effect when the subjects of their "starvation experiment" entered the refeeding phase: "*many of the men lost control of their appetites and ate more or less continuously. Even after 12 weeks of refeeding, the men frequently complained of increased hunger immediately following a large meal.... the men found it difficult to stop eating.... Their daily intake commonly ranged between 8,000 and 10,000 calories.*"

However, the period of gross over-eating only lasted a few weeks, and it seems an unlikely explanation of the obesity epidemic, since the overall timing of the renewed availability of food in Europe far preceded the period when body weight was increasing in most European countries. Moreover, a reaction to restored food availability could hardly be a factor contributing to obesity in North America, where there had been little restriction of food supplies during World War II.

Commercial incentives to eat to excess. Commercially-related incentives to excessive eating have included a sharp decrease in the price of food expressed as a function of personal income, an increase in portion sizes for restaurant and ready-prepared meals, changes in the composition of prepared foods such as an increased content of salt and refined sugar, and ever more effective marketing tactics (Matthiessen et al., 2003; Popkin et al., 2012; Swinburn et al., 2011).

Decreased relative cost of food. In modern North America, weekly supermarket purchases now reflect only a small percentage of most families total incomes; in 2006, the average household in the U.S. spent 9.9% of income on food, compared with 14.8% in the 1960s (Cohen, 2013), and the amount of food prepared by other than the householder increased from 24% to 42% (Cohen, 2013). Moreover, most western food today is eaten with greatly reduced expenditures of time in preparation and cleaning (Cutler et al., 2003). Even in poorer parts of the world, the "Green revolution" has increased the production of staples such as rice, maize and wheat, making food more readily available. For example, improvements in the varieties of rice and the use of modern fertilizers have increased the yield of rice from 4 to 10 tons per hectare, and a shortening of the growth cycle now allows the harvesting of 2 crops per year. Thus, the cost of rice in countries where this is a dietary staple has decreased by 40% relative to the 1960s (Cohen, 2013).

Increased portion sizes. The trend to the serving of increased portions began in the 1970s, and has since accelerated, particularly in the United States (Livingstone and Pourshahldi, 2014). Some reports have suggested major increases (see, for example, Table 11). Young and Nestle (2002) obtained information about current portion sizes from food manufacturers or by direct weighing, and the manufacturers also provided estimates of serving sizes in earlier decades. This data substantiates the idea that portion size began to increase in the 1970s, that it accelerated in the 1980s, and has subsequently increased yet further, with the process running in parallel with increases in body mass. Now, individual portions exceed U.S. Department of Agriculture standards, sometimes by as much as 700%. Smiciklas-Wright et al. (2003) commented that increases in portion size were particularly marked for soft drinks, coffee, tea, and ready-to-eat cereals.

Nielsen and Popkin (2003; 2004) noted that between 1977 and 1996 the portion

Table 11: Typical changes in the portion size and energy content of food products served at U.S. fast food restaurants and cinemas, 1996 and 2016, as estimated by "Business Insider."

Product	1996		2016	
	Size	Energy content	Size	Energy content
Bagel	3 inch	0.58 kJ	6 inch	2.33 kJ
Muffin	1.5 oz	0.87 kJ	4 oz	2.08 kJ
Cheeseburger		1.39 kJ		2.45 kJ
French Fries	2.4 oz	0.87 kJ	6.9 oz	2.54 kJ
Soda	6.5 oz	0.35 kJ	20 oz	1.04 kJ
Theatre popcorn	5 cups	1.12 kJ	1 tub	2.62 kJ

size of salty snacks increased on average from 1.0 to 1.6 oz; for soft drinks, the increase was from 13.1 to 19.9 fl. oz, for hamburgers from 5.7 to 7.0 oz, and for French fries from 3.1 to 3.6 oz.

Moreover, many studies have shown that portion size has a large and proportional effect upon both the rate of eating and the amount of food that is consumed (Aimiron-Rog et al., 2015; Diliberti et al., 2012; Ello-Martin et al., 2005; Rolls et al., 2004), particularly if the food has a high energy density (as with many of the items served in fast-food restaurants (Rosenheck, 2008). Rozin et al. (2003) and Ledikwe et al. (2005) both noted that in France restaurant and supermarket portion sizes were consistently some 25% smaller than in North America, as were the quantities of ingredients recommended in cook-books, and they suggested that this difference could well contribute to the low prevalence of obesity in France, as noted above.

The impact of an increase in the size of commercial food packages upon population health could have been exacerbated by the growing tendency of both families and adolescents to eat out (particularly at fast food restaurants), and (with both partners in a family commonly working outside of the home) an increased consumption of pre-packaged meals (Bauer et al., 2009; Ledikwe et al., 2005). However, one study of 7000 preschool children found no association between living close to a fast-food restaurant and obesity (Burdette and Whitaker, 2004).

Some people appear to have compensated for excessively large restaurant and pre-packaged meals by eating smaller portions of food when they cook for themselves (Anderson and Matsa, 2011), but at least in adolescents such compensation seems to be less marked among those who are obese than in their leaner peers (Ebbeling et al., 2004).

The time course of the increase in portion sizes is such that it may indeed have contributed to the obesity epidemic. Jeffery and French found an association between the availability of fast food and increases of BMI in women, but not in men (Jeffery and French, 1998). But against the inference of adverse effects arising from the secular trend to larger portions, it has been objected that allowance must also be made for food wastage, which also has increased by at least 50% since 1974. The true energy intake is substantially less than what is reported in food diaries. Indeed, in the U.S. as much as 40-50% of the nutrients that are purchased (5.8 MJ/person per day) are now being consigned to garbage dumps (Buzby and Hyman, 2012; Gunders, 2012; Hall et al., 2009).

Secular changes in food composition. Some investigators have argued that a high fat diet can increase over-eating and thus obesity, both in humans and in animals, because of its high energy density, palatability and a mistaken belief that fat has a low satiety value (Golay and Biobbini, 1997); in fact, fat (particularly unsaturated fat) increases satiety (Maljaars et al., 2009). For several decades, nutritionists headed by Ancel Keys urged a shift from a diet high in saturated and polyunsaturated fat to a high carbohydrate diet as a means of reducing the risk of cardiovascular disease (Keys et al., 1965), and some analysts suggest that this may have been one factor that initiated the obesity epidemic.

This issue of fat versus carbohydrate was raised much earlier by William

Banting (1796-1878), a notable English undertaker and author of one of the first diet books. Banting was concerned that by the age of 62 years, his own weight had crept up to 202 pounds (92 kg). On the advice of his physician, he tried to eat less, but this left him both tired and hungry, with an unchanged weight. Vigorous rowing on the River Thames also yielded little benefit. But then (at the suggestion of Dr. William Harvey) he tried restricting not only his overall caloric intake, but also the amounts of "*sugars and starches*," including breads, milk, beer, sweets and potatoes; the new diet had great effect, as recorded in his "*Letter on corpulence addressed to the public*" (Banting, 1864).

Likewise, the great Canadian physician William Osler (1849-1919) had underlined that a diet rich in fatty foods was essential to avoiding obesity, because it increased satiety (Osler, 1895). Despite this sound advice, recent decades have seen large increases in the ingestion of sugars and salt, in part engineered by the food industry to increase palatability and thus the sales of their products.

Sugar content. If a low fat diet is adopted, as suggested by Keys, energy needs are necessarily met by a high intake of carbohydrates. A high sugar content increases the palatability of food, and commercial interests were quick to recognized that this was a highly effective method of boosting sales.

One area of particular concern over the past several decades has been the ever-growing consumption of sugar-containing drinks, particularly beverages containing high concentrations of fructose corn syrup (Bleich et al., 2009; Bray, 2004). A typical North American 20 oz soda drink now contains the equivalent of up to 18 teaspoons of sugar, and provides 1 MJ of energy; the 64 oz fountain drink that first became available in 2011 offers as much as much as 2.9 MJ of energy at a single serving. Moreover, if a substantial proportion of a person's total energy needs is met by soft drinks, satiety is much less than would have followed the eating of a similar amount of energy as solid protein- and fat-containing foods (Pan and Hu 2011).

In the 1970s, sugary drinks met 4% of an American's energy needs, but by 2001 that figure had risen to 9% (Nielsen and Popkin, 2004), and in 2004, U.S. children were getting 11% of their energy needs from sugary beverages (Wang et al., 2008). The increase in the consumption of sports/energy drinks has been particularly large among adolescents (Han and Powell, 2013).

Current evidence that a heavy consumption of fructose-containing drinks makes a specific contribution to obesity is controversial. Berkey et al. (2004) found that associations between such drinks and obesity disappeared if adjustments were made for any increase in total energy intake, but Ludwig et al. (2001) reported that in children aged ~12 years, each additional daily serving of a soft drink was associated with an increase in body mass index of 0.24 kg/m^2; moreover, it gave rise to a 60% increase in the risk of obesity, after adjustment of the data for other dietary and lifestyle variables.

Many schools and universities have installed vending machines that dispense unhealthy soft drinks as an easy source of extra-budgetary revenue (Sothern, 2004), and the ready access hat this offers to such beverages has been presumed to have an adverse effect upon body fat content. There seem no empirical studies testing this supposition directly, but the potential contribution of sugary drinks to obesity has been documented in a systematic review (Malik et al., 2006). The danger is well illustrated by a 20-year longitudinal study of adults. Men and women who consumed an additional 12 oz bottle of soda per day over the course of the study increased their body mass by 110 g/year relative to those who had not increased their intake of such beverages (Mozaffarian et al., 2011). It is equally well-documented that a reduced in the consumption of sugary drinks and other forms of carbohydrate is helpful in weight reduction (Ebbeling et al., 2006; Tate et al., 2012). A review of 30 trials and 38 cohort studies commissioned by the World Health Organization showed that if adults continue to consume an *ad libitum* diet, a reduced intake of carbohydrates reduced body mass by an average of 0.8 kg, whereas an increased daily intake of sugar increased body mass by 0.75 kg, these responses apparently being due to associated changes in the intake of food energy (Te Morenga et al., 2013).

Increased salt content. Commercial foods often contain large amounts of salt, and this has a significant impact upon the risk of obesity. A study of 458 children and 785 adults estimated their salt intake from 24-hour urine samples (Ma et al., 2015). After adjusting for various confounding variables, a 1000 mg/day increase of salt intake was associated with a 28% increase in the risk of obesity in children, and a 26% increase of risk in adults. Likewise, observations on 248 adolescents found an association between overnight sodium excretion, body mass and calculated body fat percentage (Ellison et al., 1980). Grimes et al. (2013) further pointed out that salt intake was a predictor of an individual's daily intake of sugary beverages.

In mice, a high intake of salt has been shown to activate the aldose reductase–fructo-kinase pathway in the liver and hypothalamus. This in turn leads to endogenous fructose production, the development of leptin resistance and hyperphagia (Lanaspa et al., 2018).

Data from successive NHANES surveys suggest that there has been a substantial increase of average salt intake over recent decades (Briefel and Johnson, 2004; Table 12). The largest change occurred around 1980, again coinciding in timing with the peak part of the obesity epidemic.

Reduced energy expenditures at work and in schools. Most countries have seen a progressive decrease in energy expenditures incurred both at work and in schools over recent decades, and unless there has been a matching reduction in food consumption, this would inevitably increase the prevalence of obesity.

Decrease of occupational energy expenditures. The energy cost of occupational work has decreased progressively over the past century, due both to a mechanization of agriculture and a shift of much of the world's population from participation in physically demanding small-scale farming to employment in industry, office work and service jobs. Over the same time

Table 12: Salt intake of U.S. men and women aged 20-74 years, as reported in successive NHANES surveys (based on the data of Briefel and Johnson, 2004).

	Daily salt intake (mg)			
Survey Years	1971-74	1976-80	1988-94	1999-2000
Men	2780	3486	4288	4127
Women	1774	2278	2939	3002

period, factories have seen the mechanization of most forms of production, and a subsequent shift to robotics, with the displacement of any remaining labour-intensive work from North America, Western Europe and other developed countries to third world economies. In offices, too, employees have spent an ever-increasing fraction of the working day virtually motionless, seated at a computer screen. For instance, a study from Perth, Australia, estimated that in 2013, office employees were sedentary for 81.8% of their working day (Parry and Straker, 2013).

Another important occupational change over the past 50 years has been a rapid increase in the proportion of women who have continued employment outside of the home for most of their adult lives.

United States. A cross-sectional analysis of NHANES data shows an inverse association between reported occupational energy expenditures and obesity. Among that majority of the U.S. population who engage in little or no leisure time physical activity, the prevalence of obesity was 42% lower for those who described their occupation as demanding a high level of energy expenditure (King et al., 2001).

A formal analysis for the U.S. labour force attempted to examine trends in occupational energy expenditures between 1960 and 2011 (Church et al., 2011). Unfortunately, the categorization of jobs and their respective energy costs was relatively crude, there were changes in methodology over the period of analysis, and the report failed to take full account of secular trends to a reduction of hourly energy expenditures within many of the reported trade categories. Taking due note of these limitations, the report concluded that during the 1960s, more than a half of available private employment in the U.S. still demanded at least a moderate intensity of daily energy expenditures, whereas by 2011 the proportion with moderate or greater energy expenditures had dropped to 20%. Moreover, based on reported changes in major work categories there had been a drop of at least 0.4 MJ/day in mean energy expenditures at work.

Even a small decrease in occupational energy expenditures potentially has an important impact upon an individual's energy balance, because the change affects up to a half of a person's waking day. For 40-50 year old men, the age group with the highest percentage of employed individuals, the survey estimated that daily energy expenditures had decreased by at least 0.59 MJ over the 50-year period. Assuming that there had been no compensatory change of eating patterns, but making allowance for the impact of a positive energy imbalance upon a person's resting metabolic rate (as seen in short-term dieting projects, Thomas et al., 2011), this would necessarily have increased the average body mass of workers from 76.9 to 87.9 kg over an occupational lifetime, with the final body mass being quite close to the observed average value of 91.8 kg reported for 2011.

A second analysis, also from the United States, used the judgment of a panel of experts in an attempt to overcome some of the weakness and inconsistencies inherent in the official occupational data base. It concluded that the percentage of people who were engaged in high energy cost work remained steady at ~30% of the labour force from 1950 to 1970, but then declined progressively to 22.6% in 2000. At the same time, the proportion of employees who were engaged in low intensity work increased from 23.3% in

1950 to 41.0% in 2000 (Brownson et al., 2005).

Other developed countries. A progressive decrease of occupational energy expenditures has also been reported from many other parts of the developed world. A triaxial accelerometry study in Australia examined activity patterns in 7 professional actors at an historical village who mimicked the lifestyle of early settlers. Their physical activity levels were 2.3 times greater than those of modern, sedentary office workers, with extra energy expenditures equivalent to the cost of walking 16 km per day (Egger et al., 2001).

A 25-year survey of workers in Eastern Finland (1972-1997) indicated that for each quinquennium of the study, the percentage of individuals with a low level of occupational activity had increased by a further 3.5% in men, and 3.3% in women; moreover, the percentage of workers with high occupational activity had decreased by 3.2% in men and 2.6% in women during each five-year interval (Barengo et al., 2002). Another report estimated that between 1982 and 1992, the occupational energy expenditure of the average Finn had decreased by about 0.2 MJ/day (Wiklund, 2016).

Observations in the Madrid region of Spain demonstrated a progressive increase in the proportion of the labour force that was classed as physically inactive, from 38.0% in 1995 to 43.6% in 2001 and 47.8% in 2008 (Meseguer et al., 2011). Likewise, in Italy the proportion of workers whose occupations were classed as "light" rather than "moderate" or "heavy" increased from 1984-1987 to 1998-2002, with some compensatory increase of leisure activity (Table 13)(Trojani et al., 2006). And in Poland, by 2009, 42,7% of women and 30.2% of men were engaged in sedentary work (Drygas et al., 2009).

Developing countries. Data for developing countries show parallel trends. Among workers in Tehran, occupational activity decreased between 2002-2005 and 2008-2011 (Afghan et al., 2016), and in Brazil, employment in the service sector increased from 29% in 1970 to 55% in 1999, with agricultural employment decreasing from 55% to 25% over the same period (Caballero and

Table 13: Secular changes in occupational and leisure activity in Rome (based on data of Trojani et al., 2006).

	Percent of sample			
	Men			
	Total sample (n)	Sedentary work	Moderate work	Heavy work
1984-87	1164	17.7	50.0	32.3
1998-02	2796	36.8	47.2	16.0
		Inactive leisure	Moderate leisure	Vigorous leisure
1984-87	2041	55.4	32.9	11.8
1998-02	4214	34.3	47.7	18.1
	Women			
	Total sample	Sedentary work	Moderate work	Heavy work
1984-87	1410	13.3	59.0	27.7
1998-02	3254	22.8	60.0	17.2
		Inactive leisure	Moderate leisure	Vigorous leisure
1984-87	2424	59.6	25.6	14.8
1998-02	4206	45.1	44.5	10.3

Popkin, 2002). In China, the shift away from the land has been particularly dramatic, with men showing a 66% increase in the odds of engaging in light work, and women a 51% increase between 1991 and 1997 (Monda et al., 2007).

Overall picture. Expressing occupational energy expenditures in MET-hours per week, estimates of the extent of secular change have been compared between the U.S. (1965 to 2009), the United Kingdom (1961-2005), Brazil (2002-2007), China (1991-2009) and India (2000-2005)(Ng and Popkin, 2012). In the U.S., values decreased from 152 MET-h/wk in 1965 to 89 MET-h/wk in 2009, and in the U.K. and in China there were decreases of similar relative magnitude, from 146 to 95 MET-h/wk and from 346 to 184 MET-h/wk, respectively. Despite the shorter periods of observation, small decreases were also seen in Brazil (169 to 159 MET-h/wk) and India (208 to 204 MET-h/wk).

