GENDERED DIMENSIONS OF OBESITY IN CHILDHOOD AND ADOLESCENCE

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ABSTRACT

The literature on childhood and adolescent obesity is vast; this paper focuses, in the main, on other reviews. It reports how the condition has been defined and measured, and how it is distributed. Causes, including genetic, behavioral and parental influences, and physical and psychosocial consequences, both immediate and long-term, are described. Finally, treatment and prevention interventions are discussed. However, in addition to producing a general overview, the aim is to highlight gender differences or similarities, an area which has tended not to be the principal focus of this literature.

The paper suggests that the findings of genetic studies are similar for males and females, and differences in obesity rates as defined by body mass index are generally small and inconsistent. However, differences between males and females due to biology are evident in the patterning of body fat, the fat levels at which health risks become apparent, levels of resting energy expenditure and energy requirements, ability to engage in certain physical activities and the consequences of obesity for the female reproductive system. Differences due to society or culture include food choices and dietary concerns, overall physical activity levels, body satisfaction and the long-term psychosocial consequences of childhood and adolescent obesity. Differences between males and females in exposure and vulnerability to obesogenic environments, and in the consequences of, and

responses to, interventions for child and adolescent obesity, highlight the need for a clearer focus on gender differences among both researchers and policy makers within this field.

INTRODUCTION

The 'epidemic' of childhood and adolescent obesity has spawned a similar epidemic of research publications. These include many excellent reviews, produced for both clinical and epidemiological audiences (e.g. [1-3]). As an indication of the scale of the literature, Medline and Web of Science searches (September 2007) using the terms 'obesity' and ('child$' or 'adolesc$' or 'teen$' or 'youth' or 'young person' or 'young people') and limited to 1996-2007 English language publications, produced 11,280 and 9,067 hits respectively; addition of the term 'review' reduced the numbers to 1,991 and 552.

This paper reviews obesity in childhood and adolescence, but with a special focus on differences between males and females. These may result from differences in biology (sex differences) or those assumed to be due to society or culture (gender differences), or a combination of the two [4, 5]. Both sex and gender are relevant to obesity. It is a product of, and impacts upon, both biology and behavior, and is associated with socially constructed attitudes and beliefs. Given the relevance of both sex and gender, a problem arises as to how to describe differences between males and females. To use the term 'gender difference' to describe purely biological differences is to misapply it [4], however to use 'sex' and 'gender' differences interchangeably because they cannot be entirely separated [6] is confusing and fails to address the issue. Here, the term 'gender' is used, since the majority of differences are unlikely to have solely biological origins.

Given this focus, databases including Medline, Embase, Web of Knowledge, Psychinfo and Cinahl were searched using the terms described above together with 'sex', 'gender$', 'masculin$', 'feminin$', 'male$', 'female$', 'boy$' and 'girl$'. The aim was not simply to identify literature on differences between males and females, but also to investigate whether there was evidence of differences within what has been described as the 'gender/sex dichotomy' ([5], p.653). After reviewing the resulting titles and/or abstracts, it was decided to focus in the main on other reviews, both general and relating to specific aspects of obesity, in order to limit the vast potential literature. However, it should be recognized that reviews, particularly conventional narrative reviews, may be subject to errors in both data handling and reporting [7]. An exception to the use of review papers was made in respect of the first section ('Definitions and distribution'), because to do so would have meant that results from individual studies of rates among particular groups could not be presented.

The sections which follow this introduction describe definitions and distribution, causes, consequences and interventions for child and adolescent obesity. Gender differences, when identified, are highlighted.

DEFINITIONS AND DISTRIBUTION

Definitions and measurement

Obesity can be defined as a pathological, in terms of its associations with both morbidity and mortality, excess of body fat [1, 2, 8, 9]. However, fat is not homogeneous. Abdominal fat has emerged as most clinically relevant, associated with insulin resistance, type 2 diabetes, dyslipidemia and cardiovascular disease in adults, and, as demonstrated in more recent studies, with metabolic risk factors in children and adolescents [10].

Differences between males and females in adult body fat have long been recognized, the android, male, fat pattern represented by relatively greater fat in the upper body, the gynoid, female, pattern by relatively greater amounts in the hip and thigh areas [11]. It is the android pattern, or one of greater fat in the trunk relative to extremities which is associated with increased health risk [12]. Distribution of body fat is partially hormonally controlled, and differences between males and females in fat mass have generally been considered to become manifest during puberty [1, 13]. This is particularly the case in late adolescence, when males increase fat-free mass and skeletal mass at the shoulder, and females increase fat and skeletal mass at the hips [14-18]. However, recent studies of pre-pubertal children have also found higher levels of fat and evidence of the gynoid pattern among females at much younger ages [19-22].

The question then arises as to the level of fat which should be defined as obese. Studies which have assessed the degree of body fat associated with significantly elevated cardiovascular risk factors in children and adolescents, suggest 30 percent in females and 20-25 percent in males [23, 24]. Thus, while males tend to have lower levels of body fat, this is countered by the fact that health risks become evident at lower levels for males than females. There are also ethnic differences, with Asians tending to carry a proportionately higher, and blacks and Polynesians a proportionately lower fat mass, than Caucasians [25]. Studies find this to be the case in children and adolescents as well as adults [14, 26, 27]. Further, insulin metabolism seems more sensitive to adiposity among (British South) Asians, meaning that health risks may become evident at lower levels of fat among this group [28].

