Childhood Obesity

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Childhood obesity has important consequences for health and wellbeing both during childhood and also in later adult life. The rising prevalence of childhood obesity poses a major public health challenge in both developed and developing countries by increasing the burden of chronic noncommunicable diseases. Despite the urgent need for effective preventative strategies, there remains disagreement over its definition due to a lack of evidence on the optimal cut-offs linking childhood BMI to disease risks, and limited evidence on the most effective components of interventions to prevent childhood obesity. This article reviews the trends in childhood obesity, its genetic, nutritional and other risk factors, and preventative and treatment strategies. Particular emphasis is given to early-onset obesity in preschool children, which, as a precursor to later childhood and adult obesity, provides insights into the developmental and genetic origins of obesity and also offers the potential for early preventative approaches with long-lasting benefits.

Prevalence and Trends

The prevalence of childhood obesity has almost tripled in US children and adolescents since 1980,[1] suggesting that it may be increasing at a faster rate than adult obesity, with major implications for the population's future health. The proportion of children in the highest percentiles of body mass index (BMI) has seen the most rapid increase. In some Western settings such as the United States, western Europe, Australia, and Japan, recent data suggest that levels of childhood obesity may have reached a plateau in the last decade (Figures 1 and 2).[1–4] Even if this were the case, the prevalence of both childhood and adult obesity remains very high, and understanding and managing the burden of childhood obesity present difficult challenges. Furthermore, the trends may be continuing among children from more disadvantaged social conditions[5] and among those from certain ethnic backgrounds. In the United States, between 1971 to 1974 and 1999 to 2002, the prevalence of 6- to 11-year-olds with a BMI above the 95th percentile increased by 5-fold (4%–20%) among black children compared with 3-fold (4%–13%) among white children, with intermediate rates of increase seen in Mexican American children.

Increases in obesity levels have been observed even in very young preschool children and are predicted to continue. On the basis of an analysis of 450 nationally representative surveys from 144 countries, the World Health Organization (WHO) estimated that the prevalence of children <5 years of age with a BMI more than 2 SD (equivalent to the 98th percentile) increased from 4.2% in 1990 to 6.7% in 2010 and is expected to reach 9.1% in 2020.[6] Estimates in 2010 were higher in developed (11.7%) rather than developing countries (6.1%), although the relative changes in prevalence have been higher in developing countries, particularly African countries (Figure 3).[6] Nationally, there was wide variation in the prevalence of BMI above the 98th percentile in preschool children; the highest rates were seen in countries such as Albania, Bosnia and Herzegovina, and Ukraine, with prevalences >25% in the most recent surveys. In the United States, on the basis of the National Health and Nutrition Examination Survey 1999 to 2004, 8.3% of children <5 years of age had a BMI above the 98th percentile using the same WHO reference.[7] These worldwide trends in very young children are dramatic and have raised debate as to whether we can and should diagnose obesity even during infancy.[8]

Health Consequences

Adult Obesity and Disease

There is strong evidence that childhood obesity leads to adult obesity and its related comorbidities.[9] Furthermore, many obese children continue to progress in their severity of obesity. In the US National Longitudinal Study of Adolescent Health, nearly 40% of obese adolescents (BMI >95th percentile) became severely obese (BMI >40 kg/m^2) by 30 years of age compared with <5% of normal-weight teenagers.[10] In a recent study of Pima Indians in Arizona, those with the highest quartile of childhood BMI had double the incidence of death resulting from endogenous causes in adult life compared with those in the lowest childhood BMI quartile (incidence rate ratio, 2.3; 95% confidence interval, 1.46–3.62).[11] In the US Bogalusa Heart Study, overweight during adolescence was associated with an 8.5-fold increase in hypertension, a 2.4-fold increase in the prevalence of high total serum cholesterol levels, a 3-fold increase in high low-density lipoprotein cholesterol levels, and an 8-fold increase in low high-density lipoprotein cholesterol levels as adults 27 to 31 years of age.[12] In a study of 276 835 Danish schoolchildren, childhood BMI at 7 to 13 years of age was positively associated with fatal and nonfatal coronary heart