The secular trend to a decrease in occupational energy expenditures has had a substantial effect upon overall daily energy expenditures in most countries, the magnitude of this change far outweighing any small compensatory increases of leisure activity. However, recent studies have shown no associations between the current level of occupational activity and obesity in Italy (Sofi et al., 2007), and in Sweden (probably because of influences of social class) women even showed a positive rather than a negative association between heavy occupational work and obesity (Larsson et al., 2012).

In the context of the obesity epidemic, the decreases in occupational energy expenditures were already becoming well entrenched in many countries during the 1960s, and their timing is such that the lesser physical demands of industry seem unlikely to explain much of the obesity epidemic (Wiklund, 2016).

Energy expenditures at school. Concerns about accident insurance and pressures to expand the academic curriculum have led some North American schools to reduce the class time that is allocated to sport and physical education programmes (Gabbard, 2001). European schools have faced similar challenges and one report commented that school physical education programmes currently found themselves in a perilous position world-wide (Marshall and Hardman, 2000).

Trend to a curtailment of physical education. In the U.S., the Centers for Disease Control reported that the availability of daily physical education for adolescents dropped from 42% of all students in 1991 to 27% in 1997; 44% of U.S. schools reported a further reduction in the time allocated for physical education subsequent to the "No child left behind" Act of 2001, a Congressional move that called for the setting of standards-based academic education (Kohl and Cook, 2013).

Impact upon prevalence of obesity. Although there are many reasons why greater time should be allocated to physical education classes, it seems unlikely that the curtailment of school sport and physical education programmes has had a major influence upon the obesity epidemic in children and adolescents. Whereas programmes have been cut drastically at some schools, at others they have been enhanced, or money has been transferred from athletics programmes lavished upon a small minority of gifted students to physical activity programmes available to the entire student body.

Moreover, the immediate impact of most physical education programmes upon obesity seems to be slight. A cross-sectional comparison of BMIs between schools with differing physical education requirements suggested that curricular content had little impact upon the BMI or the prevalence of obesity in female students (Cawley et al., 2007). Likewise, a quasi-experimental study in Trois Rivières found that providing 5 hours a week of a telemetry-monitored vigorous physical education programme to primary school students aged 6-12 years had little influence on either the prevalence or the course of obesity in this group (Shephard et al., 1980). Others have had a similar negative experience. A three-year controlled trial in a large sample of North American Indian children from grades 3-5 found that an intervention seeking to improve diet, increase physical activity in the gym and after school, provide classroom lifestyle education and secure parental involvement had no effect upon BMI, skin-fold thicknesses or bio-impedance estimates of the percentage of body fat (Caballero et al., 2003). Further, although a two-year comprehensive health programme for disadvantaged 10-11 year old Albertan children was relatively successful in increasing daily step counts to levels seen in peers from schools in more wealthy areas, it did little to reduce the excessive prevalence of overweight and obesity in the disadvantaged group (Vander Ploeg et al., 2014).

Reasons for lack of impact of physical education upon body composition. Possible explanations for the limited impact of physical education interventions upon body composition include a compensatory reduction of physical activity when participants in the enhanced programme are not at school, a compensatory increase in food consumption, a failure of many schools to institute programmes that provide the recommended minimum of at least 60 minutes of moderate to vigorous activity per day, and poor attendance and/or participation of obese students in the exercise sessions.

An inefficient use of class time is a particular concern (Goode et al., 1976; Shephard and Trudeau, 2008). An American report estimated that a typical 30-minute elementary school physical education class increased moderately vigorous physical activity by no more than 1.87 minutes (Barrett et al., 2015), and a recent British study found no change in either physical activity or measures of obesity when 6-7 year old children participated in a 12-month obesity prevention programme that included a nominal 30 minutes per day of moderate to vigorous physical activity (Adab et al., 2018).

The Trois Rivières study was careful to maintain vigorous activity throughout the available class time, and it also monitored students for any compensatory reduction of physical activity out of school; in that experiment, it was concluded that an increased intake of food had prevented any significant reduction in body fat in response to the daily programme of physical education.

Conclusions. There seems little dispute that industrial energy expenditures have declined in most countries over the past 5-6 decades, but weaknesses in the currently available data make it difficult to be certain of either the magnitude or the precise timing of these changes. Moreover, in many countries, the timing does not seem to coincide with that of the obesity epidemic. Finally, it is very unlikely that there will ever be any return to heavy physical work in factories, underlining that whatever the magnitude of secular change, there is a need for public health measures to replace this substantial source of daily energy expenditure by vigorous physical activity taken outside of the workplace.

In the case of school children, changes in the nature and timing of physical activity and sports programmes have varied widely from one region to another, and given the apparent lack of impact of physical activity initiatives upon the body composition of participants, it is again unlikely that curricular changes bear a major responsibility for the obesity epidemic.

Trends to a reduction in active transportation. We will examine firstly the impact of active commuting upon health, and will then consider secular changes in active commuting for both adults and children.

Health effects of active commuting. A number of cross-sectional studies offer evidence suggesting that commuting by car has a significant adverse impact upon various aspects of health, particularly predisposing to the accumulation of body fat, although there is evidently also some possibility that obese individuals are less likely to engage in active commuting.

Adults. A large cross-sectional study of British adults aged 40-69 years, was conducted in 2006-2010 (Flint and Cummins, 2016); it found that relative to those commuting by car, people who traveled to work by a combination of public transport and walking had a lower average percentage of body fat (-1.3% in men, -1.1% in women). Moreover, differences in fat content were larger in those travelling only on foot or by bicycle (-2.8% in men, - 3.3% in women) than in those who used a combination of active and public transport.

Many reports from other countries confirm these findings. People living in Perth, Australia, who drove to work had a 13% increase in the risk of being classed as overweight or obese relative to active commuters (Wen et al., 2006). Likewise, in New South Wales, only 39.8% of those who cycled to work were overweight or obese, compared with 60.8% of those who traveled by car (Wen and Rissel, 2008). In Sweden, there was also a reduced odds of being classed as overweight or obese among those who engaged in active transportation (0.82 for men, 0.79 for women)(Lindström, 2008).

Even in Chile, cross-sectional data suggested that 30 minutes of active commuting per day reduced the odds of both being overweight (OR 0.93) or obese (0.87)(Steell et al., 2017). And in China, the odds of becoming obese over an 8 year period beginning in 1989 were 80% greater for that 16% of the total population who owned a vehicle, with a 1.8 kg greater than average weight gain in those who acquired a vehicle over the 8 year interval (Bell et al., 2002).

One review found an association between weekly driving time and weight status in 8 of 10 articles (McCormack and Virk, 2014). Nevertheless, not all studies have found better health outcomes among those who report active commuting. The likely explanation is that in younger adults, the volume and intensity of physical activity involved in walking to and from the place of work may be insufficient to improve health (Ogilvie et al., 2007; Shephard, 2008, 2012).

Energy expenditures are generally greater during cycling than in walking, and probably for this reason, bicycle commuting seems more likely to bring health benefits than walking. This was brought out in a Swedish survey that classified the intensity of activities incurred during an active commute (Table 14). When a person was cycling to work, an appreciable fraction of the journey usually involved high intensity effort, but for those who were walking the majority of the activity was rated as light (Veisten et al., 2011).

However, since most of these studies were cross-sectional in design, it could be argued that obesity discouraged walking and cycling, rather than the converse, leaving a need for prospective research to determine the direction of the relationship between active commuting and a reduced risk of obesity. A randomized controlled trial in a small group of initially overweight or obese young Danish adults provides some answer to this question, showing that 6 months of bicycle commuting led to a 4.2 kg average decrease in body fat mass relative to a control group followed over the same period (Quist et al., 2017).

Children. Involvement in active transportation seems to have little impact upon the course of obesity in children. As with the limited impact of physical education programmes, the probable explanation is that for most children, the energy expended in walking to and from school fails to meet even the minimum recommended daily dose of physical activity (Shephard, 2012).

One U.S. review showed a somewhat greater daily total physical activity in those children who traveled actively to school relative to those who did not, but in only one of the 10 studies considered was the average body mass lower in actively commuting students (Faulkner et al. 2009). Likewise, a Danish report found that over a 6-year period, students who began cycling to school showed an increased level of cardio-respiratory fitness relative to those who continued to be transported by car, but the active commuting had little impact upon skin-fold thicknesses (Cooper et al., 2008). Rosenberg et al. noted that although boys in the fourth and fifth grades who commuted actively to school had a lower initial BMI and thinner skin-folds than those who did not, 2 years of active commuting did not change the weight status of individual students (Rosenberg et al., 2006).

Secular changes in active transportation. There is a general belief that active transportation to and from work or school has decreased over the last two decades, although in adults the statistics for many countries do not demonstrate any dramatic change in recent years.

Adults. Factors tending to favour a progressive decrease in active transportation have included not only a growing ownership of cars in many parts

Table 14: Distribution of the intensity of physical activity incurred during active commuting to work by bicycle and on foot. Based on data obtained by Veisten et al. (2011).

Method of Commuting	Proportion of the Total Commute		
	High intensity activity	Medium intensity activity	Low intensity activity
Bicycle	22.3%	66.3%	11.4%
Walking	0.7%	43.7%	55.5%

of the world, but also reduced governmental support of public transportation. High housing prices in urban centres have forced the migration of many young workers to distant suburbs, where long commuting distances and design faults in the "built environment" such as an absence of side-walks and cycle paths have limited the potential for active transportation.

However, most workers in Canada and the United States already owned cars by 1950, and they generally used these vehicles when commuting to work. In the U.S., the National Household Transportation Survey analyzed diary accounts of travel behaviour for the period 1969 to 2001 (National, Household Transportation Survey, 2003). By the conclusion of the survey, U.S. families owned an average of 1.9 vehicles per household, with 18.3% of families owning 3 or more vehicles, and only 9.3% having no vehicle. In 2001, adults drove an average of 55 minutes per day, covering a distance of 64 km. The percentage of trips that included walking was only 14.6% in urban areas with convenient rail transit, and it dropped further to 6.6% in areas without access to rail services. Moreover, the proportion of employees who drove to work increased from 67% in 1960 to 88% in 2000. At the conclusion of the survey period, only 2.8% walked to work, and only 1.1% adopted other modes of travel such as cycling. But because only a small proportion of the North American population engaged in active transportation to and from work even in the mid 1950s, the impact of secular change upon the prevalence of obesity has necessarily been quite small.

Universal car ownership is a more recent phenomenon in Europe, and even more so in the developing world. Traffic congestion for those en route to factories in Britain was caused by bicycles rather than cars in 1950, and workers in inner-city offices tended to commute by public transport (bus, train or subway), with a walk of perhaps 1-2 km at the beginning and the end of their journey. In Britain, the number of cars on the road rose from 19 million in 1971 to 31 million in 2007 (Liebling, 2008), with 77% of households owning at least one car by 2007. In most European countries, there are also now 500-700 cars per 1000 population, whereas in India the ratio is still only 151 cars per 1000 people, and in China it is 154 per 1000 people.

The trend for most countries seems similar to that in the U.S.- an ever-growing ownership of cars, and a corresponding increase in the use of powered vehicles for all forms of transportation. In Canada, a Statistics Canada report from 2011 found 79.6% of 15.4 million commuters traveled in private cars; only 12% used some form of public transit, 6.4% walked and 1.3% cycled (Statistics Canada, 2011). The highest rate of active transportation is currently in the Netherlands. In 2008, 26% of journeys in Holland were made by bicycle and 25% by walking. On average, Dutch men and women spent 24 and 28 minutes per day respectively in such activities, more than meeting the minimum daily physical activity recommendations of public health agencies (Fishman et al., 2015). Active commuting also remains quite popular in Sweden, where 18% of men and 26% of women reported walking or cycling to work in 2004 (Lindström, 2008).

In the last few years, a number of cities in North America have introduced programmes to increase the extent of active transportation. These initiatives have had varying degrees of success

(Figure 2). In Canada, a 2004 survey found 84% of people saying that they would like to walk more often, and 64% wanting to cycle more often (York University, 2004); nevertheless, this study found that between 1996 and 2006, the actual number of walkers dropped from 7.0% to 6.4%, and the proportion of cyclists remained relatively unchanged (1.1 vs. 1.3%). However, a second analysis, based on data from the Canadian National Population Health Surveys, found that in several birth cohorts the percentage of active commuters increased substantially between 1994/95 and 2010/11 (Table 15).

In the Netherlands (where active transportation was already well-established), the installation of new bicycle boulevards did not generated the anticipated increase in the number of individuals cycling to and from work (Dill et al., 2014), but in contrast the introduction of a new guided bus-way in Cambridge England, greatly reduced the use of cars and increased the likelihood of active transportation by 80% (Heinen et al., 2015).

International comparisons of secular change in active transportation have expressed the energy expended in MET-h/week. In all of the countries considered, the total energy expended on active transportation has been relatively small (Ng and Popkin, 2012). In the U.S., there was a small decrease, from 22 MET-h/wk in 1965 to 18 MET-h/wk in 2009, and in China a larger decrease from 10.6 in 1991 to 5.3 MET-h/wk in 2009. In Brazil (14.8 MET-h/wk in 2002, 14.4 MET-h/wk in 2007) and India (7.2 MET-h/wk in 2000, 6.6 MET-h/wk in 2005) there was little change, but in the United Kingdom there was a surprising and indeed puzzling increase (from 5.1 MET-h/wk in 1961 to 17.4 MET-h/wk in 2005).

We may conclude that the early adoption of commuting by car could hardly explain the obesity epidemic in North America in the 1980s, but the timing of the change in some European countries suggests that in their case it could have been a contributing factor.

Children. The secular trend to a decrease in active commuting appears to have been particularly marked among children. Recent fears of public safety have led to children in many North American cities being driven even short distances to school in their parents' vehicles.

In the United States, 47.7% of students in Grade 1 to Grade 8 schools walked or cycled to the classroom in 1969, but by 2009 the proportion had dropped to 12.7% (Fesperman et al., 2008; McDonald, 2007; McDonald rt al., 2011). Likewise, in Canada the average percentage of children who were being driven to school on a regular basis increased from 51% in 2000 to 62% in 2010; more than a half of Canadian children now never walk to and from

Table 15: Percentage of active Canadian commuters in 1994/95 and 2010/11 (Based on data from successive Canadian National Population Health Surveys).

Birth cohort	1935-44	1945-54	1855-64	1965-74
Commuters 1994/95	13.2%	12.9%	16.7%	18.8%
Commuters 2010/11	18.5%	19.4%	17.0%	18.6%

school, and indeed 42% of parents allege that the travel distance is too great for active transportation (Gray et al., 2014). In Ottawa, for example, the actual maximum walking distances are currently 0.8 km for kindergarten students, 1.8 km for students in Grades 1-8, and 3.2 km for those in Grades 9-12, by no means unreasonable expectations of healthy children. However, among Canadian youth aged 15-17 years, the average time spent walking to and from school dropped from 17 minutes in 1992 to a mere 11 minutes in 2010 (Gray et al., 2014).

Other countries have experienced similar adverse trends. In Britain, the percentage of children aged 5-10 years who walked to school fell from 71% to 64% between the years 1975-76 and 1989-94, while the fraction who traveled by car increased from 15 to 28% (Black et al. 2001). In New South Wales, the percentage of children aged 5-9 years who walked to and from school dropped quite steeply from 57.7% in 1971 to 25.5% in 1999-2003, whereas the proportion driven to school increased from 22.8% to 66.6 %. Likewise, among students aged 10-14 years, active commuting decreased from 44.2% to 21.1%, and the proportion of children who were driven to school increased from 12.2 to 47.8% (van der Ploeg et al., 2008).

In Switzerland, 70% of children still walk or cycle to school, although even in that country the percentage of active commuters has been slowly decreasing in recent years (Grize et al., 2010). Again, in Brazil, the percentage of children aged 7-10 years who were active commuters dropped from 49% in 2001 to 41% in 2007 (Costa et al., 2012).

A recent international survey found that active transportation rates for schoolchildren in different countries currently range from 19.8% to 66.6% (Larouche et al., 2014). There have been attempts over the past 2 decades to reverse the adverse secular trend by increasing the safety of routes to school (improved sidewalks and light-controlled traffic crossings, provision of facilities for the storage of bicycles, and making arrangements for young children to walk in large groups). Unfortunately, most of these interventions have had only a minor impact upon the percentage of students engaging in active transportation (Chillón et al., 2011).

Conclusions. Plainly, there has been a large decrease in the prevalence of active transportation among both adults and children over the past 5 decades, and in some cases there is a documented association between the lack of such daily physical activity and an accumulation of body fat. However, any effect of active transportation upon the prevalence of obesity in children and young adults is small, especially for walking, since both the number of walkers and the energy expenditures involved are relatively small.

Trend to reduced energy expenditures in the home. The energy expenditures associated with running a household have decreased progressively over the past 100 years. One has only to glance at the compendium of activities listed by Durnin and Passmore (1967) during the 1950s, tasks such as scrubbing the front step, to realize the extent of changes in the energy costs of home maintenance. The frequent carrying of hods of coal and buckets of water have been replaced by the use of effortless gas or electric heating and piped water, not only in the richest countries, but in much of the world (Jimenezand Yimenez-Garcia, 2017), and power equipment has been introduced to lighten the energy cost of such tasks as the cleaning of floors and carpets and the washing of clothes. Moreover, the average mother now cares for two children, rather than the 8 or 10 that were the common responsibility of a Victorian housewife.