Given its association with health risks, it has been suggested that there should be a greater emphasis than is current on the assessment of fat, particularly abdominal fat, for both clinical and epidemiological purposes [25]. However, the most accurate measures of body fatness are generally expensive, require laboratory conditions and/or are associated with reduced acceptability to participants, although this may be changing - see [18]. Most epidemiological studies therefore rely on anthropometry, which can include measurements of skinfolds made via calipers, or of waist and hip circumferences representing abdominal fat [19, 29, 30]. Waist circumference increases with age for both males and females and is higher among males after age 10. Waist circumference percentile curves have been developed in a number of countries, including the UK [31], Australia [32] and Spain [33]. Waist-to-height ratio has also recently been proposed as a simple indicator of obesity [34]. However, the most frequently used measure is weight in relation to height, usually represented by the body mass index (BMI), defined as weight (kg) / height squared (m^2).

BMI has, despite many recognized limitations (e.g. [35]), been described as 'the backbone of the obesity classification system and surveillance statistics' ([25], p.141). Although a high BMI may not always equate to high levels of fat [25, 36], given appropriate cut-offs, it can be used to classify obese children and adolescents with high specificity, thus identifying few false positives [37]. However, BMI varies according to both gender and age, increasing from birth to one year, thereafter reducing to around age six, then increasing [38]. Further, while adult obesity has been defined as BMI over 30 kg/m^2, since this is known to be associated with higher morbidity and mortality [39], much less is known about specific levels of BMI associated with current or future health risks at younger ages [8]. The resulting lack of consensus with respect to which cut-off to apply, has meant that it is often difficult to compare obesity rates between studies, because the methods used impact on the proportion of children defined as obese [40].

For example, within the US, reference growth charts based on nationally representative surveys have been produced by the Centers for Disease Control and Prevention (CDC) since 1977 [41], and in 1991, race-specific and population-based BMI percentiles, covering ages 6-74 were generated. These are often termed the MDD criteria, after the initial letters of the authors' names [42]. A US expert committee recommended their use for children and adolescents, with the 95th BMI percentile for age and sex (or BMI 30 kg/m^2) as cut-offs for 'overweight'; the term 'obese' was not used [43, 44]. When the current (CDC 2000) US charts were produced, data obtained since 1988 from those aged over 6 years were excluded, in order to avoid the upward shift in the weight and BMI curves that would have otherwise occurred [45]. Within the UK, charts ('UK90') were produced by combining data from a number of surveys conducted between 1978-90, with the 95th centile most commonly adopted to define obesity for epidemiological purposes [46]. Similar BMI-for-age gender-specific reference charts have been developed in several other countries.

Against this background of multiple datasets and cut-offs, the International Obesity Task Force (IOTF), concluded that for consistency across the lifespan, the cut-off should agree with that used to identify obesity in adults [47]. Following this, international data were pooled, and centile curves were derived that passed through the points of 25 kg/m2 and 30 kg/m2, reflecting recommended definitions of adult overweight and obese, at age 18 [48]. Despite its limitations [35, 49], it has been suggested that prevalence studies should present results based on the IOTF cut-offs in addition to national definitions, since this would allow for comparison across populations [50]. Although the majority of studies adopt one or other of the above definitions, alternative cut-offs, such as 120% of the median or average, or greater than two SD scores of the reference population [51, 52] continue to be used, but with decreasing frequency.

Distribution of obesity as defined by BMI

TABLE 1

Table 1, which shows obesity rates at several time points and in a large number of different countries, demonstrates the impact of different definitions. Rates according to the IOTF cut-offs are lower than those in respect of CDC 2000 or UK90 (e.g. [53]). However, despite different definitions, the wide range in prevalences between countries is clear. This is also evident in the results of a study of European, Israeli and US adolescents, who self-reported height and weight in the 1997-98 WHO Health Behavior in School-Aged Children (HBSC) surveys. Here, the 95^{th} BMI centile for age and gender was derived for the whole sample and used to determine prevalence of 'overweight' in each country. These data are not shown in Table 1 since this was not a 'standard' definition. Overall rates were therefore around 5%, ranging from the lowest in Lithuania (rates among 15 year old males and females 0.8% and 2.1%), to the highest in the United States (13.9% and 15.1%) [54]. Very similarly, a comparison of obesity prevalence, based on the IOTF definition among adolescents from 34 countries who self-reported height and weight in the 2001-02 HBSC surveys found the lowest rates in Lithuania (0.4%) and Latvia (0.5%), and the highest in Malta (7.9%) and the United States (6.8%). This study, which did not present separate male and female rates, noted particularly high prevalences in countries in North America, Great Britain and south-western Europe [55]. A review of surveys conducted within 20 European countries during the 1990s, suggested higher levels of childhood overweight and obesity in southern countries and lower levels in the central and eastern countries which experienced political and economic transition over that period [56]. Within developing countries, high prevalences are found in the Middle East [57].

To return to Table 1, a further issue demonstrated is that of globally increasing rates, regardless of definition. Obesity has been described as 'the most common pediatric disease' in most of the world, with the exceptions of sub-Saharan Africa and the former Soviet Union ([58], p.429). An examination of childhood overweight and obesity, based on studies from more than sixty countries from different regions of the world, found increasing prevalence in almost all countries for which data were available, exceptions being school-aged children in Russia, and to some extent Poland, in the 1990s [59]. Data on older children and adolescents, obtained from the United States, Brazil, China and Russia between the early 1970s and late 1990s, demonstrate reductions in underweight and increases in overweight in all countries except Russia [60, 61]. Further, within Europe, the prevalence rates of overweight and obesity are not rising at a constant rate, but are accelerating [62]. In respect of secular changes, what Table 1 cannot show is that in addition to increases in obesity rates, the distribution of BMI has become more skewed, with the greatest increases at the highest levels. Comparisons of survey data collected in the 1970s and 1980s with figures obtained more recently show that obese children are now more obese than they were [63, 64]. There is also evidence of changing body composition, with increasing fat and reductions in muscle [65, 66].