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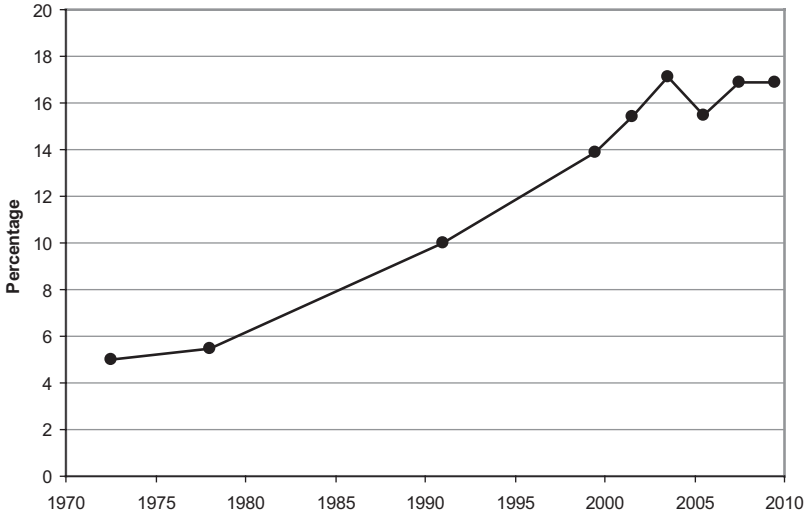

Figure 1. Prevalence of obesity (body mass index >95th percentile) among children and adolescents 2 to 19 years of age in the United States between 1971 to 1974 and 2009 to 2010 shows a recent plateau from 2003 to 2004 on. Based on data from the National Health and Nutrition Examination Survey (NHANES) published by Ogden et al.[1,4]

disease events during adulthood.[13] The associations were linear at each age, indicating that the risk of coronary heart disease increases across the entire BMI distribution. Furthermore, the effect of BMI increased with increasing age of the child, and adjustment for birth weight strengthened the results, suggesting that postnatal gains in weight or adiposity may explain these links.[13] There is also evidence that childhood obesity may increase adult morbidity and mortality independently of adult BMI and other confounding factors such as family history of cardiovascular diseases or cancer and smoking.[14]

Childhood Comorbidities

The need to tackle childhood obesity lies not only in the avoidance of poor adult health. Childhood obesity leads to many acute health problems and much suffering during childhood (Figure 4). Therefore, parents, healthcare providers, and policy makers should understand that prevention of childhood obesity is an important outcome in its own right. These BMI-related childhood and adolescent outcomes include type 2 diabetes mellitus, hypertension, early puberty, menstrual irregularities and polycystic ovary syndrome, steatohepatitis, sleep apnea, asthma, benign intracranial hypertension, musculoskeletal disorders, and psychological problems.[15] A recent systematic review also found strong evidence for type 1 diabetes mellitus as a consequence of childhood obesity; that review identified 9 studies, comprising 2658 patients with type 1 diabetes mellitus, in which the assessment of childhood obesity preceded the diagnosis of diabetes mellitus.[16] Some of the consequences of obesity such as type 2 diabetes mellitus, hypertension, and hyperlipidemia were previously seen only in adults but are now frequently observed in obese children in some populations. For type 2 diabetes mellitus, the younger age at onset of disease not only prolongs the duration of the disease but also is associated with a more advanced rate of progression to β-cell failure[17] and is likely to lead to earlier presentation of adult-life complications such as cardiovascular disease,[18] kidney failure, visual impairment, and limb amputations.[19]

Furthermore, childhood obesity can severely influence quality of life through its impact on social and psychological functioning, having been linked to low self-esteem and depression,[20] as well as educational attainment and interpersonal relationships.[21] It is plausible that the causal relationships between many of these obesity-related complications