One analysis for the United States compared the situation of women for the years 1965 and 2010. Over this period, the reported time allocated to household management had decreased from 25.7 hours/week to 13.3 hours/week, and it was estimated that in consequence there had been a 3.9 MJ/week decrease in the energy expended on household tasks (Archer et al., 2013). A second American report, from Rochester, MN, examined the decrease in energy expenditures when domestic tasks were performed by mechanical devices. Differences were substantial, for example the cost of washing the family clothes decreased from 187 kJ/d to 112 kJ/d, and that of washing dishes from 370 kJ/d to 224 kJ/d. The total impact of domestic mechanization was a decrease in energy expenditure approaching 0.5 MJ/d, which in the absence of dietary change was sufficient to have a significant impact upon the risk of obesity (Lanningham-Foster et al., 2003). Moreover, the involvement of women in household activities has continued to decrease subsequently, from 58 min in 2003 to 52 min in 2016 (Bureau of Labor Statistics, 2017). However, if the household included children under the age of 6 years, a further 1.1 h/day was still spent in giving them physical care.

Likewise, the man of the house has seen his hand-plane, hand-drill, hand-saw, lawn-mower and hedge-clippers all replaced by electrical or petrol-driven devices over the last several decades. This has reduced the rate of energy expenditure when performing a given task, although sometimes technical advances have allowed men to undertake more "do it yourself" activities, rather than reducing their total daily energy expenditures around the home. Further, some men have accepted increases in their domestic responsibilities for cooking, cleaning and washing, because their wives have now found full-time employment outside of the home. However, the average domestic energy expenditure of men remains quite small. In one U.S. survey, men undertook 18 min/d of moderate activity, compared with 35 min/d in women; moreover, involvement in such moderate activity was unrelated to estimates of their body fat content (Block et al., 2009). Another report, also from the U.S., set household maintenance at 20% of total daily energy expenditures for men and 33% for women (Dong et al., 2004); most domestic activities with the exception of taking care of children and cleaning house were rated as of only light intensity.

An international comparison of secular trends in domestic activities (Ng and Popkin, 2012), averaged across men and women, suggested a progressive decrease of weekly energy expenditures. For the U.S., the change was from 56 MET-h/wk in 1965 to 41 MET-h/wk in 2009; for the U.K., it was from 57 MET-h/wk in 1961 to 45 MET-h/wk in 2005, for Brazil from 39 MET-0h/wk in 2002 to 36 MET-h/wk in 2007, for China from 40 MET-h/wk in 1991 to 19 MET-h/wk in 2009, and in India from 26 MET-h/wk in 2000 to 24 MET-h/wk in 2005.

Trends to decreased active leisure and increased sedentary time. In 1950, only about 10% of U.S. households had television sets, and viewing opportunities were correspondingly limited. However, by 2005, 98% of households had at least one television receiver, and many people had sets in several rooms, including the spaces used by their children. Sedentary time has thus increased substantially over recent decades, both in adults and in children.

Active leisure. It is notoriously difficult to make accurate assessments of active leisure, but given ever-increasing screen time (below), one might infer a corresponding decrease in active pursuits.

Adults. Official figures indicate that despite strong health promotional efforts from governmental departments, the allocation of time to active leisure pursuits by adults in the U.S. and Canada has either remained stable or has declined over recent decades (Brownson et al., 2005). A Harris poll found that the percentage of adults who reported physical pursuits (gardening, walking, housework and yard-work) as their favourite leisure pastimes declined from 38% in 1995 to 29% in 2003 (Taylor, 2003). It seems likely that more recent data would show a continuation of this trend. In Canada (Statistics Canada, 2009), 12% of adults reported that they engaged in deliberate walking or jogging in 2005, compared with 10.6% in 1992, and other specific forms of exercise (yoga, weight-lifting, working out) were reported by 6.5 % of the population in 2005, up from 4.6% in 1992. However, sports participation, at 5.7%, showed little change over the study period.

Children. Reviews have concluded that there are still few reliable data on active leisure trends among children (Booth et al., 2015). The general impression is that the physical activity of children had decreased over the past 40-50 years (Kohl and Cook, 2013), although much of the change in total daily physical activity reflects alterations in physical education programming and decreased active transport, rather than decreases in free-time leisure activities (Salmon and Timperio, 2007). The overall decrease in daily physical activity is underscored when the lifestyle of modern children is compared with that of particular groups who have retained the lifestyle of earlier generations, such as Old Order Amish (Tremblay et al., 2008); the daily step counts for children in such environments are much higher than those for children who are living in a modern urban environment.

Sedentary time. Much of the early data on leisure behaviour was derived from subjective self-reports, but actigraph measurements now providing objective records showing the large proportion of an average day that is occupied by sedentary pursuits. In 2003-2004, American adults were sitting for an average of 7.7 h/d (Matthews et al., 2008).

Adults. Much of the leisure time of adults is now occupied by watching television, although self-reports provide inconsistent estimates. One study suggested that the time spent watching television grew in a relatively linear fashion from 4.7 h/day in 1950 to 7.5 h/day in 2000. Presumably, this change occurred at the expense of time previously allocated to eating, household chores and involvement in voluntary active leisure activities (Brownson et al., 2005; Bucksch et al., 2014) (Table 16). The U.S. Bureau of Labor Statistics (2017) recently set average TV watching at 2.7 h/day. In contrast, the New York Times estimated

TV watching at 5 h/day in 2016, and the A.C. Nielsen company put the average at 4 h/day. The Nielsen survey noted that by the year 2015, although television watching by the youngest group of adults (18-24 years) was now declining in favour of other modes of sedentary entertainment, the total media consumption time had risen to 9.5 h/day.

Further, there seems an overall linkage between sedentary behaviour and poor health, including an accumulation of body fat. A 6-year prospective study of a large sample of U.S. nurses found that In 2016, there was a 23% increase in the risk of becoming obese for every 2 h/day spent watching television (Hu et al., 2003). Another U.S. study found an adverse effect of television viewing upon BMI in women, but not in men (Jeffery and French, 1998). An Australian report compared heavy domestic users of computers (> 3h/wk) with those who did not use the internet or computers in their leisure time; the former group were 46% more likely to be overweight, and 152% more likely to be obese (Vandelanotte et al., 2009). Moreover, a parallel was found between increases in total screen time and increases in the prevalence of overweight and obesity (Duncan et al., 2012).

Interestingly, the adverse effect of television watching seems independent of the level of physical activity that a person undertakes. One study that controlled statistically for inter-individual difference in physical activity found that relative to heavy television watching, those who saw less than 2 h/day of television had a significantly lower BMI (-1.9 kg/m^2 in women, 1.4 kg/m^2 in men)(Jakes et al., 2003). A study from Japan confirmed that the adverse effect of television viewing was independent of the total volume of daily physical activity that a person undertook (Inoue et al., 2012).

Children. In children, also, recent years have seen a progressive increase in the time allocated to a combination of watching television and the undertaking of other small-screen activities. This trend has been boosted by the fact that many children now have their own television sets, computers and smart phones. However, the change from active to sedentary leisure behaviour was already well-established in the 1970s. Many children from that era were already spending 20-25 hours/week watching television, even though the number of available television channels was then relatively few (Shephard and Lavallée, 1993).

A review of recent data from the

Table 16: The time allocated by German youth aged 11-15 years to computer games, other computer use and television watching (based on the data of Bucksch et al., 2014).

Year of survey and activity	Boys		Girls	
	Weekday (min/d)	Weekend (min/d)	Weekday (min/d)	Weekend (min/d)
Games and other personal computer use				
2002	89	125	42	59
2006	85	111	78	101
2010	93	129	96	129
Television watching				
2002	145	206	133	181
2006	138	210	128	190
2010	127	202	121	181

NHANES surveys in the U.S., the European Youth Heart Study, and the Australian SPEEDY survey found rather similar figures for total self-reported sedentary time, averaging 6.4 hours per day for those aged 6-11 years, 7.4 hours per day at 12-15 years, and 7.9 h/day in those aged over16 years. Objective accelerometer data have shown a somewhat similar maximum sedentary time (Pate et al., 2011). A second review concluded that sedentary time was independently associated with weight gain from childhood to the adult years (Thorp et al., 2011).

In Britain, television watching has remained steady at 3.1 h/day since the 1950s (Biddle et al., 2004), with involvement in physical activity apparently being unrelated to the time spent in watching television, but an Australian estimate found that children's television watching increased slightly from 113 min/day in 1992 to 130 min/day in 1997 (Australian Bureau of Statistics, 1999); however, by 1997 this figure was supplemented by 10 h/wk of computer games Robinson, 2001).

In terms of the health impact of television watching, a meta-analysis of 52 trials found a significant relationship between the time allocated to television programmes and the level of obesity in children aged 3-18 years; nevertheless, this relationship was judged to be relatively weak and thus of no great clinical importance (Marshall et al., 2004). Nevertheless, in trials where television and screen time have been deliberately reduced, there have been small but statistically significant reductions of body mass index relative to controls (Epstein et al. 2008; Robinson, 1999).

Decrease in prevalence of cigarette smoking. Many countries have seen large decreases in the prevalence of smoking over the past 50 years, from around 50% of adults in 1970 to only 15-20% today. Continuing smokers are now found mainly in lower socio-economic groups. Figures for smoking behaviour are rather similar for the United States, Canada and the U.K. (Table 17), with the greatest decrease in the number of regular smokers occurring between 1975 and 1995.

Nicotine is known to have an appetite suppressant effect (Jessen et al., 2005). Smokers on average weigh substantially less than non-smokers, and an increase of body mass is well recognized as at least a temporary consequence of successful smoking cessation (Filozof et al., 2004; Flegal, et al., 1995; Klesges, Meyers, and Klesges, 1989; Perkins, 1993). One report associated smoking cessation with an immediate increase in food intake of 0.94

Table 17: Changes in the percentage of regular cigarette smokers in the U.S., Canada and Britain from 1965 to 2015.

Year	1965	1975	1985	1995	2005	2010	2015
U.S.+	42.4	37.1	30.1	24.7	20.9	19.3	15.1
Canada*	49.5	44.5	34	26	19	17	
U.K.#		43.7	33.3	27.4	23.9	20.3	17.8

+smoking one or more cigarettes in the 30 days preceding survey (data of CDC)
*smoking daily, or on an occasional basis (data of Physicians for a Smoke-free Canada)
#current smokers (Office for National Statistics)

MJ/day (Williamson et al., 1991). A Canadian analysis (Torrance et al., 2002) found that the proportion of obese individuals was greater among former smokers (Table 18), and there was also a trend to an increased percentage of the obese among both current and former smokers, although inter-category differences were relatively small.

Table 18: Percentages of obese individuals, classified by their smoking status (based on data of Torrance et al., 2002).

Smoking status	Men			Women		
	1970-72	1978-79	1986-92	1970-72	1978-79	1986-92
Current	5.9	12.8	13.2	10.3	12.1	13.0
Former	14.3	10.1	17.3	10.9	10.3	17.0
Never	7.4	11.4	8.2	14.6	16.9	15.7

In the U.S., a 10-year comparison of those quitting cigarette consumption with those who continued smoking found that the former group showed larger increases of body mass over the decade of observation (4.4 kg in men, 5.0 kg in women). Moreover, those quitting smoking were much more likely than never smokers to become overweight (odds ratios 2.4 for men, 2.0 for women)(Flegal et al., 1995). Most of the gain in body mass occurred within the first 6 months of abstinence from cigarettes; within 12 months of quitting the pace of subsequent weight gain paralleled that of non-smokers and continuing smokers, although the initial surge in body mass persisted for as long as 10 years. Approximately 10% of those quitting smoking quickly gained as much as 15 kg of body mass (Williamson et al., 1991).

The U.S. Centers for Disease Control estimated that in the U.S., smoking cessation between 1978 and 1990 was responsible for a quarter of the increased prevalence of overweight and obesity in men and a sixth of that in women (Flegal et al., 1995). One review concluded that the weight gain might persist for as long as 8 years, but that only a minority of people showed a large weight gain on quitting smoking (Pistelli et al., 2009). The timing of the decrease in cigarette consumption is such that it certainly could have contributed to a gain of average body mass among adults, and one report has indeed graphed a temptingly close inverse relationship between the 2 data sets. However, smoking cessation could not explain the gain of body mass among young children during recent years (Harris et al., 2016).

Greater cultural acceptance of obesity. Adiposity has unfortunately become the norm in the U.S. and many other developed societies, and this raises the question as to how far a greater cultural acceptance of the phenomenon has contributed to the increased prevalence of obesity.

In support of this hypothesis, laboratory studies have demonstrated that repeated exposure of an observer to photographs of obese people makes it more likely that he or she will subsequently judge an obese person as being intelligent and having an acceptable body mass (Robinson and Christiansen, 2014). Likewise, if someone is surrounded by others who are obese, perceptions of a healthy weight increase (Robinson and Kirkham, 2014). A comparison of NHANES data for 1988-1994 and 2005-2010 shows a decreasing tendency for parents to recognize their child as being overweight or obese, because of changing population norms (Duncan et al., 2014; Twarog et al., 2016); the probability of an appropriate perception of one's child diminished by 30% between the 2 surveys. Such changing perceptions could certainly be a factor encouraging an increase of obesity in the population.

Other miscellaneous causes. Many other secular changes in environment and lifestyle have been invoked as potential contributors to the obesity epidemic. Candidate causes include altered population demographics, exposure to certain micro-organisms, intra-uterine and epigenetic effects, an increase of maternal age, a greater fecundity among overweight women, assortative mating, sleep debt, exposure to endocrine disruptors, an increased use of obesogenic medications and changes in ambient temperature. Some of these potential influences have become prominent in recent decades.

Altered population demographics. In many countries there has been a change in population demographics over the past several decades. The age pyramid has shown a downward shift, with decreased numbers of children and young adults and an increased proportion of elderly and very old individuals in many populations. Since aging is associated with an increase of body fat, this demographic change has inevitably led to some increase in the overall prevalence of obesity within a given community.

Moreover, recent years have seen a substantial migration of people from impoverished parts of the world to Europe and North America. Often they have initially been thin and even under-nourished, but these groups have also brought with them their own norms with regard to dietary choices and involvement in voluntary physical activity, and as they have prospered they have become fat. In the United States, for example, individuals with an Hispanic or African ethnic background have contributed substantially to the increased prevalence of obesity (Hao and Kim, 2009), and in Norway, obesity has been concentrated among Pakistani and Sri Lankan migrants (Kumar et al., 2006).

Decreased exposure to micro-organisms. Alterations in the gut micro-flora could increase the fraction of ingested food energy that is absorbed by the body, despite a consistent food intake (Rosenbaum et al., 2015). It has also been suggested that infection with certain micro-organisms such as Adeno-virus 36 can cause fat cells to store more fat, and can transform stem cells into adipocytes (Ponterio and Gressi, 2015).

A wider availability of clean water, a growing use of Caesarean section rather than vaginal childbirth and the widespread use of antibiotics have all reduced the range of micro-organisms within the human body, but the time course of changes in micro-flora is not clearly known (Hunter, 2012).

Intra-uterine and epigenetic effects. Animal experiments suggest that a high fat diet in the mother during pregnancy can favour the development of obesity in the offspring (Diaz and Taylor, 1998; Wu et al., 1998). The catch-up growth associated with a low birth weight seems to predispose to obesity later in life (Ozanne and Hales, 2004), and it may thus be significant that the proportion of low birth weight children has increased in recent years, at least in the United States (Hamilton et al., 2004).

There is currently growing interest in the potential role of epigenetics in the genesis of obesity (Symonds et al., 2013; Van Dijk et al., 2015). At least 11 human genes are known to modulate human obesity, and there is at least a theoretical possibility that environmental change may have had epigenetic effects at these loci (Herrera et al., 2011), favouring the accumulation of body fat, and possibly transmitting a greater liability to obesity from generation to generation. However, the importance of epigenetic effects seems relatively small, accounting for only about 2% of inter-individual differences in BMI (Drong et al., 2012). Moreover, the course of any secular change in epigenetic influences as yet remains unclear.

Increases in maternal age. In recent decades, many women have chosen to delay starting a family until they reach the age of 35-40 years (Armitage and Babb, 1996; Mathews and Hamilton, 2002; Wadhera, 1989). Thus, the average age of first births in the U.S. rose from ~ 21 years in 1970 to ~ 26 years in 2010 (Centers for Disease Control and Prevention, 2016). Most developed countries have experienced a similar trend, with the age of first birth now approaching 30 years (OECD, 2012).

Older women are more likely to be obese, and this obesity is associated with higher body fat content in the neonate (Sewell et al., 2006). In addition to the direct effects of maternal age upon the risk of fat build-up in the developing embryo, the older age of the parents influences the type of diet that is provided for the growing child, and the amounts of physical activity that he or she is encouraged to adopt during the early years of life. The practical impact of older parenthood is seen in a study of 8000 British schoolchildren aged 5-11 years; a positive association was found between the maternal age at birth and the thickness of triceps and sub-scapular skin-folds (Duran-Tauleria et al., 1995). Likewise, Wilkinson et al. noted that a common risk factor among obese British children was an elderly mother (Wilkinson et al., 1977).

Findings have generally been similar in other developed countries. Among U.S. girls aged 9-10 years, the odds of obesity increased by 14% for every 5-year increase of maternal age (Patterson et al., 1997) Equally, in Sweden an increase of maternal age was associated with lesser physical activity and other manifestations of an adverse lifestyle in the offspring as adolescents, possibly in part because older women had greater occupational responsibilities, and thus less time to exert a positive influence the behaviour of their offspring (Barclay and Myrskyla, 2016). In Norwegian young adults (Eriksen and Tambs, 2013), obesity was associated with older paternal age, but in this study no correlation was seen with the age of the mother.

Plainly, the increase of parental age in recent years could thus be one more factor contributing to a growing prevalence of obesity.

Influence of body fat content upon fecundity. Unduly thin women have difficulty in conceiving. A body mass index of less than 18.5 kg/m^2 leads to disturbances of the menstrual cycle and reduced fertility (Frisch, 1987; Frisch and McArthur, 1974). Equally, a low body mass reduces male fertility (Jensen et al., 2004). It might thus be speculated that heavier women, those carrying genes conducive to obesity would reproduce at a greater rate than those who were slimmer, giving a vicious cycle of an increasing prevalence of obese individuals. A further intervening variable is social class; obese women tend to marry into low socio-economic group families, and these generally have larger families than their wealthier counterparts (Lipowicz, 2003).