In respect of gender differences, Table 1 suggests no consistent male or female excess. Differences are generally small, and there is no suggestion that either males or females consistently predominate within particular age groups, or according to particular definitions. Although international patterns are, in general, also difficult to discern, Table 1 suggests that within Asia, a male excess may exist in Korea, Taiwan and China, in contrast to a female excess in Middle Eastern countries. A proposal that the male excess in China may result from gender differences in child care associated with the one-child policy [67], has been challenged [68]. An apparent female excess in some UK studies using the IOTF definition is artefactual, since this definition has been shown to have lower sensitivity in UK males than females [69]. The study which derived 95th BMI centiles for age and gender within its sample of European, Israeli and US adolescents found higher rates among males in some countries, such as Greece (rates of 10.8% in males and 5.5% in females at age 15), while in others, such as Denmark, there was a female excess (3.2% in males and 6.5% in females). However, in almost all cases the gender differences were not statistically significant [54]. Similarly, the review of surveys conducted within 20 European countries during the 1990s surveys found the number of countries with higher prevalences for females was almost the same as that with higher prevalences for males [56]. It is possible that gender differences may emerge in future; a study conducted in the US found significantly greater increases in rates of (CDC 2000) ‘overweight’ among males between 1986-98 [70]. It has therefore been suggested that prevalence estimates for both males and females should always be presented [2].

While gender differences may be small overall, patterns may differ according to ethnic group. Among females, British studies almost always find the highest rates of obesity among black females, with the lowest levels generally found among South Asians. This was evident in a sample of 2-20 year olds [71] and an adolescent cohort followed from ages 11-15 [72]. Among samples large enough to sub-divide into black African and black Caribbean groups, one UK study of 11-13 year olds found higher BMIs among both groups than in their white, Indian, Pakistani, Bangladeshi or mixed ethnicity peers [73]. These studies have generally found smaller, and less consistent ethnic differences in obesity rates among males. However, a US study found the same pattern among both males and females, the highest rates of (CDC 2000) ‘overweight’ occurring in Mexican Americans at ages 6-11, and Non-Hispanic blacks at ages 12 to 17 [74]. Among US 4-12 year olds, increases in (CDC 2000) ‘overweight’ between 1986 and 1998 were highest for African-Americans and lowest for Non-Hispanic whites (separate results for males and females not presented) [70]. Different results in respect of rates according to ethnicity by gender in studies conducted in the UK and US may result in part from the different groups included; there are few US data on the health and weight status of Asian Americans [75].

In respect of socioeconomic status (SES), one review has summarized the picture as ‘overweight is high among the poor in rich countries, and the rich in poor countries’ ([1], p.18). A comparison of family income differences in levels of obesity found higher rates among low income groups in the US, high income groups in China and both (compared with middle income) groups in Russia [76]. It is suggested that this is because in developing nations, higher SES individuals have become globalized, with easy access to relatively cheap, calorie-dense foods, while those of lower SES remain localized and undernourished [77]. Within the US, increases in ‘overweight’ have also been greatest among children and adolescents from the lowest income families, so increasing SES disparities [70]. However, as one review points out, this should not be taken to mean that higher SES children and adolescents in rich countries are not at risk of obesity [2]. Further, not all studies in such countries find SES differences [71, 78, 79], and among those that report separately, there is some evidence that SES differences may be clearer among females than males [72, 80].

CAUSES

Genetic factors

Like height, weight is heritable. One recent review suggests that twin and adoption studies point to a genetic contribution for BMI of 40-70 percent [81], while a more extensive, but earlier, review of familial resemblance suggests that genetic factors explain 50-90 percent of BMI [82]. The results of genetic studies, where presented separately for males and females, appear broadly similar. Overall, the findings of such studies mean that genetic factors determine individual susceptibility to gain weight. Such 'thrifty' genes provide an evolutionary advantage in times of famine, when humans have to stockpile energy to survive, but a disadvantage when food is plentiful [83, 84]. However, as several authors point out, while the propensity for obesity may have existed for a long time, the recent rapid rise in rates demonstrates the central role of environmental factors [81, 82, 85].

Behavioral factors

Obesity is related to an imbalance between energy input and output, the size of which may be very small if over a long period [86]. One review suggests that in children, an imbalance of around 2%, which is the equivalent of around 30 calories or 15 minutes of tv instead of play a day, may lead to obesity [87]. Behavioral determinants therefore include excess energy intake and/or inadequate energy expenditure [88], although the emphasis given to these 'Big Two', and the neglect of other plausible contributors to the secular increase in obesity has recently been questioned [89].

In respect of energy intake, dietary surveys do not suggest a secular increase among children and adolescents. However, the results of such studies may be confounded by an increasing trend towards greater under-reporting, to the extent that reported intake may be below the estimated required physiological minimum, especially among older girls. Regular consumption of high energy-dense fast-foods and sugary drinks which are associated with less satiation and so insufficient compensation via subsequent reductions in intake, increased portion size, eating outside the home and snacking have been particularly implicated in promoting weight gain. This is especially the case among older children, who are less influenced by biological cues of satiety [85, 90]. In respect of energy expenditure and physical activity, assessment is difficult [91], and evidence for secular trends is scarce because of the absence of suitable baseline data [92]. However, a decline in UK adolescent energy intake from the 1930s to the 1980s with no concurrent change in body mass, increasingly pervasive electronic and screen-based entertainment, greater car travel and reduced walking or cycling, together with evidence of reductions in fitness in developed countries all point to lower activity levels [92-95].