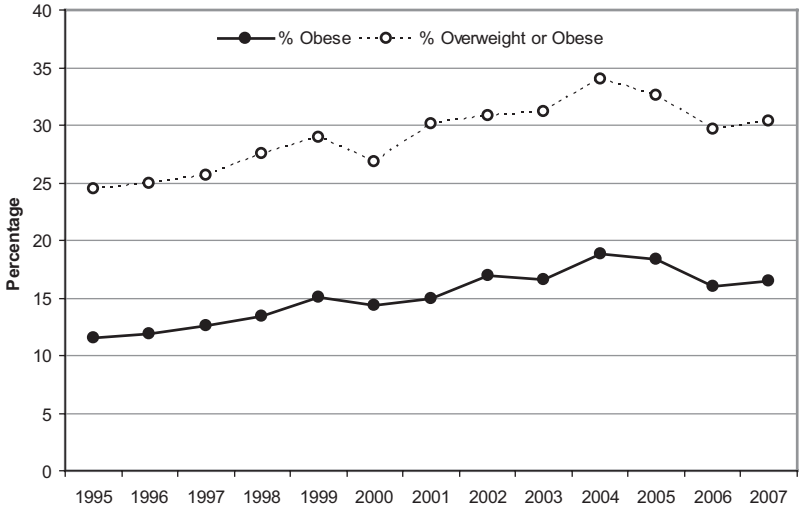

Figure 2. Recent plateau in the prevalences of obesity (body mass index >95th percentile) and "overweight or obesity" (body mass index >85th percentile) among children 2 to 15 years of age in England, 1995 to 2007. Based on data published by the Association of Public Health Observatories.[2]

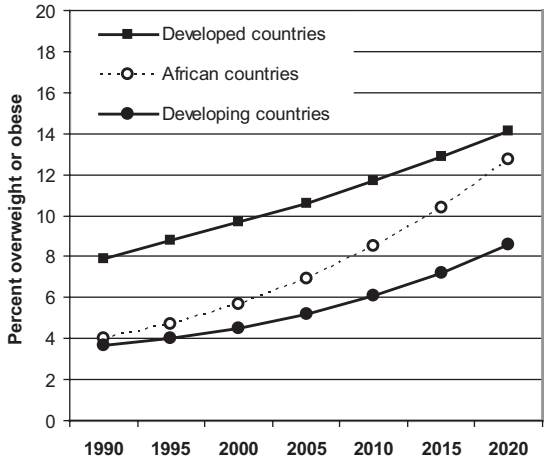

Figure 3. Trends between 1990 and 2010 and predicted ongoing rise from 2010 to 2020 in the prevalence of body mass index above 2 SD (equivalent to the 98th centile) in preschool children in developed and developing countries. Based on data published by de Onis et al.[6,53]

are bidirectional; adverse health, stress, or poor psychosocial functioning could lead to sedentary lifestyles and subsequently greater BMI.

Definition

Obesity is defined as a condition of excess body fat that creates increased risk for morbidity and/or premature mortality, and the adult BMI thresholds of 25 and 30 kg/m^2 for overweight and obesity, respectively, are based on prospective associations between BMI in middle- to late-aged adults and their subsequent mortality.[22] In contrast, there is little consensus as to the best way to operationalize this definition in children.

In many countries, including in the United States since 2010,[23] childhood obesity is defined as a BMI above the 95th percentile for age and sex (and above the 85th percentile for overweight); however, a wide range of reference BMI charts are available. In contrast, the WHO and the United Kingdom use statistics-based cutoffs corresponding to number of standard deviations above the median. The WHO uses a BMI above 2 SD, which is equivalent to the more extreme 98th percentile, to define overweight, whereas in the United Kingdom, this same threshold is used to define obesity in clinical practice settings because the 91st and 98th percentile lines, rather than the 85th and 95th percentiles, are typically displayed on growth charts.[24] A third approach was proposed by the International Obesity Task Force and is based on identifying the childhood BMI thresholds that correspond to adult definitions. Reference charts were created from international data on 97 876 boys and 94 851 girls from Brazil, America, the United Kingdom, Hong Kong, Singapore, and the Netherlands. BMI percentile lines were drawn from 2 to 18 years that pass through the adult overweight and obesity BMI cutoff points of 25 and 30 kg/m^2 at 18 years of age.[25] These International Obesity Task Force criteria are the most stringent of all the current definitions of childhood obesity because relatively few 18-year-olds have such high BMI levels, and the International Obesity Task Force threshold for childhood obesity is roughly equivalent to the 99th percentile.