However, the overall importance of differences in fecundity is debatable. Indeed, many studies have shown that being obese or even overweight is actually an obstacle to conception both for women (Yilmaz et al., 2009) and for men (Jensen et al., 2004; Kort et al., 2006). Thus, a vicious cycle based upon fatness leading to increased fecundity seems improbable.

Assortative mating. Assortative mating implies that some factor other than chance leads to the pairing of couples. For example, positive assortative mating could occur with the pairing of two obese individuals; this would in turn increase the likelihood of the birth of offspring who are genetically predisposed to obesity (Katzmarzyk et al., 2002), as well as establishing a household where sedentary living and over-eating were the norm.

There is evidence of growing assortative mating based upon the level of education in recent years (Johnson et al., 1980; Mare, 1991; Schwartz and Mare, 2005). Societal disapproval of obesity has also led, by default, to the assortative mating of obese couples (Hebebrand et al., 2000), with a small but statistically significant correlation between the BMI of husband and wife (Katzmarzyk et al. 1999; Katzmarzyk et al., 2002). To the extent that social disapproval of obesity has increased in recent years, there may have been a corresponding growth in this influence upon the prevalence of obesity.

Possible increases in sleep debt. There is popular belief that the time allocated for sleeping has decreased in recent decades, although good evidence to support this hypothesis is lacking. Often, analyses have been made on the basis of rather fallacious self-reports, and there remains a need for objective, actigraph-based data.

One review found little evidence of a change in average sleep times, although it speculated that there may have been an increased number of people with very short and very long sleep times (Bin et al., 2012). An empirical study from Sweden found a 15-minute shortening of average reported sleep times in middle-aged women over a 36-year interval from 1968 to 2004 (Ravan et al., 2010). A more significant change over this same interval was a doubling of women who complained of poor quality sleep.

Bonnet and Arand (1995) noted that many adults were getting insufficient sleep at the time of their research, but they did not present any evidence that this was a recent phenomenon, nor did they show a secular trend to decreases in sleep times. On the other hand, a comparison of children and adolescents between 1974, 1979 and 1986 suggested that sleep times in young people had decreased substantially over the period of observation (Iglowstein et al., 2003).

Certainly, unduly short sleep times are positively associated with obesity (Fogelholm et al., 2007) in cross-sectional analyses (Von Kries et al., 2002) and linkages of short sleep times to incident obesity have been noted in longitudinal observations made over a 10-year period

(Gangwisch et al., 2005). Moreover, prolonged sleep deprivation is known to produce hyperphagia; there is also a decrease in the secretion of leptin and thyroid-stimulating hormones, and an increase the secretion of ghrelin, these changes being found both in animals (Everson, 1995) and in humans (Spiegel et al. 2004). However, we cannot assess the contribution of this factor to the obesity epidemic until we have objective evidence concerning any secular change in sleep patterns. Based upon the review of Bin et al. (2012) it seems unlikely that this evidence will be forthcoming in the near future.

Endocrine disrupters. Industrial pollution has caused an increasing inadvertent exposure of urban populations to various chemical disrupters of the endocrine system. The chemical concerned are often derivatives of plastics (Heindel et al., 2015; Heindel and Schug, 2014). Such chemicals "*interfere with the synthesis, secretion, transport, binding, action, or elimination of natural hormones in the body that are responsible for development, behavior, fertility, and maintenance of homeostasis (normal cell metabolism)*" (Crisp et al., 1998). They act at very small doses, particularly in early life (the period between fertilization of the ovum and the development of a fully formed infant, when the body is not normally exposed to certain hormonal influences) (Zoeller et al., 2012), and they have the potential to cause epigenetic change, thus predisposing subsequent generations of adults to obesity (Manikkam et al., 2013). Exposed males have developed elevated levels of anti-androgens such as phthalates. Although much of the focus of research to date has been upon disruption of reproductive function, there is also evidence that some of these agents have an adverse effect upon metabolism, predisposing to obesity (Hatch et al., 2010; Nappi et al., 2016).

The list of obesogenic pollutants includes dichlorodipheny-ltrichloroethane, bisphenol A and phthalates, substances that are derived from industrial packaging components, pesticides, fungicides and insecticides, effluents containing the metabolites of birth control medication, and naturally occurring phyto-oestrogens. Many of the compounds in this group of pollutants are recognized to be lipophilic (Darbre, 2017), and thus tend to accumulate in body fat. Some are anti-androgens, and thus stimulate an increased storage of body fat. National surveys in the U.S. have demonstrated associations between levels of phthalate metabolites and abdominal obesity (Stahlhut et al., 2007), and some endocrine disrupters appear to modify stem cells, increasing the number and/or size of adipocytes in the body (Kanayama et al., 2005; Muscogiuri et al., 2017), predisposing to obesity from an early age (Janesick and Blumberg, 2012; 2016). BMI and body fat content are significantly associated with cumulative body levels of endocrine disruptors, and if a person chooses to adopt rapid dieting, these compounds are released into the blood stream from their sites of accumulation in body fat (Pelletier et al., 2003).

The exposure to endocrine disruptors seems to have increased in recent decades. One pertinent statistic is provided by the polybrominated diphenyl ether content of maternal milk; in Swedish women, this has doubled every 5 years from 1972 to 1998 (Noren and Meironyté, 2000).

Pharmaceutical influences. Chronic medication has increased in recent decades, and some of the drugs that are now frequently prescribed have unintentional side-effects such as decreasing habitual physical activity or boosting appetite. A number of widely prescribed medicaments, particularly anti-psychotic drugs (Houston et al., 2012; Zhang et al., 2016), but including also anti-depressants, antihistamines, anti-hypertensives, contraceptives, corticosteroids, mood stabilizers and anti-diabetic medications are known to increase the risk of obesity (Fava, 2000; Garland et al., 1988; Ness-Abramof and Apovian, 2005; Riobó et al., 2003; Sharm et al., 2001; Sussman et al., 2001). For example, most anti-diabetic drugs encourage adipocyte proliferation (Fonseca, 2003), tone report found that the use of oral contraceptives was associated with a 5 kg increase of body mass (Espey et al., 2000), and in another study the use of beta-blockers increased body mass by an average of 1.2 kg (Sharma et al., 2001),

Given the ever-increasing sales of prescription medications, particularly the increased use of anti-psychotic (Hermann et al., 2002), antidiabetic (Wysowski et al., 2003) and antihypertensive (Psaty et al., 2002) medications over recent decades, this could well be a factor contributing to the obesity epidemic.

Secular changes in the thermal environment. Energy conservation is greatest when a person is living in a thermally neutral environment. With cold exposure, additionally energy is expended to maintain body temperature, and if the temperature rises above the thermally neutral zone, appetite is reduced. Changes in a person's thermal environment thus have the potential to modify energy balance and cause obesity.

Secular changes in the thermal environment predisposing to a positive energy balance include an increase in the number of excessively hot summer days (discouraging physical activity, but also reducing appetite)(Stroebele and De Castro, 2004) and a progressive increase in the availability of air-conditioning and effective heating systems. The better heating of dwellings tends to reduce the body content of brown adipose tissue and decreases the need for energy expenditure to maintain core body temperatures during the winter months (Mavrogianni et al., 2013; Moellering and Smith, 2012; Westerterp-Plantenga et al., 2002).

In terms of the external environment, the past 40 years has seen a reduction in the number of extremely cold days per year (Zhai et al., 2013), and an increase in the number of very hot days (Alexander et al., 2006).

Some countries already had indoor air-conditioning in a substantial fraction of homes 50 years ago, but even in the U.S. the winter standard for thermal comfort increased from 18º C in 1923 to 24.6º C in 1986 (Keith et al., 2006). Further, the use of central air conditioning in the U.S. increased from 23% to 47% of homes between 1978 and 1997 (Keith et al., 2006). In Britain, full air conditioning is a fairly recent development; the average temperature in a British home increased from 13º C to 18º C between 1970 and 2000 (Deputy Prime Minister, 1996), with a rise in winter readings of 1.3º C per decade between 1978 and 1996 (Mavrogianni et al., 2013).

If other factors were to remain equal, an increase of winter temperatures, whether outdoors or indoors, could lead to a substantial decrease of resting energy expenditures, and thus an accumulation of body fat (Dauncey, 1981; Hansen et al., 2010). Much of the potential metabolic impact of a rise of indoor winter temperature has been offset by the wearing of lighter clothing and changes in diet. Nevertheless, there can be an impact upon the risk of obesity. Thus, a cross-sectional study comparing different geographic regions of Korea demonstrated an association between the mean ambient temperature of the region and waist circumferences, and a negative association between body fat content and the number of days when the environmental temperature was <0° C (Yang et al., 2015).

Other possible influences. Even the long list above does not entirely exhaust factors that may have contributed to the obesity epidemic and merit investigation. Other possibilities include a decreased consumption of dairy products, a lack of opportunities for exercise and dietary problems associated with an increase of shift work, and a decreased prevalence of breast feeding (Keith et al., 2006).

Current assessment. Among the many changes of lifestyle and environment that have occurred over the past several decades, a number seem to run in parallel with an increased prevalence of obesity, and it is as yet difficult to assert which have played a dominant role in causing the obesity epidemic. It is certainly unlikely that any one of these factors bears the entire responsibility, and at present it is perhaps most useful for practitioners to focus upon factors that are relatively easy to change, such as the type and amount of food ingested, the level of habitual physical activity, exposure to a range of environmental temperatures and the obtaining of adequate amounts of sleep.

Many investigators have indeed focused on the current social environment that encourages an excessive intake of food and limits the potential for voluntary physical activity (Hill and Peter, 1998). Probable contributing influences of this type include a decreased daily energy expenditure due to less active transportation and an increase in sedentary pursuits, coupled with orchestrated increases in the portion size and sugar content of food products. Cigarette withdrawal has also increased the weight of a substantial segment of the adult population, but it does not seem desirable to discourage this process in the interests of controlling obesity.

Discussion and Conclusions

Over the past 2-3 decades, a substantial increase in average weight for height ratios and skin-fold thicknesses in the people many countries provide evidence for the existence of a world-wide "obesity epidemic." Moreover, an associated decrease of lean tissue has probably led to an under-estimation of the extent of this adverse secular change in human health. A secular decrease of habitual physical activity and social influences encouraging over-eating are both likely to have been primary factors leading to the phenomenon, but a multitude of other factors could also have played a contributory role.

In most parts of the world, data on the time course of secular changes in environment and lifestyle are relatively sketchy, but a more important difficulty in attributing responsibility for the growing prevalence of obesity is the slow process of fat accumulation in most of the affected people; 10 kg of excess fat may have built up over the course of as long as 20 years, and given an energy equivalence of around 29 kJ per g of fat, investigators must therefore search for a factor or a combination of factors leading to an energy imbalance of only 40 kJ/day, an increased intake of food that would be virtually impossible to detect by any sort of dietary record or an equally miniscule diminution of cumulative daily energy expenditures.

Nevertheless, the long-term health consequences of the observed changes in body composition are important for both the individual and society, and attempts at a clarification of causation remain important to the design of more effective preventive efforts.

Acknowledgments

The author acknowledges no funding relationships or other conflicts of interest.

Author's Qualifications

The author's qualifications are as follows: Roy J. Shephard, C.M., Ph.D., M.B.B.S., M.D. [Lond.], D.P.E., LL.D., D.Sc., FACSM, FCSEP, FFIMS.

References

Adab, P., Pallan, A., Lancashire, E. R., Hemming, K., Frew, E., Barrett, T., et al. (2018). Effectiveness of a childhood obesity prevention programme delivered through schools, targeting 6 and 7 year olds: cluster randomized controlled trial (WAVES). *Br Med J.*360, k211. https://doi.org/10.1136/bmj.k211

Afghan, M., Ghasemi, A., and Azizi, F. (2016). Seven-year changes of leisure-time and occupational physical activity among Iranian adults (Tehran Lipid and Glucose study). *Iran J Publ Health. 45(1),* 41-47. PMid:27057520

Aimiron-Rog, E., Tsiountsioura, M., Lewis, H.B., Wu, J., Solis-Trapala, I., and Jebb, S.A. (2015). Large portion sizes increase bite size and eating rate in overweight women. *Physiol Behav. 139*, 297-302. https://doi.org/10.1016/j.physbeh.2014.11.041

Alexander, L.V., Zhang, X., Peterson, T.C., Caesar, J., Gleason, B., Klein Tank, A.M.G., et al. (2006). Global observed changes in daily climate extremes of temperature and precipitation. *J Geophys Res Atmos. 111(5)*, Unnumbered. https://doi.org/10.1029/2005JD006290

American Heart Association. (2016a). Understanding the American obesity epidemic. https://www.heart.org/HEARTORG/HealthyLiving/WeightManagement/Obesity/Understanding-the-American-Obesity-Epidemic_UCM_461650_Article.jsp. Web-site accessed April 3rd, 2018.

American Heart Asociation. (2016b). American Heart Association Statement on New WHO Report "Ending Childhood Obesity." http://newsroom.heart.org/news/american-heart-association-statement-on-new-who-report-ending-childhood-obesity. Web-site accessed April 3rd, 2018.

Anderson, M.L., and Matsa, D.A. (2011). Are restaurants really supersizing America? *Am Econ J Appl Econ. 3(1),* 152-188. https://doi.org/10.1257/app.3.1.152

Archer, E., Shook, R.P., Thomas, D.M., Church, T.S., Katzmarzyk, P.T., Hébert, R., et al. (2013). 45-year trends in women's use of time and household management energy expenditure. *PLOS ONE,* 8(2):e56620. https://doi.org/10.1371/journal.pone.0056620

Armitage, B., and Babb, P. (1996). Population review (4). Trends in fertility *Popul Trends. 84*, 7-13.

Australian Bureau of Statistics. (1999). *Australian Social Trends.* Canberra, Australia: Australian Government Publishing Service.

Australian Institute of Health and Welfare. (2017). *Overweight and obesity in Australia: a birth cohort analysis*. Canberra, Australia: Australian Insitute of Health & Welfare. PHE 215, pp. 1-35.

Avis, W.S., Drysdale, P.D., Gregg, R.G., and Scargill, M.H. (1967). *Dictionay of Canadian English. The senior dictionary.* Toronto, ON., W.J. Gage, pp.1-1284.

Banting, W. (1864). *Letter oin corpulence addressed to the genera lpublic, 3rd ed.* London, U.K., H. Harrison, pp. 1-50.

Barclay, K., and Myrskyla, M. (2016). Maternal age and offspring health and health behaviours in late adolescence in Sweden. *SSM Population Health. 2,* 68-76. https://doi.org/10.1016/j.ssmph.2016.02.012

Barengo, N C., Nissinen, A., Tuomilehto, J., and Pekkarinen, H. (2002). Twenty-five-year trends in physical activity of 30- to 59-year-old populations in eastern Finland. *Med Sci Sports Exerc. 34(8)*,1302-1307. https://doi.org/10.1097/00005768-200208000-00011

Barrett, J.L., Gortmaker, S.L., Long, M.W., Ward, Z.J., Resch, S.C., Moodie, M.L. et al. (2015). Cost effectiveness of an elementary school active physical education policy. *Am J Prev Med.* 49(1), 148-159. physical education policy. Am J Prev Med. 49(1), 148-159. https://doi.org/10.1016/j.amepre.2015.02.005

Bauer, K.W., Larsson, N.L., Nelson, M.C., Story, M., and Neumark-Sztainer, D. (2009). Fast food intake among adolescents: Secular and longitudinal trends from 1999 to 2004. *Prev Med.* 48(3), 284-287. https://doi.org/10.1016/j.ypmed.2008.12.021

Bell, A.C., Ge, K., and Popkin, B.M. (2002). The road to obesity or the path to prevention: motorized transportation and obesity in C hina. *Obes Res.* 10, 277-283. https://doi.org/10.1038/oby.2002.38

Berkey, C.S., Rockett, H.R., Field, A.E., Gillman, M.W., and Colditz, G.A. (2004). Sugar-added beverages and adolescent weight change. *Obes Res.* 12, 778-788. https://doi.org/10.1038/oby.2004.94

Biddle, S.J., Gorely, T., and Stensel, D.J. (2004). Health-enhancing physical activity and sedentary behaviour in children and adolescents. *J Sports Sci.* 22, 679-701. https://doi.org/10.1080/02640410410001712412

Bin, Y.S., Marshall, N.S., and Glozier, N. (2012). Secular trends in adult sleep duration: A systematic review. *Sleep Med Rev.* 16(3), 223-230. https://doi.org/10.1016/j.smrv.2011.07.003

Black, C., Collins, A., and Snell, M. (2001). Encouraging walking: the case of the journey-to-school trips in compact urban areas. *Urban Stud.* 38, 1121-1141. https://doi.org/10.1080/00420980124102

Bleich, S.N., Wang, Y.C., Wang, Y., and Gortmaker, S.L. (2009). Increasing consumption of sugar-sweetened beverages among US adults: 1988–1994 to 1999–2004. *Am J Clin Nutr.* 89(1), 372-381. https://doi.org/10.3945/ajcn.2008.26883

Block, G., Jensen, C.D., Block, T.J., Norris, J., Dalvi, T.B., & Fung, E.B. (2009). The work and home activities questionnaire: energy expenditure estimates and association with percent body fat. *Phys Act Health.* 6 (Suppl. 1), S61-S69. https://doi.org/10.1123/jpah.6.s1.s61

Bonnet, M.H., and Arand, D.L. (1995). We are chronically sleep deprived. *Sleep Med.* 18(10), 908-911. https://doi.org/10.1093/sleep/18.10.908

Booth, V.M., Rowlands, A.V., and Dollman, J. (2015). Physical activity temporal trends among children and adolescents. *J Sci Med Sport.* 16(4), 418-425.https://doi.org/10.1016/j.jsams.2014.06.002

Bray, G.A. (2004). The epidemic of obesity and changes in food intake: the fluoride hypothesis. *Physiol Behav.* 82, 115-121. https://doi.org/10.1016/j.physbeh.2004.04.033

Briefel, R.R., and Johnson, C.L. (2004). Secular trends in dietary intake in the United States. *Annu Rev Nutr.* 24, 401-431. https://doi.org/10.1146/annurev.nutr.23.011702.073349

Brownson, R.C., Boehmer, T.K., and Luke, D.A. (2005). Declining rates of physical activity in the United States: What are the contributors? *Annu Rev Public Health.* 26, 421-443. https://doi.org/10.1146/annurev.publhealth.26.021304.144437

Bucksch, J., Inchley, J., Hamrik, Z., Finne, E., Kolip, P., and HBSC Study Group Germany. (2014). Trends in television time, non-gaming PC use and moderate-to-vigorous physical activity among German adolescents 2002–2010. *BMC Publ Health.* 14:351. https://doi.org/10.1186/1471-2458-14-351

Burdette, H.L., and Whitaker, R.C. (2004). Neighborhood playgrounds, fast food restaurants, and crime: relationships of overweight in low-income preschool children. *Prev Med.* 38, 57-63. https://doi.org/10.1016/j.ypmed.2003.09.029

Bureau of Labor Statistics. (2017). American time use survey- 2016 results *USDL-17-0880*.