Gender differences in many areas of nutrition emerge in childhood and adolescence. The greater fat-free mass of males, particularly post puberty, requires a higher energy intake. The US Government's 2005 'Dietary Guidelines for Americans' suggests approximate daily calorie requirements for moderately active children and adolescents as follows: 4-8 years - 1,500 kcal (males and females); 9-13 years – 2,000 (m), 1,800 (f); and 14-18 years – 2,600 (m), 2,000 (f) [96]. Studies of adolescents have found that females are more likely to pay attention to foods as a way to influence health and to meet nutritional recommendations, while males eat more fast foods. It has been suggested that these differences arise not only because of differences in Western societies' perception of ideal body weights, but also because some foods are gendered; for example meat may represent strength and virility. In addition, the menstrual cycle has been associated with cravings for foods rich in fat and carbohydrate [13, 97].

Gender differences in energy expenditure can also be attributed to both biological and social factors. Total energy expenditure (TEE) includes resting energy expenditure, energy needed to process food, energy expended in physical activity and, in children, energy required for growth [94]). It is strongly correlated with body weight, largely because of the relationship between resting energy expenditure and body weight [98]. Differences in body composition at puberty are associated with higher TEE among males than females, however there is limited and inconsistent data on male-female differences in TEE pre-pubertally [98, 99]. Of all the components of TEE, physical activity is most amenable to modification [85], and a review of prospective observational studies has concluded that increased physical activity and decreased sedentary behavior protect against relative weight and fatness gains in childhood and adolescence [94].

It has been suggested that 'perhaps the most evident biological correlate' of physical activity in children and adolescents is gender ([100], p.550), and also that the effect of energy expenditure on the etiology of obesity may vary by gender, ethnicity or age [86, 87, 98]. Gender differences in physical activity may begin early; a longitudinal study found that while boys' daily TEE increased continuously between ages 5 and 10, that of girls increased from 1,365 kcal at 5 to 1,815 kcal at 6, but by age 9 had reduced to 1,608 kcal. This reduction was explained by a 50% reduction in physical activity between ages 6 and 9 [87]. One review cites data suggesting that levels of moderate or vigorous physical activities in US 11-12 year old boys are nearly twice those of girls, and while age-related decreases in activity levels occur in adolescence, they are higher in girls. Thus a 1990 UK study found decreases between ages 11 and 18 in mean self-report daily activity causing at least slight breathlessness from 83 to 57 minutes among males and from 49 to 26 among females. A review of the world literature suggested annual declines in physical activity of up to 2.7% among boys and 7.4% among girls between the ages of 10 and 17 (see [91, 100, 101]). Such findings have been related to differences in motor skills development, body composition, socialization towards sports and physical activity and freedom to engage in activities independently outside the home [91, 100].

Sedentary behavior has also been associated with body composition and BMI. For example children who watch more tv have been shown to have higher skinfold thicknesses, while one study has suggested that approximately 17% of early adult overweight may be attributable to watching tv for two or more hours daily in childhood (reported in [92]). Given this, it is interesting that a review of studies of screen-based media use in contemporary youth, most from Europe or the US, found that males are also higher users of tv and video games. For example, 30% of males and 25% of females watched tv for more than four hours a day, while 30% males and 7% females played video games for more than four hours a week. This suggests that females may spend time in sedentary activities not measured by most current instruments [102].

Parental influences

Obesity clusters in families, and parental obesity is the most important risk factor for obesity in their children [103], although the influence of parental weight on persistence of obesity into adulthood is greatest prior to adolescence [1]. While implicating genetic factors, the environments of children and, to a lesser extent, adolescents, are also generally provided by their parents [104, 105]. There is evidence that familial patterns of adiposity may be partly attributable to similarities in diet. There is also evidence that self-regulation of energy intake by infants and children can be over-ridden by parental control, at first among those who are formula fed and who may be encouraged to finish the bottle, and then as well-meaning parents attempt to restrict children's eating. Gender differences have also been reported here: maternal restriction of snacks has been found to promote their over-consumption in an unrestricted setting by females, but not males; greater parental control has been linked to increased adiposity in females, but not males; mothers who use more control have been found to have daughters, but not sons, with poor energy regulation [104, 106, 107]. In addition, there is some evidence that parents are less likely to encourage sons to lose weight, perhaps because of the larger, more muscular ideal male body shape [108]. Parents also appear to be strong influences on physical activity in childhood, and again, there is evidence of gender differences; for example, stronger relationships with parental activity for girls [100, 109].

CONSEQUENCES

Several reviews summarize the consequences, both short- and long-term, of childhood and adolescent obesity (e.g. [1, 2, 110-115]). The first review to systematically search and critically appraise this literature divided it 'logically' into childhood co-morbidities and adult consequences [113]; it can also be divided into physical and psychosocial consequences.

Physical health consequences

Childhood physical health consequences were, until fairly recently, largely unrecognized. In fact, there are few organ systems that severe obesity does not affect [1]. Associated outcomes include: cardiovascular risk factors, which have been identified in children as young as 5 years - [115]; type 2 diabetes; non-alcoholic fatty liver disease; asthma; sleep-disordered breathing; systemic inflammation; and orthopedic problems [1, 2, 110-113]. There is a marked tendency for obesity, particularly adolescent obesity, to track into adulthood, and so be associated with adult obesity-related disorders. However, even after controlling for current risk factors including weight, childhood obesity is associated with increased risk of all-cause and coronary heart disease mortality [2, 8, 110-113].