Some may believe that stringent BMI thresholds for childhood obesity are more appropriate to better identify those children at highest risk of comorbidities. However, although the use of higher BMI thresholds will increase

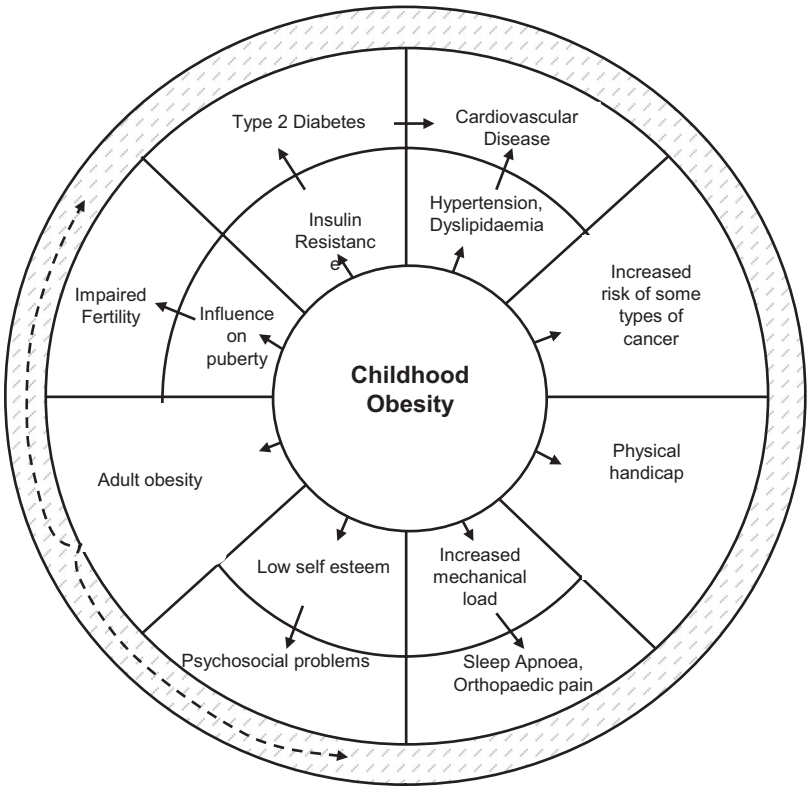

Figure 4. Schematic summary of the complications of childhood obesity. Comorbidities of childhood obesity are depicted in the outer ring with their intermediate processes in the inner ring. Childhood obesity also increases the risk of adult obesity, which in turn increases the likelihood of those comorbidities.

specificity and positive predictive values, this should be balanced against the inevitable increase in the likelihood of false negatives (ie, children with BMI below the 99th percentile who are still at increased risk for obesity-related comorbidities). Currently, there are few data on the true shape of the association between childhood BMI and any important child health outcomes to inform the optimal prediction thresholds.

Childhood Risk Factors

Although the core of the problem of obesity can be simply stated as an imbalance between energy intake and energy expenditure over a prolonged period, the factors behind this are complex. The UK Foresight report described obesity as a "complex web of societal and biological factors that have, in recent decades, exposed our inherent vulnerability to weight gain." That report presented an obesity system map with energy balance at its center being influenced by >100 variables acting at the individual, household, community, or wider societal levels.[26]

A description of these wide-ranging childhood risk factors is well beyond the scope of this article, and we refer the reader to recent systematic reviews that describe the evidence for a number of individual-level lifestyle factors that affect the energy intake-energy expenditure balance and that have been shown to be associated with childhood weight gain and obesity in school-aged children, including the intake of sugar-sweetened beverages,[27] dietary fat,[28] dietary energy density,[29] physical activity,[30] sedentary behaviors,[31,32] and short sleep duration.[31] In a review of prospective studies, the authors concluded that these classic individual-level lifestyle risk factors seem to play a role in the development of obesity in school-aged children and adolescents and that the most consistent evidence was for sugar-sweetened beverages.[28] They also commented on the value of studying new risk factors such as short sleep duration, chronic inflammation, anxiety, depression, and behavioral problems as potential targets for future interventions in this age group.[28]

Early Life and Intergenerational Factors

Considering the rapid rise in prevalence of early-onset obesity in preschool children and its links to later childhood and adult obesity, particular attention should be paid to identifying the early life risk factors for obesity with a view to developing strategies for the early prediction and prevention of obesity.