Buzby, J.C., and Hyman, J. (2012). Total and per capita value of food loss in the United

States. *Food Policy.* 37(5), 561-570. https://doi.org/10.1016/j.foodpol.2012.06.002

Caballero, B., Clay, T., Davis, S.M., Ethelbah, B., Rock, B.H., Lohman, T., et al. (2003). Pathways: a school-based, randomized controlled trial for the prevention of obesity in American Indian schoolchildren *Am J Clin Nutr.* 78, 1030-1038. https://doi.org/10.1093/ajcn/78.5.1030

Caballero, B., and Popkin, B.M. (2002). *The nutrition transition: Diet and disease in the developing world.* Amsterdam, Netherlands, Academic Press/Elsevier, pp. 1-261. PMid:12428074

Campos, P., Saguy, A., Ernsberger, P., Oliver, E., and Statistics Gaesser, G. (2006). The epidemiology of overweight and obesity: public health crisis or moral panic? *Int J Epidemiol.* 35, 55-60. https://doi.org/10.1093

Cawley, J. (2004). An economic framework for undertanding physical activity and eating behaviors. *Am J Prev Med.* 27, 117-125. https://doi.org/10.1016/j.amepre.2004.06.012

Cawley, J., Meyerhoefer, C., and Newhouse, D. (2007). The impact of state physical education requirements on youth physical activity and overweight. *Health Econ.* 16, 1287-1301.

Centers for Disese Control and Prevention. (2000). NHANES: Healthy weight, overweight and obesity among U.S. adults from Centers for Disease Control: Website https://www.cdc.gov/nchs/data/nhanes/databriefs/adultweight.pdf Accesed April 10th, 2018.

Centers for Disease Control and Prevention. (2011). The obesity epidemic. https://www2c.cdc.gov/podcasts/player.asp?f=7972036. accessed April 10th, 2018.

Centers for Disease Control and Prevention. (2016). Births and natality: https://www.cdc.gov/nchs/fastats/births.htm. Accessed April 10th, 2018.

Chambers, B. (2013). *Whole body vibration:The future of good health.* Charlottesville, VA, : Quartet Books, pp. 1-130.

Charles, M.A., Eschwege, E., and Basdevant, A. (2008). Monitoring the obesity epidemic in France: the Obepi Surveys, 1997-2006. *Obesity (Silver Spring).* 16, 2182-2186. https://doi.org/10.1038/oby.2008.285

Chillón, P., Evenson, K.R., Vaughn, A., and Ward, D.S. (2011). A systematic review of interventions for promoting active transportation to school. *Int J Behav Nur Phys Activ.* 8:10. https://doi.org/10.1186/1479-5868-8-10

Church, T.S., Thomas, D.M., Tudor-Locke, C., Katzmarzyk, P.T., Earnest, C.T. Rodarte, R.Q., et al. (2011). Trends over 5 decades in U.S. occupation-related physical activity and their associations with obesity. *PLOS ONE,* 6(5): e19657*.* https://doi.org/10.1371/journal.pone.0019657

Cohen, D. A. (2013). Obesity and the built environment: Changes in environmental cues cause energy imbalances. *Int J Obes.* 32(7), S137-S142.

Cooper, A.T., Wedderkopp, N., Jago, R., Kristensen, P.L., Moller, N.C., Froberg, K., et al. (2008). Longitudinal associations of cycling to school with adolescent fitness. *Prev Med.* 47(3), 324-328.https://doi.org/10.1016/j.ypmed.2008.06.009

Costa, F.F., Silva, K.S., Schmoelz, C.P., C ampos, V.C., and de Assis, M.A. (2012). Longitudinal and cross-sectional changes in active commuting to school among Brazilian schoolchildren. *Prev Med.* 55(3), 212-214. https://doi.org/10.1016/j.ypmed.2012.06.023

Crisp, T.M., Clegg, E.D., Cooper, R.L., Wood, W.P., Anderson, D.G. , Baetcke, K.P., et al. (1998). Environmental endocrine disruption: an effects assessment and analysis. *Environ Health Perspect.* 106(Suppl. 1), 11-56. https://doi.org/10.1289/ehp.98106s111

Cutler, D.M., Glaeser, E.L., and Shapiro, J.M. (2003). Why have Americans become more obese? *J Econ Perspect.* 17(3), 93-118. https://doi.org/10.1257/089533003769204371

Darbre, P. (2017). Endocrine disrupters and obesity. *Curr Obes Rep.* 6(1),18-27. https://doi.org/10.1007/s13679-017-0240-4

Dauncey, M.J. (1981). Influence of mild cold on 24h energy expenditure, resting metabolism and diet-induced thermogenesis. *Br J Nutr.* 45, 257-267. https://doi.org/10.1079/BJN19810102 de Garine, I. (2001). *Drinking: Anthropological approaches.* New York, NY, Berghahn Books, pp. 1-248.

Deputy Prime Minister. (1996). *English House Coindition Survey, 1996.* London, U.K. : H.M. Stationery Office.

Deurenberg-Yap, M., and Sediell, J.C. (2003). Diet, nutrition and the prevention of chronic diseases: Report of a joint FAO/WHO expert consultation. *WHO Tech Rept Series,* 916, 1-419.

Diaz, J., and Taylor, E.M. (1998). Abnormally high nourishment during sensitive periods results in body weight changes across generations. *Obes Res.* 6, 368-374. https://doi.org/10.1002/j.1550-8528.1998.tb00365.x

Diliberti, N., Bordi, P.L., Conklin, M.T., Roe, L.S., and Rolls, B.J. (2012). Increased portion size leads to increased energy intake in a restaurant meal. *Obesity.* 12(3), 562-568. https://doi.org/10.1038/oby.2004.64

Dill, J., McNeill, M., Broach, J., and Ma, L. (2014). Bicycle boulevards and changes in physical activity and active transportation: Findings from a natural experiment. *Prev Med.* 69(Suppl.), S74-S78. https://doi.org/10.1016/j.ypmed.2014.10.006

Diouf, I., Charles, M.A., Ducimitière, P., Basdevant, A., Easchwege, E., and Heude, B. (2010). Evolution of obesity prevalence in France: an age-period-cohort analysis. *Epidemiol.* 21(3), 360-365. https://doi.org/10.1097/EDE.0b013e3181d5bff5

Dollman, J., Olds, T., Norton, K., and Stuart, D. (1999). The evolution of fitness and fatness in 10–11-year-old Australian schoolchildren: changes in distributional characteristics between 1985 and 1997. *Pediatr Exerc Sci.* 11, 108-121. https://doi.org/10.1123/pes.11.2.108

Dong, L., Block, G., and Mandel, S. (2004). Activities contributing to total energy expenditures in the United States: Results from the NHAPS study. *Int J Behav Nutr Phys Activ.* 1:4. https://doi.org/10.1186/1479-5868-1-4

Drewnowski, A., and Specter, S.E. (2004). Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr.* 79, 6-16. https://doi.org/10.1093/ajcn/79.1.6

Drong, A.W., Lindgren, C.M., and McCarthy, M.I. (2012). The genetic and epigenetic basis of type 2 diabetes and obesity. *Clin Pharmacol Therap.* 92(6), 707-715. https://doi.org/10.1038/clpt.2012.149

Drygas, W., Kwaśniewska, M., Kaleta, D., Pikala, M., Bielecki, W., Gluszek, J., et al.. (2009). Epidemiology of physical inactivity in Poland: prevalence and determinants in a former communist country in socioeconomic transition. *Public Health (Oxf).* 123(9), 592-597. https://doi.org/10.1016/j.puhe.2009.08.004

Duncan, D.T., Tarasenko, T.N., Jan, F., and Zhang, J. (2014). Generational shift in parental perceptions of overweight. *Pedatrics.* 134(3), 481-488. https://doi.org/10.1542/peds.2014-0012

Duncan, M., Vandelanotte, C., Caperchione, C., Hanley, C., and Mummery, W.K. (2012). Temporal trends in and relationships between screen time, physical activity, overweight and obesity. *BMC Publ Health.* 12:1060. https://doi.org/10.1186/1471-2458-12-1060

Duran-Tauleria, E., Rona, R.J., and Chinn, S. (1995). Factors associated with weight for height and skinfold thickness in British children *Epidemiol Community Health.* 49, 466-473. https://doi.org/10.1136/jech.49.5.466

Durnin, J.V.G.A., and Passmore, R. (1967). *Energy, work and leisure.* London, U.K., Heinemann, pp. 1-168.

Ebbeling, C.B., Feldman, H.A., Osganian, S.K., Chomitz, V.R., Ellenbogen, S.j. and Ludwig, D. (2006). Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. *Pediatrics. 117,* 573-580. https://doi.org/10.1542/peds.2005-0983

Ebbeling, C.B., Sinclair, K.B., Pereira, M.A., Garcia-Largo, E., Feldman, H.A., and Ludwig, D.S. (2004). Compensation for energy intake from fast food among overweight and lean adolescents. *JAMA.* 291, 2828-2833. https://doi.org/10.1001/jama.291.23.2828

Editor, British Medical Journal. (1979). Nutrition in Germany. *BMJ.* i (4506), 684-685. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2053232/

Egger, G., Vogels, N., and Westerterp, K.R. (2001). Estimating historical changes in physical activity levels. *Med J Austr.* 175, 635-636. PMid:11837872

Ellison, R.C., Sosenko, J.M., Harper, G.P., Gibbons, L., Pratter, F.E., and Miettiner, O.S. (1980). Obesity, sodium intake, and blood pressure in adolescents. *Hypertension.* 2(4 Pt.2), 77-82.

Ello-Martin, J.A., Ledikwe, J.H., & Rolls, B. J. (2005). The influence of food portion size and energy density on energy intake: implications for weight management. *Am J Clin Nutr.* 82(1), 236S-241S. https://doi.org/10.1093/ajcn/82.1.236S

Epstein, L.H., Roemmich, J.N., and Robinson, J.L. (2008). A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. *Arch Pediatr Adolesc Med.* 162(3), 230-245. https://doi.org/10.1001/archpediatrics.2007.45

Eriksen, W., Sundet, J.M., and Tambs, K. (2013). Paternal age at birth and the risk of obesity in young adulthood: A register-based birth cohort study of Norwegian males. *Am J Hum Biol.* 25(1), 29-34. https://doi.org/10.1002/ajhb.22333

Espey, F., Steinhart, J., Ogburn, T., and Qualls, C. (2000). Depo-provera associated with weight gain in Navajo women. *Contraception.* 62, 55-58. https://doi.org/10.1016/S0010-7824(00)00144-X

Esteghamati, A., Zadeh, O.K., Mohammad, K., Meysamie, A., Rashidi, A., Kamgar, A. et al. (2010). Secular trends of obesity in Iran between 1999 and 2007: National surveys of risk factors of non-communicable diseases. *Metab Syndr Rel Disord.* 8(3), 209-213. https://doi.org/10.1089/met.2009.0064

Everson, C.A. (1995). Functional consequences of sustained sleep deprivation in the rat. *Behav Brain Res.* 69, 43-54. https://doi.org/10.1016/0166-4328(95)00009-I

Faulkner, G.E., Buliung, R.N., Flora, P.K., and Fusco, C. (2009). Active school transport, physical activity levels and body weight of children and youth: a systematic review. *Prev Med.* 48(1). 3-8. https://doi.org/10.1016/j.ypmed.2008.10.017

Fava, M. (2000). Weight gain and anti-depressants. *J Clin Psychiatr.* 61(Suppl. 11), 37-41. PMid:10926053

Fesperman, C.E., Evenson, K.R., Rodriguez, D.A., and Salvesen, D. (2008). A comparative case study on active transport to and from school. *Prev Chronic Dis.* 5(2), A40. PMid:18341776

Filozof, C., Fernández Pinilla, M.C., and Fernández Cruz, A. (2004). Smoking cessation and weight gain. *Obes Rev.* 5, 95-103. https://doi.org/10.1111/j.1467-789X.2004.00131.x

Fishman, E., Böcker, L., and Helbich, M. (2015). Adult active transport in the Netherlands: An analysis of its contribution to daily physical activity requirements. *PLOS ONE.* 10(4):e0121871. https://doi.org/10.1371/journal.pone.0121871

Flegal, K.M., Carroll, R.J., Kuczmarski, R.J., and Johnson, C.L. (1998). Overweight and obesity in the United States; prevalence and trends, 1960-1994. *Int J Obes.* 22, 39-47. https://doi.org/10.1371/journal.pone.0121871

Flegal, K.M., Kruszon-Moran, D., and Carroll, R.J. (2016). Trends in obesity among adults in the United States, 2005-2014. *JAMA.* 315(21), 2284-2291. https://doi.org/10.1001/jama.2016.6458

Flegal, K.M., and Troiano, R.P. (2000). Changes in the distribution of body mass index of adults and children in the U.S. population. *Int J Obes.* 24, 807-818. https://doi.org/10.1038/sj.ijo.0801232

Flegal, K.M., Troiano, R.P., Pamuk, E.R., Kuczmarski, R.J., and Campbell, S.M. (1995). The influence of smoking cessation on the prevalence of overweight in the United States. *N Engl J Med.* 333, 1165-1170. https://doi.org/10.1056/NEJM199511023331801

Flint, E., and Cummins, S. (2016). Active commuting and obesity in mid-life: cross-sectional, observational evidence from UK Biobank. *Lancet Diabetes Endocrinol.* 4(5), 420-435. https://doi.org/10.1016/S2213-8587(16)00053-X

Fogelholm, M., Kronholm, E., Kukkonen-Harjula, K., Partonen, T., Partinen, M., and Härmä, M.I. (2007). Sleep-related disturbances and physical inactivity are independently associated with obesity in adults. *Int J Obes.* 31(11), 713-721. inactivity are independently associated with obesity in adults. Int J Obes. 31(11), 713-721. https://doi.org/10.1038/sj.ijo.0803663

Fonseca, V. (2003). Effect of thiazolidinediones on body weight in patients with diabetes mellitus. *Am J Med.* 115 (Supp. 8A), 42S-48S. https://doi.org/10.1016/j.amjmed.2003.09.005

Food and Agricultural Organisation. (2013). *The state of food and agriculture.* Rome, Italy, Food and Agricultural Organisation, pp. 1-100.

Freedman, D.S., and Ford, E.S. (2015). Are the recent secular increases in the waist circumference of adults independent of changes in BMI? *Am J Clin Nutr.* 101(3), 425-431. https://doi.org/10.3945/ajcn.114.094672

Freedman, D.S., Khan, L.K., Sedula, M.K., Galuska, D.A.,and Dietz, W.H. (2002). Trends and correlates of Class 3 obesity in the United States from 1990 through 2000. *JAMA.* 288, 1758-1761. https://doi.org/10.1001/jama.288.14.1758

Freedman, D.S., Kit, B.K., and Ford, E.S. (2015). Are the recent secular increases in waist circumference among children and adolescents independent of changes in BMI? *PLOS ONE.* 10(10):e0141056. https://doi.org/10.1371/journal.pone.0141056

Freedman, D.S., Zemel, B.S., and Ogden, C.L. (2017). Secular trends for skinfolds differ from those for BMI and waist circumference among adults examined in NHANES from 1988–1994 through 2009–2010. *Am J Clin Nutr.* 105(1), 169-176. https://doi.org/10.3945/ajcn.116.135574

Frisch, R.E. (1987). Body fat, menarche, fitness and fertility. *Hum Reprod.* 2(6), 521-533. https://doi.org/10.1093/oxfordjournals.humrep.a136582

Frisch, R.E., and McArthur, J.W. (1974). Menstrual cycles: fatness as a determinant of minimum weight for height necessary for their maintenance or onset. *Science.*185(4155), 949-951. https://doi.org/10.1126/science.185.4155.949

Gabbard, C. (2001). The need for quality physical education. *J Sch Nursing.* 17, 73-75. https://doi.org/10.1177/105984050101700203

Gangwisch, J.E., Malaspina, D., Boden-Albala, B., and Heymsfield, S.B. (2005). Inadequate sleep as a risk factor for obesity: analysis of NHANES I. *Sleep.* 28, 1289-1296. https://doi.org/10.1093/sleep/28.10.1289

Garland, E.L., Remick, R.A., and Zis, A.P. (1988). Weight gain with antidepressants and lithium. *J Clin Psychpharmacol.* 8, 323-330. https://doi.org/10.1097/00004714-198810000-00003

Global Burden of Disease Study 2013. (2014). Global, regional and national prevalence of overweight and obesity in children and adults 1980-2013: A systematic analysis. *Lancet.* 384(9945), 766-781.