Some of the physical consequences of obesity are gendered. There have been suggestions of a stronger relationship between obesity and asthma in females, but results in this respect are inconsistent [116, 117]. Further, there is some evidence that adult mortality risks are higher in respect of adolescent obesity among males [110, 111]. Among females, obesity is associated with early onset of puberty and menarche which has, in turn, been linked to breast cancer, although the relationship between early menarche, obesity in adolescence rather than later, and pre- versus post-menopausal breast cancer is complex [118]. Obesity has also been related to other cancers of the female reproductive system, increased risk of spontaneous abortion and menstrual problems, particularly polycystic ovary syndrome which can lead to infertility [1, 11, 13, 84, 103, 119]. The relationship between obesity and female puberty led to the suggestion that a threshold level of fatness was required for the female growth spurt and menarche; this is not now thought to be the case [120, 121]. Indeed, there is a growing body of evidence suggesting the opposite, that puberty effects levels of fatness [35].

Increasing levels of obesity, coupled with its association with female puberty have also been linked with claims of recent reductions in age of menarche. Reviews conflict, some suggesting ‘clear evidence’ that the age of menarche is falling [122] and others that while menarche may be stable, the first signs of puberty, such as breast budding may now be occurring earlier [120, 121]. However, it may be the case that there has been no recent secular change in either, but rather that obesity is associated with premature development of pubic hair and apparent breast tissue separate from true puberty [123].

Since markers of puberty are more overt and recordable for females, there is less information about its timing for males [122]. However, some reviews of obesity and puberty appear to extrapolate the female findings to males or children/adolescents as a whole; for example, ‘childhood obesity is associated with … early puberty’ ([103], p.873); ‘obesity is usually associated with … earlier pubertal development’ ([120] p,375). In fact, although the evidence is much sparser, there is some evidence that in males, obesity is associated with later sexual maturation [1, 35, 121].

Psychosocial consequences

The immediate psychosocial consequences of childhood and adolescent obesity have been long-recognized [124]. Stigmatization and discrimination by peers is well-documented; from very young ages, obese children are characterized in negative ways, less preferred as friends and more likely to be the targets of teasing or bullying

[1, 2, 110]. There is also evidence of bias and stereotyping by teachers and even some parents [125]. While it could be argued that such behaviors might diminish as obesity becomes more commonplace, this does not appear to have occurred [1].

Evidence in respect of the psychological consequences of child and adolescent obesity is mixed [1]. While some reviews conclude that it is associated with psychological or psychiatric problems, increasing with age and particularly among girls [113], others suggest that research has failed to find consistent differences in the global self-esteem [126], depression or anxiety [127] of obese or overweight children and adolescents compared with the rest of the population. Such conflicting results may have arisen in part because obese clinic samples, that is those seeking treatment, tend to have poorer psychological well-being and quality of life than community samples. While obese community samples have lower body satisfaction and physical self-competence than non-obese, few are depressed or have low global self-esteem [128, 129]. Small differences in their psychological well-being may also be explained, at least partly, by weight-related teasing or bullying [130]. There have been suggestions of associations between depression and obesity, and that - reversing the direction of causality - major depression in adolescents, or young females, predicts increased adult BMI [130, 131]. However, the relationship between obesity and depression 'is far from proven' ([129], p.436).

Reductions in body satisfaction and well-being amongst the obese are greater among adolescents than children, and among females than males. Reflecting this, 12 of 18 recent studies of body dissatisfaction and 7 of 28 of self-esteem reported in one review included female participants only [129]. The consensus is that gender differences in body satisfaction emerge around 8-10 years of age [108]. While both males and females with a high BMI wish to be thinner, the picture is more complex for males because of the larger muscular male ideal. In relation to stereotypes and attitudes, some studies have demonstrated equivalent stereotyping of obese peers, regardless of the gender of rater or target. However others have suggested that females express stronger dislike of obese peers than males, and also that obese females are rated more negatively than obese males. There is also some evidence that females may be more vulnerable to obesity-related victimization, but again, this is not a consistent finding [125, 132]. The picture in relation to body satisfaction and obesity is also complicated by ethnic differences. For example, in line with preferences among adult black women for a larger body size, black girls with high BMIs are less likely than those from other ethnic groups to consider themselves overweight or desire to be thin [125, 133].

Gender differences in weight-control methods are also evident. Males are more likely to exercise than diet, begin dieting at a higher BMI than females, and tend to focus on increasing upper body size while reducing fat [134]. In contrast to professionally administered, 'sensible' weight loss programs, [135], the use of unhealthy quick-fix dieting practices by some adolescents has been linked to a range of negative outcomes. These include: adverse physiological outcomes, such as electrolyte disturbances; psychological consequences such as reduced self-esteem, particularly if dieting 'fails'; other unhealthy behaviors, such as smoking [136]; cycles of weight loss and regain; and increased likelihood of eating disorders [137]. As is well-recognized, such behaviors are significantly more likely among females than males [137, 138], however males are not immune to disordered eating behaviors

[134, 139]. The finding of one study that femininity as represented by self-ascribed expressive personality traits, was predictive of eating problems among both male and female adolescents [140], highlights the need to consider such characteristics within each gender, rather than just compare the behaviors of males and females.

Finally, to return to the longer-term consequences, longitudinal studies in both the US and UK have demonstrated that child and adolescent obesity is associated with adverse social and economic outcomes, such as reduced years of education, income and rates of marriage, in young adulthood. Again, there are gender differences, these effects being stronger for females [1, 2, 110, 111, 113].