Birth Weight and Antenatal Factors

There is consistent evidence from large cohort studies of a linear and positive association between birth weight and later-life BMI, and this may be equally attributable to correlations with adiposity and lean mass.[33] Furthermore, maternal obesity, gestational weight gain, and glycemia during pregnancy are positively associated with offspring obesity and metabolic disorders.[34,35] Such intergenerational associations may be explained by genetic transmission and shared postnatal environment. In addition, animal models show long-term "programming" effects of antenatal exposure to maternal diet, and indirect support for this in humans comes from a study of prepregnancy bariatric surgery, which was associated with a 52% lower risk of offspring obesity.[36]

In contrast to the positive birth weight associations with obesity, studies of the major comorbidities of obesity generally report inverse birth weight associations. For example, each 1-kg-higher birth weight was associated with a 10% to 20% lower risk of ischemic heart disease,[37] and with a 1.5-mm Hg-lower systolic blood pressure in men and 2.8-mm Hg-lower systolic blood pressure in women.[38] A meta-analysis of the association between birth weight and type 2 diabetes mellitus identified increased risks associated with both low (<2.5 kg; odds ratio, 47% higher) and high (>4 kg; odds ratio, 36% higher) birth weights compared with the reference group (birth weight, 2.5–4 kg).[39]

These contrasting associations with both low and high birth weight might be explained by the coexistence of 2 separate early life pathways to obesity and later metabolic disease.

The "Thrifty" or "Mismatch" Pathway

Hales and Barker [40] proposed that the relationship between low birth weight and later disease susceptibility was a result of fetal adaptations such as insulin resistance to survive antenatal undernutrition that were then inappropriate in the face of a subsequent affluent postnatal environment. To better explain why they should persist into postnatal life, Gluckman and colleagues[41] proposed that these adaptations were "predictive adaptive responses," ie, that the fetus exposed to poor nutrition anticipates a similar harsh postnatal environment. These responses include a preference for a high-fat diet, hyperphagia, less investment in muscle mass, and greater deposition of visceral adipose stores. The term thin-fat baby has been coined to describe this phenotype in some South Asian babies, and this condition is exacerbated by an obesogenic childhood environment.[42] Thus, later-life obesity and metabolic risk may be determined by the mismatch between the intrauterine and subsequent postnatal environments.[41,43]

The "Early Life Hypernutrition" Pathway

The second proposed developmental pathway to obesity follows the effects of hypernutrition during fetal and/or early postnatal life. Maternal hyperglycemia leads to increased glucose transport across the placenta and in turn to increased insulin secretion by the fetal pancreas. Insulin is adipogenic in late fetal and infant life and probably increases both fat cell number and content.[44] Increased fetal adipogenesis is believed to underlie the macrosomia observed in infants of diabetic mothers.[45] The relevance of this pathway may be of increasing importance in settings of rising maternal obesity, gestational weight gain, and hyperglycemia.

Weight Gain During Infancy

Infancy is the period of life with the highest rates of weight gain both in absolute terms (approximately 6 kg in the first year) and relative to body size (the average infant triples in size during the first year). Faster infancy weight gain is consistently associated with an increased risk of childhood and adult obesity, and there is increasing evidence from randomized, controlled trials to support the existence of long-term "programming" effects of infant nutrition and weight gain on later obesity and obesity-related diseases.[46]

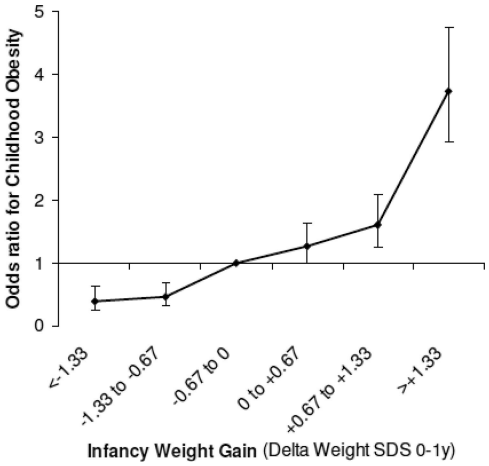

Figure 5. Odds ratio for childhood obesity by infant weight gain between 0 and 1 year adjusted for sex, age, and birth weight. SDS indicates standard deviation score. Reproduced from Druet et al[47] with permission from the publisher. © 2012, Wiley and Sons Inc.

Overall, there appears to be a 2- to 3-fold increase in childhood obesity risk in those infants who cross upward through at least 1 major weight percentile band on their growth chart (2nd to 9th percentile, 9th to 25th percentile, etc), which is equivalent to a gain in weight *Z* score >0.67, between birth to 1 year of age (Figure 5).[47] In a meta-analysis of 7 studies, this rapid early growth pattern also predicted adult obesity up to 66 years of age.[47] In addition to higher BMI, rapid infancy weight gain is associated with greater total adiposity, central adiposity, and higher metabolic syndrome risk markers in young adults.[48–50]

In historical cohorts, being thin at birth and thin until around 2 years of age but then showing rapid childhood weight gain was associated with increased risk for later cardiovascular disease[51] and impaired glucose tolerance.[52] In contrast, in a contemporary cohort, rapid weight gain (>0.67 *Z* score) within the first 3 months of life had an even greater influence on markers of cardiovascular disease and type 2 diabetes mellitus in early adulthood compared with a similar rate of rapid weight gain spread over the first 12 months of life.[50] Hence, both the degree and timing of infant and childhood weight gain may be important in conferring later disease risk.