Golay, A., and Biobbini, E. (1997). The role of dietary fat in obesity. *Int J Obes Relat Metab Disord.* 21(Suppl. 3), S2-S11. PMid:9225171

Goode, R. C., Virgin, A., Romet, T., Crawford, P., Duffin, J., and Pallandi, T. (1976). Effects of a short period of physical activity in adolescent boys and girls. *Can J Appl Sports Sci.* 1, 241-250.

Gordon-Larsen, P., Nelson, M.C., Page, P., and Popkin, B.M. (2006). Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics.* 117, 417-424. https://doi.org/10.1542/peds.2005-0058

Gray, C.E., Larouche, R., Barnes, J D., Colley, R.C., Bonne, J.C., Arthur, M., et al. (2014). Are we driving our kids to unhealthy habits? Results of the active healthy kids Canada 2013 report card on physical activity for children and youth. *Int J Enviroin Res Public Health.* 11(6), 6009-6020. https://doi.org/10.3390/ijerph110606009

Grimes, C.A., Riddell, L.J., Campbell, K.J., and Nowson, C.A. (2013). Dietary salt intake, sugar-sweetend beverage consumption, and obesity risk. *Pediatrics.* 131(1), 14-21. https://doi.org/10.1542/peds.2012-1628

Grize, L., Bringolf-Isler, B., Martin, E., and Braun-Fahrländer, C. (2010). Trend in active transportation to school among Swiss school children and its associated factors: three cross-sectional surveys 1994, 2000 and 2005. *Int J Behav Nutr Phys Activ.* 7:28. https://doi.org/10.1186/1479-5868-7-28

Gunders, D.P. (2012). Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. *NRDC Issue Paper.* 12-06B.

Hall, K.D., Guo, J., Dore, M., and Chow, C.C. (2009). The progressive increase of food waste in America and its environmental impact. *PLOS ONE.* 4:e7940. https://doi.org/10.1371/journal.pone.0007940

Hamilton, B.E., Martin, J.A., and Sutton, P.D. (2004). Births: Preliminary data for 2003. *Natl Vital Stat Rep.* 53, 1-17. PMid:15622995

Han, E., and Powell, L.M. (2013). Consumption patterns of sugar-weetened beverages in the United States. *J Am Acad Nutr Dietet.* 113(1), 43-53. Han, E., and Powell, L.M. (2013). Consumption patterns of sugar-weetened beverages in the United States. J Am Acad Nutr Dietet. 113(1), 43-53. https://doi.org/10.1016/j.jand.2012.09.016

Hansen, J.C., Gilman, A.P., and Odland, J.A. (2010). Is thermogenesis a significant causal factor in preventing the ''globesity'' epidemic?. *Med Hypoth.* 75, 250-256. https://doi.org/10.1016/j.mehy.2010.02.033

Hao, L., and Kim, J.J.H. (2009). Immigration and the American obesity epidemic. *Int Immigr Rev.* 43(2), 237-262.https://doi.org/10.1111/j.1747-7379.2009.00764.x

Harper, S., and Lynch, J. (2007). Trends in socioeconomic inequalities in adult health behaviors among U.S. States, 1990-2004. *Publ Health Rep.* 122,177-189. https://doi.org/10.1177/003335490712200207

Harris, K.K., Zopey, M., and Friedman, T.C. (2016). Metabolic effects of smoking cessation. *Nat Rev Endocrinol.* 12(5), 299-308. https://doi.org/10.1038/nrendo.2016.32

Harris, W.T., and Sturges Allen, F. (1927). *Webster's New International Dictionary.* London, U.K., G. Bell, pp. 1-2020.

Hatch, E.E., Nelson, J.W., Stahlhut, R.W., and Webster, T.F. (2010). Association of endocrine disruptors and obesity: perspectives from epidemiological studies. *Int J Androl.* 33(2), 324-332. https://doi.org/10.1111/j.1365-2605.2009.01035.x

Hebebrand, J., Wulltange, H., Goerg, T., Ziegler, A., Hinney, A., Barth, N., et al. (2000). Epidemic obesity: are genetic factors involved via increased rates of assortative mating? *Int J Obes.* 24, 345-353. https://doi.org/10.1038/sj.ijo.0801135

Heindel, J.J., Newbold, R., and Schug, T.T. (2015). Endocrine disruptors and obesity. *Nature Rev Endocrinol.* 11, 653-661. https://doi.org/10.1038/nrendo.2015.163

Heindel, J.J., and Schug, T.T. (2014). The obesogen hypothesis: current status and implications for human health. *Curr Environ Health Rpt.* 1, 333-340. https://doi.org/10.1007/s40572-014-0026-8

Heinen, E., Penter, J., Mackett, R., and Ogilvie, D. (2015). Changes in mode of travel to work: a natural experimental study of new transport infrastructure. *Int J Behav Nutr Phys Activ.* 12:81.https://doi.org/10.1186/s12966-015-0239-8

Heitmann, B.L., Strøger, U., Mikkelsen, K.L., Holst, C., and Sørensen, T.I.A. (2003). Large heterogeneity of the obesity epidemic in Danish adults. *Publ Health Nutr.* 7(3), 453-460.

Hermann, R.C., Yang, D., Ettner, S.L., Marcus, S.C., Yoon, C., and Abraham, M. (2002). Prescription of anti-psychotic drugs by office-based physicians in the United States 1989-1997. *Psychiatr Serv.* 53, 425-430. https://doi.org/10.1176/appi.ps.53.4.425

Herrera, B.M., Kelldson, S., and Lindgren, C.M. (2011). Genetics and epigenetics of obesity. *Maturitas.* 69(1), 41-49. https://doi.org/10.1016/j.maturitas.2011.02.018

Hill, J O., and Peters., J.C. (1998). Environmental contributions to the obesity epidemic. *Science.* 280, 1371-1374. https://doi.org/10.1126/science.280.5368.1371

Houston, J.P., Kohler, J., Bishop, J.R., Ellingrod, V.R., Ostbye, K.M., Zhao, F. et al. (2012). Pharmacogenomic associations with weight gain in olanzapine treatment of patients without schizophrenia. *J Clin*

Psychiatr. 73(8), 1077-1086. https://doi.org/10.4088/JCP.11m06916

Hu, F.B., Li, T.Y., Colditz, G.A., Willett, W.C., and Manson, J.E. (2003). Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *JAMA.* 289, 1785-1791. https://doi.org/10.1001/jama.289.14.1785

Hunter, P. (2012). The changing hypothesis of the gut. The intestinal microbiome is increasingly seen as vital to human health. *EMBO Rep.* 13(6), 498-500. https://doi.org/10.1038/embor.2012.68

Iglowstein, I., Jenni, O.G., Molinari, L., and Largo, R.H. (2003). Sleep duration from infancy to adolescence: Reference values and generational trends. *Pediatrics.* 111, 302-307. https://doi.org/10.1542/peds.111.2.302

Inoue, S., Sugiyama, T., Takamiya, T., Oka, K., Owen, N., and Shimomitsu, T. (2012). Television time is associated with overweight/obesity among older adults, independent of meeting physical activity and health guidelines. *J Epidemiol.* 22(1), 50-56. https://doi.org/10.2188/jea.JE20110054

Jacobsen, B.K., Njølstad, I., Thune, I., Wilsgaard, T., Lochen, M., and Schirmer, H. (2001). Increase in weight in all birth cohorts in a general population. The Tromsø study, 1974-1994. *Arch Intern Med.* 161, 466-472. https://doi.org/10.1001/archinte.161.3.466

Jakes, R.W., Day, N.E., Khaw, H.T., Luben, R., Oakes, S., Welch, A., et al. (2003). Television viewing and low participation in vigorous recreation are independently associated with obesity and markers of cardiovascular disease risk: EPIC-Norfolk population-based study. *Eur J Clin Nutr.* 57, 1089-1096.

Janesick, A.S., and Blumberg, B. (2012). Obesogens, stem cells and the developmental programming of obesity. *Int J Androl.* 35(3), 437-448. https://doi.org/10.1111/j.1365-2605.2012.01247.x

Janesick, A.S., and Blumberg, B. (2016). Obesogens: an emerging threat to public health. *Am J Obstet Gynecol.* 214(5), 559-565. https://doi.org/10.1016/j.ajog.2016.01.182

Jeffery, R.W., and French, S.A. (1998). Epidemic obesity in the United States: are fast foods and television viewing contributing? *Am J Publ Health.* 88(2), 277-280. https://doi.org/10.2105/AJPH.88.2.277

Jensen, T.K., Andersson, A-M., Jørgensen, N., A ndersen, A-G., Carlsen, E., Petersen, J.H. et al. (2004). Body mass index in relation to semen quality and reproductive hormones among 1,558 Danish men. *Fertil Steril.* 82(4*),* 863-870. https://doi.org/10.1016/j.fertnstert.2004.03.056

Jessen, A. B., Buemann, B., Toubro, S., Skovgard, I. M., and Astrup, A. (2005). The appetite suppressant effect of nicotine is enhanced by caffeine. *Diabet Obes Metab.* 7, 327-333. https://doi.org/10.1111/j.1463-1326.2004.00389.x

Jimenez, R., and Yepez-Garcia, A.. (2017). *Inter-American Development, Bank, Working Paper.* IDB-WP-805 1-33.

Johnson, R.C., Ahern, F., and Cole, R.E. (1980). Secular change in degree of assortative mating for ability? *Behav Genet.* 10(1), 1-8. https://doi.org/10.1007/BF01067315

Johnson Foundation (2014). The state of childhood obesity. https://stateofobesity.org/childhood-obesity-trends/ Accessed April 11th, 2018.

Jones, H.W., Hoerr, N.L., and Orol, S. (1949). *Blakiston's New Gould Medical Dictionary*. Philadelphia, PA, Blakiston, pp.1-1294.

Kanayama, T., Kobayashi, N., Mamiya, S., Nakanishi, T., and Nishikawa, J. (2005). Organotin compounds promote adipocyte differentiation as agonists of the perioxosome proliferation-activated receptor gamma/retinoid X receptor pathway. *Mol Pharmacol.* 67, 766-774. https://doi.org/10.1124/mol.104.008409

Katzmarzyk, P. (2002). The Canadian obesity epidemic: An historical perspective. *Obes Res. 10*, 666-674. https://doi.org/10.1038/oby.2002.90

Katzmarzyk, P. (2009). Obesity epidemic: An historical perspective. From University of Saskatchewan: https://www.cs.usask.ca/faculty/ndo885/DynamicModelingForHealthPolicy/KatzmarzykObesityEpidemicAnHistoricalPers pectiveFromNorthAmerica2009.pdf. Accessed April 2nd, 2018.

Katzmarzyk, P., Perusse, L., Rao, D.C., and Bouchard, C. (1999). Spousal resemblance and risk of 7-year increases in obesity and central adiposity in the Canadian population. *Obes Res.* 7, 545-551. https://doi.org/10.1002/j.1550-8528.1999.tb00712.x

Katzmarzyk, P.T., Hebebrand, J., and Bouchard, C. (2002). Spousal resemblance in the Canadian population: implications for the obesity epidemic. *Int J Obes Relat Metab Disord. 26*, 241-246. https://doi.org/10.1038/sj.ijo.0801870

Keating, C., Backholer, K., Gearon, E., Stevenson, C., Swinburn, B., Moodie, M., et al. (2015). Prevalence of class-I, class-II and class-III obesity in Australian adults between 1995 and 2011-12. *Obes Res Clin Pract.* 9(6), 953-962. https://doi.org/10.1016/j.orcp.2015.02.004

Keith, S.W., Redden, D.T., Katzmarzyk, P.T., Boggiano, M.M., Hanlon, E.C., Benca, R.M., et al. (2006). Putative contributors to the secular trend in obesity: exporing the roads less traveled. *Int J Obes.* 30, 1585-1594. https://doi.org/10.1038/sj.ijo.0803326

Keys, A., Anderson, J., and Grande, R. (1965). Serum cholesterol response to changes in the diet. IV. Particular saturated fats in the diet. *Metabolism.* 14, 776-786.

Keys, A., Brozek, J., Henschel, A., Mickelson, O., and Taylor, H.L. (1950). *The biology of human starvation.* Minneapolis, MN, University of Minnesota Press, pp. 1-763

King, G.A., Fitzhugh, E.C., Bassett, D.R., McLaughlin, J.E., Strath, S.J., Swartz, A.M., et al. (2001). Relationship of leisure-time physical activity and occupational activity to the prevalence of obesity. *Int J Obes.* 25, 606-612. https://doi.org/10.1038/sj.ijo.0801583

Klesges, R.C., Meyers, A.W., Klesges, L.M. and La Vasque, M.E. (1989). Smoking, body weight, and their effects on smoking behavior: a comprehensive review of the literature. *Psychol Bull.* 106, 204-230. https://doi.org/10.1037/0033-2909.106.2.204

Kohl, H.D., and Cook, H.D. (2013). *Educating the student body: Taking physical activity and physical education to school.* Washington, DC National Academies Press, pp. 1-420.

Kort, H.I., Massey, J.B., Elsner, C.W., Mitchell-Leef, D., Shapiro, D.B., Witt, M., et al. (2006). Impact of body mass index values on sperm quality and quality. *J Androl.* 27(5), 450-452. https://doi.org/10.2164/jandrol.05124

Kumar, B.N., Meyer, H.E., Wandel, M., Dalen, I., and Holmboe-Ottesen, G. (2006). Ethnic differences in obesity among immigrants from developing countries, in Oslo, Norway.. *Int J Obes.* 30, 684-690. https://doi.org/10.1038/sj.ijo.0803051

Lahti-Koski, M., Jousilahti, P., and Petinin, P. (2001). Secular trends in body mass index by birth cohort in eastern Finland from 1972 to 1997. *Int J Obes.* 25, 727-734. https://doi.org/10.1038/sj.ijo.0801588

Lanaspa, M.A., Kuwabarna, M., Andres-Hernando, A., Li, N., Cicerchi, C., Jensen, T. et al. (2018). High salt intake causes leptin resistance and obesity in mice by stimulating endogenous fructose production and metabolism. *Proc Natl Acad Sci USA. In Press.* https://doi.org/10.1073/pnas.1713837115

Lanningham-Foster, L., Nysse, L.J., and Levine, J.A. (2003). Labor saved, calories lost: the energetic impact of domestic labor-saving devices. *Obes Res.* 11(10), 1178-1181. https://doi.org/10.1038/oby.2003.162

Larouche, R., Oyeyemi, A.L., Prista, A., Onywera, V., Akinroye, K.K., and Tremblay, M.S. (2014). A systematic review of active transportation research in Africa and the psychometric properties of measurement tools for children and youth. *Int J Behav Nutr Phys Activ.* 11:129.https://doi.org/10.1186/s12966-014-0129-5

Larsson, C.A., Krøll, L., Bennet, L., Gullberg, B., Råstam, L., and Lindblad, U. (2012). Leisure time and occupational physical activity in relation to obesity and insulin resistance: a population-based study from the Skaraborg Project in Sweden. *Metabolis.,* 61(4), 590-598. https://doi.org/10.1016/j.metabol.2011.09.010

Ledikwe, J.H., Elio-Martin, J.A., and Rolls, J. (2005). Portion sizes and the obesity epidemic. *J Nutr.* 135(4), 905-909. https://doi.org/10.1093/jn/135.4.905

Li, C., Ford, E.S., McGuire, L.C., and Mokdad, A.H. (2007). Increasing trends in waist circumference and abdominal obesity among U.S. adults. *Obesity.* 15, 216-224. https://doi.org/10.1038/oby.2007.505

Li, C., Ford, E.S., Mokdad, A.H., and Cook, S. (2006). Recent trends in waist circumference and waist-height ratio among US children and adolescents. *Pediatrics.* 118(5), 390-398. https://doi.org/10.1542/peds.2006-1062

Liebling, D. (2008). *Car ownership in Britain.* London, U.K., Royal Automobile Club, pp. 1-15.