INTERVENTIONS

The goal of any weight loss intervention is to achieve an energy imbalance so that intake is less than expenditure [112]. Most therefore target food consumption and/or physical activity either directly or indirectly [141]. A large number of reviews are now available, all focusing on the same, surprisingly small, evidence base. The majority conclude that: (a) treatment or prevention efforts have some positive effects, although these are generally small or very small; (b) a global approach, including various methods and settings, is likely to be more effective; and (c) given proper implementation and monitoring, there is little evidence of negative effects, either physiological or psychological. [105, 112, 115, 135, 141-157]. While some reviews have been unable to identify any particular interventions that characterize the positive studies [153], others have suggested that effective interventions can be distinguished on the basis of such factors as 'compulsory' aerobic physical activity [158], parental involvement [159] or more motivated participants [156, 160]. Some authors have been more optimistic about the treatment of pediatric, as opposed to adult obesity, because of factors such as family support, and the fact that weight stabilization, rather than reduction, may be sufficient. Despite this, most pediatric obesity interventions are marked by relapse, although there is some evidence for long-term efficacy [142].

In respect of methodological approaches, the most common include diets such as the traffic light diet (foods categorized as 'go', 'caution' and 'stop'), exercise sessions and increased general lifestyle activity, combined with the use of behavior change methods. For example, since obese children have a more negative perception of physical activity than non-obese children, and also find activity less reinforcing than sedentary behaviors, rewarding reductions in sedentary behaviors in order to increase physical activity has been found to be effective [142].

In respect of setting, a recent American Dietetic Association (ADA) position paper, based on a systematic evidence-based approach to the literature [141], categorized pediatric obesity interventions into three types; tertiary, secondary and primary. Tertiary prevention aims to slow down or reverse increased BMI and prevent related complications among those categorised, using US definitions, as 'overweight'. Secondary prevention is aimed at those who are 'at risk of overweight' and primary prevention at those with lower BMIs. Limited evidence was found for individual-based interventions for tertiary prevention among 'overweight' children or adolescents. However, there was evidence that family-based interventions including parent training, dietary, activity and behavioral components such as self-monitoring and goal-setting, should be routinely recommended for ‘overweight’ 5-12 year olds, but less evidence to support similar recommendations among adolescents. School-based programs including behavioral counseling, nutrition education, activity education and associated environmental changes, and parental involvement were recommended for primary prevention of both child and adolescent ‘overweight’. Although equally effective for secondary prevention (for those ‘at risk of overweight’), they were not recommended due to the risk of stigma among those targeted and because continually increasing rates of ‘overweight’ suggest the need for population-wide approaches. There was insufficient evidence to evaluate community-based approaches such as promoting change through policy, social marketing and/or environmental change among groups or the whole population (for an extensive list of such policies see [161]). However, such interventions were recommended due to their potential to impact on the greatest numbers [141].

The ADA paper identified no studies which evaluated the efficacy of popular weight loss approaches, such as programs via the internet, in self-help formats or in non commercial settings [141]. The internet has been identified as a potentially powerful tool for obesity intervention for a number of reasons, including its anonymity and accessibility. It has been suggested that it may be particularly successful for use with adolescents, given their high rates of internet use [162].

The ADA paper did not consider gender differences, however another recent review of the literature on the prevention and treatment of childhood obesity did [115]. Importantly, from the perspective of the current review, one of the gaps identified was that, along with immigrant and minority ethnic groups, and those aged below six years, males represented a population subgroup where obesity prevention programs and evidence of effectiveness were limited. In addition, it was noted that few programs were gender-specific.

There are a number of reasons why obesity prevention programs are more likely to be developed for girls, particularly adolescent girls [115]. As noted above, concerns about body image and vulnerability to eating disorders are greater, and participation in physical activity lower, among girls. However, this may have blinded those working in this field to the fact that the growing prevalence of obesity affects males and females equally. Further, gender-specific programs may be more effective than blanket approaches; some trials have found different effects for males compared with females. Examples include a Norwegian school-based activity intervention which found increased frequency of physical activity among boys only (reported in [163]; a randomized controlled trial (RCT) of a school-based intervention, conducted in the US, which targeted television viewing, diet and vigorous activity, finding significantly reduced obesity among girls, but not boys (reported in [112]; and another US-based RCT which included health education and dance exercise and found significant reductions in BMI and resting heart rate between intervention and control girls, but smaller effects for boys (reported in [150]. Such evidence as there is suggests that males respond better to physical activity interventions [160]. It has been suggested that such gender differences in the effects of interventions may become more apparent in adolescence, as biological and environmental differences increase [164, 165].

Despite such findings, a recent review of RCTs of exercise for treating obesity in children and adolescents found that not all trials described gender characteristics, and many which did reported combined results for males and females. Further, between-group differences in gender distribution and maturation stage tended not to be considered, despite their potential confounding effects on obesity outcomes [166]. Ignoring potential gender differences in effectiveness might result in failure to identify successful programs [157], while investigation of different effects for males and females might increase understanding of mechanisms of behavior change and optimize interventions [167].

CONCLUSIONS

Although not generally the principal focus of the literature on childhood and adolescent obesity, gender is a thread running through much of it. This review has highlighted the ways in which differences between males and females, both biological and those due to society or culture are relevant to obesity in childhood and adolescence. While the findings of genetic studies are broadly similar for males and females, and differences in obesity rates as defined by BMI are small and inconsistent, biological differences between males and females are apparent in the development of fat patterning and the association between levels of fat and health risks. Biological differences are also evident in respect of the female-limited consequences of obesity.