Infant Nutrition

In most developed settings, formula milk–fed infants are heavier and grow faster than breastfed infants. Indeed, these early growth differences form the rationale for the WHO 2006 International Growth Standard for 0- to 5-year-old children, which is based on predominantly breastfed children.[53] Accordingly, most observational studies report that obesity risk at school age is 15% to 20% lower in breastfed compared with formula milk–fed infants.[54] Systematic reviews have also shown that breastfeeding is associated with a lower risk of type 2 diabetes mellitus,[55] lower cholesterol levels,[56] and lower blood pressure[57] in adulthood. However, breastfeeding is strongly socially patterned and is associated with other healthy behaviors; therefore, it is possible that observational links between breastfeeding and better health outcomes are confounded by these and other unmeasured factors.[58] A randomized, controlled trial of breastfeeding promotion found no effect on childhood obesity[59]; in that setting, however, breastfed infants were heavier than formula milk–fed infants, which could explain the lack of protection against childhood obesity.

Among formula milk–fed infants, higher intakes of milk and other sources of energy are positively associated with infancy weight gain and childhood BMI.[60] Indeed, as a percentage of total energy intake, the energy demands for growth are substantially higher during infancy than during later childhood. Energy deposition as a percentage of total energy requirements decreases from 40% at 1 month to 17.5% at 3 to 6 months, 6% at 6 to 12 months, 3% at 12 months, and 1% to 2% from 12 months until midadolescence and gradually disappears by 20 years of age.[61] Therefore, infancy weight gain is more closely related to energy intake than is weight gain in childhood or in later life.

A few studies have investigated the role of age at the time of introduction of complementary foods (weaning) in childhood obesity. The evidence suggests that complementary foods displace milk intakes, with no clear effect on energy intake or obesity risk.[62] Furthermore, reverse causality cannot be ruled out because infants who gain weight rapidly are more likely to be weaned earlier.[63]

Genetic Factors

Monogenic Obesity

Over the last 15 years, profound insights into the biological regulation of appetite, food intake, and weight gain have been gained by identifying and characterizing the rare genetic mutations in individuals and families with extreme obesity. Deleterious mutations have been detected in genes encoding leptin, the leptin receptor, pro-opiomelanocortin, the melanocortin-4 receptor, and brain-derived neurotropic factor.[64] Other causes of severe monogenic obesity associated with hyperphagia and disorders or learning and behavior arise as a result of large chromosomal deletions.[65] It is noteworthy that many of these advances in the understanding of the genetics of obesity have been achieved through studies of extremely obese children with early-onset obesity and that this possibly reflects stronger effects of these rare mutations on BMI gains in children than in adults.[66,67]

Common Genetic Variants

Advances in understanding the polygenic basis of common obesity and normal variations in BMI have occurred much more recently. Genome-wide association studies in large-scale population-based studies have identified several common genetic variants that are robustly associated with adult BMI and obesity. The first BMI locus was found in the *FTO* locus in 2007, followed by *MC4R* in 2008; loci in or near *TMEM18*, *SH2B1*, *KCTD15*, *MTCH2*, *NEGR1*, *BDNF*, *SEC16B*, *GNPDA2*, and *ETV5* in 2009; and 18 additional loci in 2010.[68] Although those studies focused on BMI or obesity in adult populations, those reports also showed that several of these variants showed significant associations with childhood BMI.[68,69] Indeed, recent follow-up studies have reported that