Liese, A.D., Hirsch, T., von Mutius, E., and Weiland, S.K. (2006). Burden of overweight in Germany: prevalence differences between former East and West German children. *Eur J Publ Health.* 16(5), 526-531. https://doi.org/10.1093/eurpub/ckl052

Lindström, M. (2008). Means of transportation to work and overweight and obesity: a population-based study in southern Sweden. *Prev Med.* 16(1), 22-28. https://doi.org/10.1016/j.ypmed.2007.07.012

Lipowicz, A. (2003). Effect of husbands' education on fatness of wives. *Am J Hum Biol.* 15, 1-7. https://doi.org/10.1002/ajhb.10119

Livingstone, M.B E., and Pourshahldi, L.K. (2014). Portion size and obesity. *Adv Nutr.* 5, 829-834. https://doi.org/10.3945/an.114.007104

Ludwig, D.S., Peterson, K.E., and Gortmaker, S.L. (2001). Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective observational analysis. *Lance.,* 357, 505-508. https://doi.org/10.1016/S0140-6736(00)04041-1

Ma, Y., He, F.J., and MacGregor, G.A. (2015). High salt intake. Independent risk factor for obesity. *Hypertension.* 66(4), 843-849. https://doi.org/10.1161/HYPERTENSIONAHA.115.05948

Maillard, G., Charles, M.A., Thibult, N., Forhan, A., Sermet, C., Basdevant, A., et al. (1999). Trends in the prevalence of obesity in the French adult population between 1980 and 1991. *Int J Obes Relat Metab Disord. 23,* 389-394. https://doi.org/10.1038/sj.ijo.0800831

Malik, V.S., Schulze, M.B., and Hu, F.B. (2006). Intake of sugar-sweetened beverages and weight gain: A systematic review. *Ann J Clin Nutr.* 64(2), 274-288. https://doi.org/10.1093/ajcn/84.2.274

Maljaars, J., Romeyn, E.A., Haddeman, E., Peters, H.P.F., and Masclee, A. (2009). Effect of fat saturation on satiety, hormone release, and food intake. *Am J Clin Nutr.* 89(4), 1019-1024. https://doi.org/10.3945/ajcn.2008.27335

Manikkam, M., Tracey, R., Guerro-Bosagna, C., and Skinner, M.K. (2013). Plastics derived endocrine disruptors (BPA, DEHP and DBP) induce epigentic transgenerational inheritance of obesity, reproductive disease and sperm epimutations. *PLOS ONE.* 8(1):e55387. https://doi.org/10.1371/journal.pone.0055387

Mare, R.D. (1991). Five decades of educational assortative meting. *Am Sociol Rev.* 56(1), 15-32. https://doi.org/10.2307/2095670

Marshall, J., and Hardman, K. (2000). The state and status of physical education in schools in international context. *Eur Phys Ed Rev.* 6(3), 203-229. https://doi.org/10.1177/1356336X000063001

Marshall, S.J., Biddle, S.J. , Gorely, T., Cameron, N., and Murdey, I. (2004). Relationships bteween media use, body fatness and physical activity in children and youth: a meta-analysis. *Int J Obes Relat Metab Disord.* 28,1238-1246. https://doi.org/10.1038/sj.ijo.0802706

Mathews, T.J., and Hamilton, B.E. (2002). Mean age of mother, 1970-2000. *Natl Vital Stat Rep.* 51, 1-13. PMid:12564162

Matthews, C.E., Chen, K.Y., Freedson, P.S., Buchowski, M.S., Beech, B.M., Pate, R.R. et al. (2008). Amount of time spent in sedentary behaviors in the United States, 2003-2004. *Am J Epidemiol.* 167(7), 875-881. https://doi.org/10.1093/aje/kwm390

Matthiessen, J., Fagt, S., Biltoft-Jensen, A., Beck, A.M., and Ovesen, L. (2003). Size makes a difference. *Publc Health Nutr.* 6(1), 65-72 https://doi.org/10.1079/PHN2002361

Mavrogianni, A., Johnson, F., Ucci, M., Marmot, A., Wardle, J., Ores.zcyn, T. et al. (2013). Historic variations in winter indoor domestic temperature and potential implications for body weight gain. *Interior Built Environ.* 22(2), 360-375.

https://doi.org/10.1177/1420326X11425966
McAlister, E.J., Dhurandhar, N.V., Keith, S.W., Aronne, L.J., Barger, J., Baskin, M., et al. (2009). Ten putative contributors to the obesity epidemic. *Crit Rev Food Sci Nut.* 49(10), 868-913. https://doi.org/10.1080/10408390903372599
McCormack, G.R., and Virk, J.S. (2014). Driving towards obesity: a systematized literature review on the association between motor vehicle travel time and distance and weight status in adults. *Prev Med.* 66, 49-55. https://doi.org/10.1016/j.ypmed.2014.06.002
McDonald, N.C. (2007). Active transportation to school: trends among U.S. schoolchildren, 1969-2001. *Am J Prev Med.* 22(6), 509-516. https://doi.org/10.1016/j.amepre.2007.02.022
McDonald, N.C., Brown, A.L., Marchetti, L.M., and Pedroso, M. (2011). U.S. school travel, 2009 an assessment of trends. *Am J Prev Med.* 41(2),146-151. https://doi.org/10.1016/j.amepre.2011.04.006
Mensink, G.B.M., Schienkiewitz, A., Haftenberger, M., Lampert, T., Ziese, T., and Scheldt-Nave, C. (2013). Overweight and obesity in Germany. Results of the German Health Interview and Examination Survey for Adults (DEGS1). *Bundesgesundheitsbl.* 56, 786-794. https://doi.org/10.1007/s00103-012-1656-3
Meseguer, C.M., Galán, M., Herruzo, R., Rodriguez-Artalejo, F. (2011) Trends in leisure time and occupational physical activity in the Madrid region, 1995-2008. *Rev Esp Cardiol.* 64(1), 21-27. https://doi.org/10.1016/j.recesp.2010.07.007
Ministry of Food (1946). How Britain was fed in wartime. London, U.K., His Majesty's Stationery Office.
Mitchell, N., Catenacci, V., Wyatt, H.R., and Hill, J.O. (2011). Obesity: Overview of an epidemic. *Psychiatr Clin North Am.* 34(4), 717-732. https://doi.org/10.1016/j.psc.2011.08.005
Moellering, D.R., and Smith, D.L. (2012). Ambient temperature and obesity. *Curr Obes Rep.* 1(1), 26-34. https://doi.org/10.1007/s13679-011-0002-7
Molarius, A., Lindén-Boström, M., Granström, F., and Karlsson, J. (2016). Obesity continues to increase in the majority of the population in Mid-Sweden- a 12-year follow-up. *Eur J Publ Health.* 26(4), 622-627. https://doi.org/10.1093/eurpub/ckw042
Monda, K.L., Gordon-Larsen, P., Stevens, J., and Popkin, B.M. (2007). China's transition: The effect of rapid urbanization on adult occupational physical activity. *Soc Sci Med.* 64(4), 858-870. https://doi.org/10.1016/j.socscimed.2006.10.019
Monteiro, C.A., D'A. Benicio, M.H., Conde, W.L., and Popkin, B.M. (2000). Shifting obesity trends in Brazil. *Eur J Clin Nutr.* 54(4), 342-346. https://doi.org/10.1038/sj.ejcn.1600960
Mozaffarian, D., Hao, T., Rimm, E.B., Willett, W.C., and Hu, F.B..(2011). Changes in diet and lifestyle and long-term weight gain in women and men. *N Engl J Med.* 364, 2392-2404. https://doi.org/10.1056/NEJMoa1014296
Muscogiuri, G., Barrea, L., Laudisio, D., Sayastano, S., and Colao, A. (2017). Obesogenic endocrine disruptors and obesity: myths and truths. *Arch Toxicol.* 91(11), 3469-3475. https://doi.org/10.1007/s00204-017-2071-1
Nappi, F., Barrea, L., Disomma, C., Savanelli, M.C., Muscoguiuri, G., Orio, F. et al. (2016). Endocrine aspects of environmental “obesogen” pollutants. *Int J Environ Res Public Health.* 13, 765. https://doi.org/10.3390/ijerph13080765
National Health lService. (2017). *Statistics on obesity, physical activity and diet. England 2017.* London, U.K., National Statistics, pp. 1-38.
Nationmaster (2003). Obesity: Countries compared: http://www.nationmaster.com/country-info/stats/Health/Obesity. Site accessed April 17th, 2018.
National Center for Health Statistics. (2016). Obesity and overweight. from Centers for Diease Conrol: https://www.cdc.gov/nchs/fastats/obesi

ty-overweight.htm. Accessed April 11th, 2018.

National Health Statistics. (2014). Health Survey for England, 2013. London, U.K., National Health Service.

National Household Travel Survey. (2003). NHTS 2001 Highlights Report. Washington, DC, US Dept. of Transportation, pp. 1-131.

NCD Risk Factor Collaboration. (2016). Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. *Lancet.* 387 (10026), 1377-1396. https://doi.org/10.1016/S0140-6736(16)30054-X

Neovius, M., Teixeira-Pinto, A., and Rasmussen, F. (2008). Shift in the composition of obesity in young adult men in Sweden over a third of a century. *Int J Obesity.* 12, 832-836. https://doi.org/10.1038/sj.ijo.0803784

Ness-Abramof, R., and Apovian, C.M. (2005). Drug-induced weight gain. *Drugs Today (Barc).* 41(8), 547-555. https://doi.org/10.1358/dot.2005.41.8.893630

Ng, S.W., and Popkin, B.M. (2012). Time use and physical activity: a shift away from movement across the globe. *Obes Rev.* 13, 659-680. https://doi.org/10.1111/j.1467-789X.2011.00982.x

Nielsen, S.J., and Popkin, B.M. (2003). Patterns and trends in food portion sizes, 1977-1998. *JAMA.* 289(4), 450-453.https://doi.org/10.1001/jama.289.4.450

Nielsen, S.J., and Popkin, B.M. (2004). Changes in beverage intake between 1977 and 2001. *Am J Prev Med, 27* 205-210. https://doi.org/10.1016/j.amepre.2004.05.005

Noren, K., and Meironyté, D. (2000). Certain organochlorine and organobromine contaminants in Swedish human milk in perspective of past 20-30 years. *Chemosphere.* 40, 1111-1123. https://doi.org/10.1016/S0045-6535(99)00360-4

OECD. (2012). Family data base. www.oecd.org/social/family/database. Accessed April 17th, 2018.

OECD. (2017). *Obesity update 2017.* Paris, France, Organisation for Economic Cooperatiion and Development, pp. 1-12.

Ogden, C.L., Carroll, M.D., Curtin, L.R., Lamb, M.M., and Flegal, K.M. (2010). Prevalence of high body mass index in US children and adolescents. *JAMA.* 303, 242-249. https://doi.org/10.1001/jama.2009.2012

Ogilvie, D., Foster, C.E., Rothnie, H., Cavill, N., Hamilton, V., Fitzsimons, C.F., et al. (2007). Interventions to promote walking: systematic review. *Br Med J.* 334, 1204-120.7 https://doi.org/10.1136/bmj.39198.722720.BE

Olds, T.S., and Harten, N.R. (2001). One hundred years of growth: The evolution of height, mass and body composition in Australian children, 1899-1999. *Hum Biol.* 73(5), 727-738. https://doi.org/10.1353/hub.2001.0071

Olsen, L.W., Baker, J.L., Holst, C., and Sørensen, T.L.A. (2006). Birth cohort effect on the obesity epidemic in Denmark. *Epidemiol.* 7(3*),* 292-295. https://doi.org/10.1097/01.ede.0000208349.16893.e0

Orwell, G. (1946). *Critical essays*. Lodon, U.K., Secker and Warburg, pp.1-169.

Osler, W. (1895). *Principles and Practice of Medicine*. Philadelphia, PA, Appleton, pp. 1-1143.

Ozanne, S.E., and Hales, C.N. (2004). Lifespan: Catch-up growth and obesity in male mice. *Nature.* 427, 411-412. https://doi.org/10.1038/427411b

Paccaud, F., Wietlisbach, V., and Rickenbach, M. (2001). Body mass index: comparing mean values and prevalence rates from telephone and examination surveys. *Rev Epidémiol Santé Publ.* 49(1), 33-40. PMid:11226917

Pan, A., and Hu , F.B. (2011). Effects of carbohydrates on satiety: differences between liquid and solid food*. Curr Opin Clin Nutr Metab Care* 14, 385-390. https://doi.org/10.1097/MCO.0b013e328346df36

Parrino, C., Rossetti, P., Baratta, R., La Spina, N., La Delfa, N., Squatrito, S. e. a. (2012). Secular Trends in the prevalence of overweight and obesity in Sicilian schoolchildren aged 11–13 years during the last decade. *PLOS ONE.* 7(4):e34551.

https://doi.org/10.1371/journal.pone.0034551
Parry, S., and Straker, L. (2013). The contribution of office work to sedentary behaviour associated risk. *BMC Publ Health.* 13:296. https://doi.org/10.1186/1471-2458-13-296
Pate, R.R., Mitchell, J.A., Byun, W., and Dowda, M. (2011). Sedentary behaviour in youth. *Br J Sports Med.* 45, 906-913. https://doi.org/10.1136/bjsports-2011-090192
Patterson, M.L., Stern, S., Crawford, P.B., McMahon, R.P., Similo, S.L., Schreiber, G., et al. (1997). Sociodemographic factors and obesity in preadolescent black and white girls. NHLBI's growth and health study. *J Natl Med Assoc.* 89, 594-600. PMid:9302856
Pelletier, C., Imbeault, P., and Tremblay, A. (2003). Energy balance and pollution by organochlorines and polychlorinated biphenyls. *Obes Rev.* 4, 17-24. https://doi.org/10.1046/j.1467-789X.2003.00085.x
Perkins, K.A. (1993). Weight gain following smoking cessation *J Consult Clin Psychol.* 61, 768-777. https://doi.org/10.1037/0022-006X.61.5.768
Pett, L.B., and Ogilvie, G.F. (1956). The Canadian weight-height survey. *Hum Biol.* 28, 177-188. PMid:13345358
Pistelli, F., Aquilini, F., and Carrozzi, L. (2009). Weight gain after smoking cessation. *Arch Chest Dis.* 71(2); 81-87.
Pi-Sunyer, F.X. (1998). *Clinical guidelines on the identification, examination and treatment of overweight and obesity in adults: The evidence report*. Bethesda, D.C., National Heart, Lung, and Blood Institute, pp. 1-228.
Ponterio, E., and Gressi, L. (2015). Adenovirus 36 and obesity: An overview. *Viruses.* 7(7), 3719-3740. https://doi.org/10.3390/v7072787
Popkin, B.M., Adair, L.S., and Ng, S.W. (2012). Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev.* 70(1). 3-21. https://doi.org/10.1111/j.1753-4887.2011.00456.x
Prentice, A. (2006). THe emerging epidemic of obesity in developing countries. *Int J Epidemiol.* 35(1), 93-99. https://doi.org/10.1093/ije/dyi272
Prentice, A.M., and Jebb, S.A. (1995). Obesity in Britain: gluttony or sloth? *BMJ.* 311, 437-439.https://doi.org/10.1136/bmj.311.7002.437
Psaty, B.M., Manolio, T.A., Smith, N.L., Heckbert, S.R., Gottdiener, J.S.,Burke, G.L., et al. (2002). Time trends in high blood pressure control and use of antihypertensive medications in older adults. *Arch Intern Med.* 162, 2325-2332.
Quist, J.S., Rosenkilde, M., Petersen, M.B., Gram, A.S., Sjödin, A., and Stallnećht, B. (2017). Effects of active commuting and leisure-time exercise on fat loss in women and men with overweight and obesity: A randomized controlled trial. *Int J Obes.* 42(3), *In press.*
Ramachandran, A., and Snehalatha, C. (2010). Rising burden of obesity in Asia. *J Obesity.* 2010: 868573. https://doi.org/10.1155/2010/868573
Ravan, A.R., Bengtsson, C., Lissner, L., Lapidus, L., and Björkelund, C. (2010). Thirty-six-year secular trends in sleep duration and sleep satisfaction, and associations with mental stress and socioeconomic factors – results of the Population Study of Women in Gothenburg, Sweden. *J Sleep Res.* 19(3), 496-503. https://doi.org/10.1111/j.1365-2869.2009.00815.x
Riobó, P., Fernández-Bobadilla, B., Kozarcewski, M., and Fernández Moya, J.M. (2003). Obesidad en mujeres (obesity in women) *Nutr Hosp.* 18(5) ,233-237. PMid:14596030
Robinson, E., and Christiansen, P. (2014). The changing face of obesity. Exposure to and acceptance of obesity. *Obesity.* 22(5), 1380-1386. https://doi.org/10.1002/oby.20699
Robinson, E., and Kirkham, T.C. (2014). Is he a healthy weight? Exposure to obesity changes perception of the weight status of others. *Int j Obes, 38(5)* 663-667 https://doi.org/10.1038/ijo.2013.154
Robinson, T.N. (1999). Reducing children's television viewing to prevent obesity: A rnandomized controlled trial. *JAMA.* 282(16), 1561-1567. https://doi.org/10.1001/jama.282.16.1561
Robinson, T.N. (2001). Television viewing and childhood obesity. *Pediatr Clin North Am.* 48 ,1017-1025.

https://doi.org/10.1016/S0031-3955(05)70354-0

Rokholm, B., Baker, J.L., and Sørensen, T.I.A. (2010). The levelling off of the obesity epidemic since the year 1999 – a review of evidence and perspectives. *Obes Rev.* 11, 835-846. https://doi.org/10.1111/j.1467-789X.2010.00810.x

Rolls, B.J., Roe, L.S., Meengs, J.S., and Wall, D.E. (2004). Increasing the portion size of a sandwich increases energy intake. *J Am Diet Assoc.* 104, 367-372. https://doi.org/10.1016/j.jada.2003.12.013

Rosenbaum, M., Knight, R., and Leibel, R.L. (2015). The gut microbiota in human energy homeostasis and obesity. *Trends Endocrinol Metab.* 26(9), 493-501. https://doi.org/10.1016/j.tem.2015.07.002

Rosenberg, D.E., Sallis, J.F., Conway, T.L., Cain, K.L., and McKenzie, T.L. (2006). Active transportation to school over 2 years in relation to weight status and physical activity. *Obesity.* 14, 1771-1776. https://doi.org/10.1038/oby.2006.204

Rosenheck, R. (2008). Fast food consumption and increased caloric intake: a systematic review of a trajectory towards weight gain and obesity risk. *Obes Rev.* 9(6), 535-547. https://doi.org/10.1111/j.1467-789X.2008.00477.x

Rowland, M.L. (1990). Self-reported weight and height. *Am J Clin Nutr.* 52, 1125-1133. https://doi.org/10.1093/ajcn/52.6.1125

Rozin, P., Kabnick, K., Pete, E., Fischier, C., and Shields, C. (2003). The ecology of eating: smaller portion sizes in France than in the United States help explain the French paradox. *Psychol Sci.* 14(5), 450-454. https://doi.org/10.1111/1467-9280.02452

Salmon, J. and Timperio, A. (2007). Prevalence, trends and environmental influences on child and youth physical activity. In: G.R. Tomkinson and T.S. Olds (eds.), *Pediatric fitness. Secular trends and geograpohic variability.*Basel, Switzerland, Karger, pp. 183-199. https://doi.org/10.1159/000101391