Biological and social factors merge in the development and impact of obesogenic behaviors, the long-term physical health consequences of the condition and the success of certain interventions. The greater fat-free mass of males is associated with greater energy expenditure and requirements, and differences between the bodies of males and females may impact on abilities to engage in certain physical or sporting activities. However, gender differences in food choices and dietary concerns, as in overall physical activity levels are the result of social factors. Culture-bound conventions and roles determine these behaviors, with societal expectations and stereotypes for males and females being transmitted via parental, peer and media influences. Finally, social, rather than biological factors are evident in respect of gender differences in body satisfaction and the long-term psychosocial consequences of childhood and adolescent obesity. Being thin is highly valued in our Western society, but more so for females for whom it is associated with beauty, and poorer social or economic outcomes for obese females suggest gendered stigmatization and prejudice.

This review has also suggested that the patterning of child and adolescent obesity according to ethnicity or SES may differ for males compared with females. This highlights the importance of reporting not only overall prevalences, but also the socio-demographic patterning of obesity separately for males and females or, alternatively, noting that gender differences are absent. Studies which fail to do this, or which extrapolate from one gender to the other, may obscure differences which, in turn, might help explain the distribution of obesity. One aim of this review was to identify gender differences within, as well as between males and females, for example in respect of masculine and feminine traits associated with obesity or behaviors. With one or two exceptions [132, 140], it appears that almost no attention has been paid to this area.

In sum, the evidence reviewed here suggests differences between males and females in both exposure and vulnerability to obesogenic environments, as well as in the consequences of obesity and responses to interventions. In doing so, it highlights the need for a clearer focus on gender differences among both researchers and policy makers within the field of childhood and adolescent obesity. To date, work in this area has tended to assume that the biological and social correspond, and that a biological male is 'a social male and a biological female a social female' ([168] p.66), thus polarizing males and females. However, in relation to areas such as body image, self-esteem, dietary and exercise behaviors and interventions, it may be valuable to go further and to consider the impact of masculinity and femininity among both males and females.

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TABLE 1: Examples of international obesity rates; different definitions, ages and dates – males and females

Country	Survey/data	Definition	Age(s)	Date(s)	% males	% females	Reference
North Amerca							
United States	National Health and Nutrition Examination Surveys	National Center for Health Statistics (1979) weight for length (children younger than 3) and weight for stature curves > 95th percentile	< 1	1976-80	4.0	6.2	Ogden, Troiano & Briefel et al, 1997 [169]
				1988-94	7.5	10.8	
			4-5	1976-80	4.4	7.6	
				1988-94	5.0	10.8	
United States	National Health and Nutrition Examination Surveys	CDC 2000 >= 95th percentile	6-11	1976-80	6.6	6.4	Baskin, Ard & Franklin et al, 2005 [170]
				1999-2002	16.9	14.7	
			12-19	1976-80	4.8	5.3	
				1999-2002	16.7	15.4	
Canada	Nationally representative surveys (1981 Canada Fitness Survey; 1996 National Longitudinal Survey of Children and Youth)	IOTF obesity	7-13	1981	2.0	2.0	Tremblay, Katzmarzyk & Willms, 2002 [171]
				1996	10.0	9.0	
Trinidad and Tobago	Nationally representative cross-sectional schools-based survey	IOTF obesity	5-6	1999	1.7	2.4	Gulliford, Mahabir Rocke et al (2001) [172]
			8-9		3.0	2.5	
Martinique	Schools-based surveys	IOTF obesity	14	1999	6.3	4.8	Benefice, Caiius & Garnier (2003) [173]
South America							
Chile	School census data	IOTF obesity	6	1987	1.8	2.1	Kain, Uauy & Vio et al, 2002 [53]
				2000	7.2	7.5	
		CDC 2000 >= 95th percentile	6	1987	5.1	4.0	
				2000	14.7	15.8	
Mexico	Schools-based surveys	CDC 2000 >=95th percentile	11-14	1998-99	12.9	10.8	Salazar-Martinez, Allen & Fernandez-Ortega et al (2006) [174]
			15-19		8.0	4.9	
Australia							
Australia	National surveys (1985 Australian Health & Fitness Survey; 1995 National Nutrition Survey)	IOTF obesity	7-11	1985	1.5	1.9	Magarey, Daniels & Boulton, 2001 [175]
				1995	3.7	6.3	
			12-15	1985	1.9	1.3	
				1995	6.1	4.4	

Table continued over

TABLE 1 continued: Examples of international obesity rates; different definitions, ages and dates – males and females

Country	Survey/data	Definition	Age(s)	Date(s)	% males	% females	Reference
Europe							
England	National Study of Health and Growth (independent cross-sectional surveys)	IOTF obesity	4-11	1974 1994	1.4 1.7	1.5 2.6	Chinn & Rona, 2001 [176]
Scotland			4-11	1974 1994	1.7 2.1	1.9 3.2	Chinn & Rona, 2001 [176]
England	Health Survey for England	UK90 obesity >= 95th percentile	2-10 11-15	1995 2004 1995 2004	9.6 16.2 13.5 23.7	10.3 11.9 15.4 26.2	National Health Service Information Centre, 2006 [177]
Scotland	Scottish Health Survey	UK90 obesity >= 95th percentile	12-15	1998 2003	15.6 20.9	15.2 14.7	Scottish Public Health Observatory, 2007 [178]
Northern Ireland	Schools-based surveys	IOTF obesity	12 15	1989-90 2000 1989-90 2000	4.0 4.7 0.4 3.1	1.6 4.7 3.9 4.8	Watkins, Murray & McCarron et al, 2005 [179]
France	Schools-based surveys	IOTF obesity CDC 2000 >= 95th percentile	7-9	2000	3.9 7.5	3.6 5.2	Rolland-Cachera, Casetbon & Arnault et al, 2002 [180]
Spain	Schools-based surveys	IOTF obesity	6-14	1980 1995	1.5 2.1	1.4 3.3	Moreno, 2001 [181]
Portugal	Schools-based surveys	IOTF obesity	7-9	2002-03	10.3	12.3	Padez, Fernandes & Mourao, 2004 [182]
Italy	Schools-based surveys in north (N) and south (S) Italy	IOTF obesity	2-6	2002	5.7 (N) 12.3 (S)	5.8 (N) 10.7 (S)	Maffeis, Consolaro & Cavarzere et al, 2006 [183]
Sicily, Italy	Schools-based surveys	IOTF obesity	11 15	1999-2001	13.1 7.2	10.7 5.0	Baratta, Degano & Leonardi et al, 2006 [184]
Greece	Schools-based surveys	IOTF obesity	6-11	1994 2005	9.4 12.3	8.3 9.9	Papadimitriou, Kounadi & Konstantinidou et al, 2006 [185]
Greece	Schools-based surveys	IOTF obesity	7-10	2002-03 *	16.0	13.4	Tokmakidis, Kasambalis & Christodoulos, 2006 [186]

Table continued over

TABLE 1 continued: Examples of international obesity rates; different definitions, ages and dates – males and females

Country	Survey/data	Definition	Age(s)	Date(s)	% males	% females	Reference
Finland	Nationally representative Adolescent Health and Lifestyle Survey	IOTF obesity	12	1977	2.0	0.9	Kautiainen, 2005 [187]
				2003	3.1	1.9	
			16	1977	0.8	0.3	
				2003	4.2	2.1	
Denmark	Nationally representative samples	IOTF obesity	14-16	1971-72	0.4	0.9	Kautiainen, 2005 [187]
				1996-97	2.0	2.6	
East Germany	Schools-based surveys	IOTF obesity	5-7	1992-93	4.7	3.5	Frye & Heinrich, 2003 [188]
				1998-99	2.7	4.8	
			11-14	1992-93	2.8	3.5	
				1998-99	7.1	7.9	
Poland	Schools-based surveys	IOTF obesity	7-9	2001	3.6	3.7	Malecka-Tendera, Klimek & Matusik et al, 2005 [189]
Russia	Nationally representative household survey	IOTF obesity	6-9	1992	9.5	11.2	Wang & Wang, 2002 [190]
			10-18		2.4	1.3	
		MDD obesity	6-9		13.2	15.9	
Africa							
Egypt	Schools-based surveys	CDC 2000 >=95th percentile	11-14	1997	6.6	7.6	Salazar-Martinez, Allen & Fernandez-Ortega et al, 2006 [174]
			15-19		5.9	8.6	
Senegal	Survey of members of birth cohort	IOTF obesity	12-17	1998-2000	0.0	0.0	Benefice, Caiius & Garnier, 2003 [173]
South Africa	Schools-based surveys	IOTF obesity	8	1994-95	0.4	0.6	Jinabhai, Taylor & Sullivan, 2003 [191]

Table continued over

TABLE 1 continued: Examples of international obesity rates; different definitions, ages and dates – males and females

Country	Survey/data	Definition	Age(s)	Date(s)	% males	% females	Reference
Asia							
Saudi Arabia	Cross-sectional survey of children from randomly selected households	IOTF obesity	1-18	1994-98	6.0	6.7	El-Hazmi & Warsy, 2002 [192]
Qatar	Schools-based surveys	MDD obesity	7	2002	1.6	5.4	Qotba & Al-Isa, 2007 [193]
Bahrain	Schools-based surveys	IOTF obesity MDD obesity	12-17	2000	14.9 16.5	17.9 20.2	Al-Sendi, Shetty & Musaiger, 2003 [194]
Japan	Annual cross-sectional household surveys	IOTF obesity	6-8 12-14	1976-80 1996-2000 1976-1980 1996-2000	1.8 4.6 1.0 2.7	1.8 4.6 0.5 1.0	Matsushita, Yoshiike & Kaneda et al, 2004 [195]
Korea	National survey	>120% ideal body weight	0-19	2001	15.1	10.2	Kim, Ahn & Nam, 2005 [196]
Taiwan	Schools-based surveys	>120% ideal body weight	12-15	1980-82 1994-96	12.4 16.4	10.1 11.1	Chu, 2001 [197]
China - Beijing	Schools-based surveys in Beijing (B) and Shanghai (S)	BMI classification reference provided by Working Group on Obesity in China	7-18	1985 2000	1.2 (B) 1.1 (S) 10.0 (B) 7.2 (S)	1.1 (B) 0.4 (S) 5.2 (B) 4.1 (S)	Ji, 2007 [198]
China	Schools-based surveys	IOTF obesity	13-14 16-17	2002	2.6 4.3	1.5 1.0	Xie, Chou & Spruijt-Metz et al, 2007 [199]
China	Schools-based surveys	IOTF obesity	11-17	2004	5.0	2.1	Li, Dibley & Sibbritt et al, 2006 [67]
Punjab, India	Schools-based surveys of children from affluent families	IOTF obesity	6-11	2002 *	5.9	6.3	Sidhu, Kaur & Kaur, 2006 [200]
India	Schools-based surveys	Triceps skinfold thickness >=90th percentile	9-15	1998 *	12.4	9.9	Chhatwal, Verma & Kaur, 2004 [201]

* survey dates provided by authors (personal communication).