Scholz, L.C. (2010). The Dutch hunger winter and the developomental origins of health and disease. *Proc Nat Acad Sci.* 107(39), 16757-16758. https://doi.org/10.1073/pnas.1012911107

Schwartz, C.E., and Mare, R.D. (2005). Trends in educational assortative marriage from 1940 to 2003. *Demography.* 42(4), 621-646. https://doi.org/10.1353/dem.2005.0036

Sewell, M.F., Huston-Presly, L. Super, D.M., and Catalano, P. (2006). Increased neonatal fat mass, not lean body mass, is associated with maternal obesity. *Am J Obstr Gynec.* 195(4), 1100-1103. https://doi.org/10.1016/j.ajog.2006.06.014

Sharma, A. M., Pischon, T., Hardt, S., Kunz, I., and Luft, F.C. (2001). Hypothesis: beta-adrenergic receptor blockers and weight gain: A systematic analysis. *Hypertension.* 37, 250-254.https://doi.org/10.1161/01.HYP.37.2.250

Sharma, A.N. (2002). Adipose tissue: a mediator of cardiovascular risk. *Int J Obes Relat Metab Disord.* 26(Suppl. 4), S5-S7. https://doi.org/10.1038/sj.ijo.0802210

Shephard, R.J. (2008). Is active commuting the answer to poulation health? *Sports Med.* 38(9), 751-758. https://doi.org/10.2165/00007256-200838090-00004

Shephard, R.J. (2012). The exercising commuter. Is commuting a healthy way to be active? *Curr Cardiovascv Rep.* 6(4), 293-306. https://doi.org/10.1007/s12170-012-0240-6

Shephard, R.J. (2015). *An illustrated history of health and fitness, from prehistory tom our post-modern world.* Cham, Switzerland, Springer, pp. 1-1057. PMid:25366252

Shephard, R J., and Lavallée, H. (1993). Impact of enhanced physical education in the prepubescent child: Trois Rivières revisited. *Pediatr Exerc Sci.* 5(2), 177-189. https://doi.org/10.1123/pes.5.2.177

Shephard, R.J., Lavallée, H., Jéquier, J.C., Rajic, M., and LaBarre, R. (1980). Additional physical education in the primary school: A preliminary analysis of the Trois Rivières regional experiment. In: M. Ostyn (Ed.), *Kinanthropometry II.* Basel, Switzerland, Karger, pp. 306-316

Shephard, R.J., and Rode, A. (1996). *The health consequences of modernization.* Cambridge, U.K., Cambridge University Press, pp. 1-306

Shephard, R.J., and Trudeau, F. (2008). Research on the outcomes of elementary school phyical education. *Elem School J.* 108(3), 251-264.

Shields, M. (2004). Measured obesity: Overweight Canadian children and adolescents. Nutrition: Findings from the Canada Health Survey. Ottawa, ON, Statistics Canada Report 82-620-XIE.

Shober, E., Rami, B., Kirchengast, S., Waidhör, T., and Sefranek, R. (2007). Recent trend in overweight and obesity in male adolescents in Austria: a population-based study. *Eur J Pediatr.* 166, 709-714. https://doi.org/10.1007/s00431-006-0312-z

Simpson, J.A., and Weiner, E.S.C. (2001). *The Oxford English Dictionary*. Oxford, UK. Clarendon Press.

Smiciklas-Wright, H., Mitchell, D.C., Mickle, S.J., Goldman, J.D., and Cook, A. (2003). Foods commonly eaten in the United States, 1989–1991 and 1994–1996: are the portion sizes changing? *J Am Diet Assoc*. 103, 41-47. https://doi.org/10.1053/jada.2003.50000

Smith, M.W. (2016). Obesity epidemic astronomical. https://www.webmd.com/diet/obesity/features/obesity-epidemic-astronomical#1. Accessed 17th April, 2018.

Sofi, F., Capalbo, A., Marcucci, R., Gori, M., Fedi, S., Macchi, C., et al. (2007). Leisure time but not occupational physical activity significantly affects cardiovascular risk factors in an adult population. *Eur J Clin Invest.* 37(12), 947-953. https://doi.org/10.1111/j.1365-2362.2007.01884.x

Sothern, M.S. (2004). Obesity prevention in children: physical activity and nutrition. *Nutrition.* 20, 704-708. https://doi.org/10.1016/j.nut.2004.04.007

Spiegel, K., Tasali, E., Penev, P., and Van Cauter, E. (2004). Brief communication: sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. *Ann Intern Med*. 141, 846-850. https://doi.org/10.7326/0003-4819-141-11-200412070-00008

Stahlhut, R.W., van Wijngaarden, E., Dye, T.D., cook, S., and Swan, S.H. (2007). Concentrations of urinary phthalate metabolites are associated with increased waist circumference and insulin resistance in adult U.S. males. *Environ Health Perspect.* 115, 876-882. https://doi.org/10.1289/ehp.9882

Statistics Canada. (2009). Who participates in active leisure. Statistics Canada: http://www.statcan.gc.ca/pub/11-008-x/2009001/article/10690-eng.htm Accessed April 10th, 2018.

Statistics Canada. (2011). Commuting to work (National Household Survey, 2011). *Staistics Canada.* 99-012X.

Steell, L., Garrido-Méndez, A., Petermann, F., Martinez, X.D., Martinez, M.A., Leiva, A.M., et al. (2017). Active commuting is associated with a lower risk of obesity, diabetes and metabolic syndrome in Chilean adults. *J Publ Health.* In press. https://doi.org/10.1093/pubmed/fdx092

Stroebele, N., and De Castro, J.M. (2004). Effect of ambience on food intake and food choice. *Nutrition.* 20(9), 821-838. https://doi.org/10.1016/j.nut.2004.05.012

Sussman, N., Ginsberg, D.L., and Bikoff, J. (2001). Effects of nefazodone on body weight: a pooled analysis of selective serotonin reuptake inhibitor- and imipramine-controlled trials. *J Clin Psychiatr.* 62, 256-260. https://doi.org/10.4088/JCP.v62n0407

Swinburn, B.A., Sacks, G., Hall, K.D., McPherson, K., Finegood, D.T., Moodie, J.L., et al. (2011). The global obesity pandemic: shaped by global drivers and local environments. *Lancet.* 378(9793), 804-814. https://doi.org/10.1016/S0140-6736(11)60813-1

Symonds, M.E., Budge, H., and Frazier-Wood, A.C. (2013). Epigenetics and obesity: a relationship waiting to be explained. *Hum Hered.* 75(2-4), 90-97. https://doi.org/10.1159/000352009

Tate, D.F., Turner-McGrievy, G., Lyons, E., Stevens, J., Erickson, K., Polzien, K., et al. (2012). Replacing caloric beverages with water or diet beverages for weight loss in adults: main results of the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. *Am J Clin Nutr.* 95, 555-563.

https://doi.org/10.3945/ajcn.111.026278

Taylor, H. (2003). Lare declines since 1995 in favorite activities which require physical exercise. Rochester, NY: Harris Interact.

Te Morenga, L., Mallard, S., and Mann, J. (2013). Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ.* 346:e7492. https://doi.org/10.1136/bmj.e7492

Thomas, D.M., Martin, C.K., Heymsfield, S., Redman, L.M., Scchoeller, D.A., and Levine, J.A. (2011). A simple method predicting individual weight change in humans. *J Biol Dyn.* 5(6), 570-599. https://doi.org/10.1080/17513758.2010.508541

Thorp, A.A., Owen, N., Neuhaus, M., and Dunstan, D.W. (2011). Sedentary behaviors and subsequent health outcomes in adults. A systematic review of longitudinal studies, 1996-2011. *Am J Prev Med.* 41(2), 207-215. https://doi.org/10.1016/j.amepre.2011.05.004

Torrance, G.M., Hooper, M.D., and Reeder, B.A. (2002). Trends in overweight and obesity among adults in Canada (1970–1992): evidence from national surveys using measured height and weight. *Int J Obes.* 26, 797-804. https://doi.org/10.1038/sj.ijo.0801991

Tremblay, M.S., Esliger, D.W., Copeland, J.L., Barnes, J.D., and Bassett, D.R. (2008). Moving forward by looking back: lessons learned from long lost lifestyles. *Appl Physiol Nutr Metab..* 33, 836-842. https://doi.org/10.1139/H08-045

Tremblay, M.S., Katzmarzyk, P.T., and Willms, J.D. (2002). Temporal trends in overweight and obesity in Canada, 1981–1996. *Int J Obes.* 28(4), 538-543. https://doi.org/10.1038/sj.ijo.0801923

Trojani, M., Palmieri, L., Vanuzzo, D., Donfrancesco, C., Panico, S., Pilotto, L., et al. (2006). Attività fisica nel tempo libero e professionale: tendenza nella popolazione italiana [Occupational and leisure time physical activity: trend in the Italian population]. *G Ital Cardiol.* 7(7), 487-497.

Twarog, J.P., Politis, M.D., Woods, E.L., Daniel, L.M., and Sonneville, K.R. (2016). Is obesity becoming the new normal? Age, gender and racial/ethnic differences in parental misperception of obesity as being 'About the Right Weight'. *Int J Obes.* 40(7), 1051-1055. https://doi.org/10.1038/ijo.2016.40

Uauy, R., Albala, C., and Kain, J. (2001). Obesity trends in Latin America: Transiting from under- to overweight. *J Nutr.* 131(3), 893S-899S. https://doi.org/10.1093/jn/131.3.893S

Ulset, E., Undheim, R., and Malterud, K. (2007). Har fedmeepidemien nådd Norge? (Has the obesity epidemic reached Norway ?). *Tidsskr Nor Laegeforen.* 127(1), 34-37. PMid:17205087

van der Ploeg, H.P., Merom, D., Corpuz, G., and Bauman, A.E. (2008). Trends in Australian children traveling to school 1971-2003: burning petrol or carbohydrates? *Prev Med.* 46(1), 80-82. https://doi.org/10.1016/j.ypmed.2007.06.002

Van Dijk, S., Tellam, R.L., Morrison, J.L., Muhlhausler, B.S., and Molloy, P. (2015). Recent developments on the role of epigenetics in obesity and metabolic disease. *Clin Epigen.* 7:66 . https://doi.org/10.1186/s13148-015-0101-5

Vandelanotte, C., Sugiyama, T., Gardiner, P., and Owen, N. (2009). Associations of leisue time internet and computer use with overweight and obesity: Physical activity and sedentary behaviours: cross-sectional study. *J Med Internet Res.* 11(3): e28. https://doi.org/10.2196/jmir.1084

Vander Ploeg, K.A., Maximova, A.K., McGavock, J., Davis, W., and Veugelers, P. (2014). Do school-based physical activity interventions increase or reduce inequalities in health? *Soc Sci Med.* 112, 80-87. https://doi.org/10.1016/j.socscimed.2014.04.032

Veisten, K., Flűgel, S., Ramjerdi, F., and Minken, H. (2011). Cycling and walking for transport: estimating net health effects from comparison of different transport mode users' self-reported physical activity. *Health Econ Rev.* 1:3. https://doi.org/10.1186/2191-1991-1-3

Von Kries, R., Toschke, A.M., Wurmser, H., Sauerwald, T., and Koletzko, B. (2002). Reduced risk for overweight and obesity in 5- and 6-year-old children by duration of sleep- a cross-sectional study. *Int J Obes*

Relat Metab Disord. 26, 710-716. https://doi.org/10.1038/sj.ijo.0801980

Wadhera, S. (1989). Trends in birth and fertility rates, Canada, 1921-1987. *Heath Rep.* 1, 211-223. PMid:2491133

Walls, H.L., Stevenson, C.E., Mannan, H.R., Abdullah, A., Reid, C.M., and McNeill, J.J., et al. (2011). Comparing trends in BMI and waist circumference. *Obesity,* 2010:149. https://doi.org/10.1038/oby.2010.149

Wang, Y., Mi, J., Shan, C.Y., Wang, Q.J., and Ge, K.Y. (2007). Is China facing an obesity epidemic and the consequences? Trends in obesity and chronic disease in China. *Int J Obes.* 31, 177-188. https://doi.org/10.1038/sj.ijo.0803354

Wang, Y.C., Bleich , S., and Gortmaker, S.L. (2008). Increasing caloric contribution from sugar-sweetened beverages and 100% fruit juices among US children and adolescents, 1988-2004. *Pediatrics.*121:e1604-14. https://doi.org/10.1542/peds.2007-2834

Wen, L.M., Orr, N., Millett, C., and Rissel, C. (2006). Driving to work and overweight and obesity: findings from the 2003 New South Wales Health Survey, Australia. *Int J Obes.* 30(5), 782-786. https://doi.org/10.1038/sj.ijo.0803199

Wen, L.M., and Rissel, C. (2008). Inverse associations between cycling to work, public transport, and overweight and obesity: Findings from a population based study in Australia. *Prev Med.* 46, 29-32. https://doi.org/10.1016/j.ypmed.2007.08.009

Westerterp-Plantenga, M.S., van Marken Lichtenbelt, W.D., and Cilissen, C. (2002). Energy metabolism in women during short exposure to the thermoneutral zone. *Physiol Behav.* 75(1-2), 227-233. https://doi.org/10.1016/S0031-9384(01)00649-7

Wiklund, P. (2016). The role of physical activity and exercise in obesity and weight management: Time for critical appraisal. *J Sport Health Sci.* 5, 151-154. https://doi.org/10.1016/j.jshs.2016.04.001

Wilkinson, P.W., Parkin, J.M., Pearlson, J., Philips, P.R., and Sykes, P. (1977). Obesity in childhood: a community study in Newcastle upon Tyne. *Lancet.* 309(8007), 350-352. https://doi.org/10.1016/S0140-6736(77)91147-3

Williams, W.F. (2013). *Encyclopaedia of Pseudoscience.* Abingdon, OX, Routledge, pp. 1-444.

Williamson, D.F., Madans, J., Anda, R.F. Kleinman, J.C., Glovinoi, G.A., and Byers, T. (1991). Smoking cessation and severity of weight gain in a national cohort. *N Engl J Med. 324,* 739-745. https://doi.org/10.1056/NEJM199103143241106

World Health Organization. (2003). Controlling the global obesity epidemic. http://www.who.int/nutrition/topics/obesity/en/. Accessen April 19th, 2018.

World Health Organization. (2014). Obesity and overweight fact sheet from World Health Organsation. http://www.who.int/mediacentre/factsheets/fs311/en/ accessed August 1st 2017.

Wu, Q., Mizushima, Y., Komiya, M., Matsuo, T., and Suzuki, M. (1998). Body fat accumulation in the male offspring of rats fed high fat diet *J Clin Biochem Nutr.* 25, 71-79. https://doi.org/10.3164/jcbn.25.71

Wu, Y. (2006). Overweight and obesity in China. The once lean giant has a weight problem that is increasing rapidly. *Br Med J.* 333(7564), 362-363. https://doi.org/10.1136/bmj.333.7564.362

Wysowski, D.K., Armstrong, G., and Governale, L. (2003). Rapid increase in the use of oral anti-diabetic drugs in the United States 1990-2001. *Diabetes Care.* 26, 1852-1855. https://doi.org/10.2337/diacare.26.6.1852

Xi, B., Mi, J., Zhao, M., Jia, C., Li, J., Zeng, T., et al. (2014). Trends in abdominal obesity among U.S. children and adolescents. *Pediatrics.* 134(2), e334-e339. https://doi.org/10.1542/peds.2014-0970

Yang, H.K., Han, K., Cho, J-H., Yoon, K-H., Cha, B-Y., and Lee, S-H. (2015). Ambient temperature and prevalence of obesity: A nation-wide population based study in Korea. *PLoS ONE.* 10(11), e0141724. https://doi.org/10.1371/journal.pone.0141724

Yilmaz, N., Kilic, S., Kanat-Pektas, M., Gulerman, C., and Mollamamhutoglu, L.M. (2009). The relationship between obesity and fecundity. *J Women's Health.* 18(5), 633-

636. https://doi.org/10.1089/jwh.2008.1057

York University. (2004). National survey on active transportation. Toronto, ON, York University.

Yoshike, N., Kaneda, F., and Takimoto, H. (2003). Epidemiology of obesity and public health strategies for its control in Japan. *Asia-Pacific J Clin Nutr.* 11(Suppl. 8), S727-S731. https://doi.org/10.1046/j.1440-6047.11.s8.18.x

Young, L.R., and Nestle, M. (2002). The contribution of expanding portion size to the U.S. obesity epidemic. *Am J Publ Health. 92(2)*, 246-249. https://doi.org/10.2105/AJPH.92.2.246

Zhai, P., Sun, A., Ren, F., Liu, X., Gao, B., and Zhang, Q. (2013). Weather and climate extremes. In: T.R. Karl, N. Nicholls and A. Ghazi (eds.), *Weather and climate extremes.* Dordrecht, Netherlands, Springer, pp. 203-218.

Zhang, J-P., Lencz, T., Zhang, R.X., Nitta, M., Maayan, L. , John, M., et al. (2016). Pharmacogenetic associations of antipsychotic drug-related weight gain: A systematic review and meta-analysis. *Schizophren Bull.* 42(6),1418-1437. https://doi.org/10.1093/schbul/sbw058

Zoeller, R. ., Brown, T.R., Doan, L.L., Gore, A.C., Skakkebaek, N.E., Soto, A.M., et al. (2012). Endocrine-disrupting chemicals and public health protection: a statement of principles from the Endocrine Society. *Endocrinoilogy.* 153(9), 4097-4110. https://doi.org/10.1210/en.2012-1422

Zweininger-Bergielowska, I. (2000). *Austerity in Britain.* Oxford, U.K., Oxford University Press, pp. 1-277.