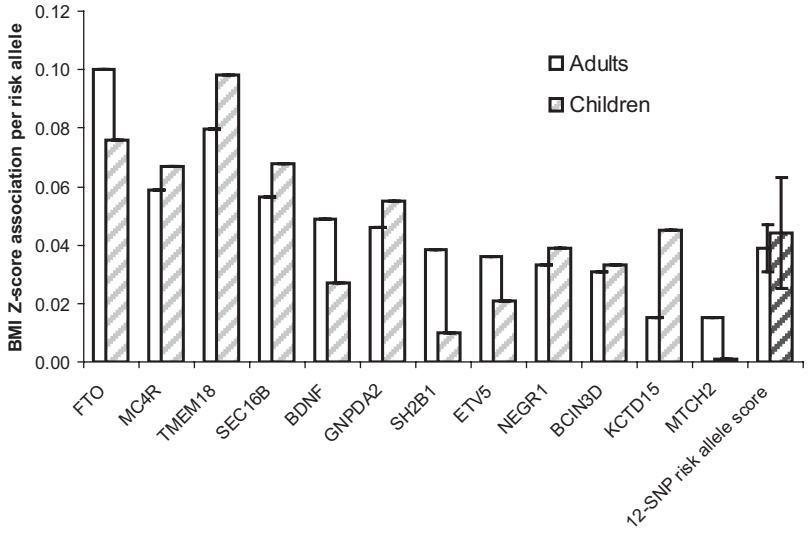

Figure 6. Comparison of the effect sizes on body mass index (BMI) *Z* score in adults and children of various obesity-related genetic variants. The 12 single-nucleotide polymorphism (SNP) risk allele score represents the effect of each additional obesity risk allele averaged across all 12 variants (error bars represent 95% confidence interval). Based on data published by den Hoed et al.[70]

most of these variants have comparable effect sizes in children and adolescents compared with adults in terms of age-standardized BMI *Z* scores (Figure 6).[70]

Other studies have explored longitudinal BMI and growth associations with these BMI loci. In the prospective 1946 British Birth Cohort, associations between the *FTO* and *MC4R* variants and BMI and body weight loci strengthened during childhood and adolescence, peaked at 20 years of age, and then weakened into adulthood.[71] In larger studies, the *FTO* variant has a surprising inverse association with infancy BMI: It confers an earlier adiposity rebound in early childhood and subsequent higher childhood BMI,[72] but then it appears to have no further positive effect on weight gain during adult life.[73] In combination, the obesity variants in genome-wide association studies appear to have little influence on birth weight but promote more rapid weight gain and growth from even the earliest weeks of postnatal life and prevent against risks of underweight and failure to thrive, which may point to a potential evolutionary advantage of genetic obesity susceptibility.[74] These findings of the childhood timing of action of genetic mutations and common variants are supported by the observation that the heritability of BMI changes with age, increasing with age in childhood and decreasing with age in adults, and in general is higher in children than in adults.[75]

With regard to its mechanism of action, the obesity susceptibility variant at *FTO* has been associated with increased dietary energy intake in children[76] and associated traits such as lower levels of satiety[77] and a greater intake of dietary fat.[78] However, there is some discordance with the results of animal models that a highlight a role of *FTO* in the regulation of energy expenditure.[79] Although one of the goals of using further genomic approaches is to explain substantially more of the heritability of BMI, the current findings are already helping to direct new avenues of research into the biological regulation of body weight.[79]

Prevention

In 2010, Michelle Obama launched the "Let's Move" childhood obesity prevention campaign in the United States with the aim to "solve the childhood obesity problem within a generation." In 2009, the UK government set a target to reduce the proportion of overweight and obese children to 2000 levels by 2020.[80] Such ambitious targets require health and education policies that are based on well-evidenced intervention components.

Interventions in School-Aged Children

Schools have been a popular setting for obesity intervention because they offer continuous and intensive contact with children. School infrastructure and physical environment, policies, curricula, and staff all have the potential to positively influence knowledge and lifestyle. A recent systematic review found strong evidence for beneficial effects of childhood obesity prevention programs based on 27 946 children and adolescents in 37 studies.[81] A large majority of the identified studies were based in school settings among children 6 to 12 years of age, and these appeared to be more effective in reducing BMI (mean change in BMI *Z* score, −0.17; 95% confidence interval, −0.25 to −0.09) than studies that took place in noneducational or mixed settings (−0.07; 95% confidence interval, −0.24 to 0.10). The most promising school-based intervention strategies were inclusion of teaching about healthy eating, physical activity, and body image within the school curriculum; more school-based sessions on physical activity and movement skills; better nutritional quality of food at schools; and better support for teachers and staff to implement health promotion. However, the studies usually used complex interventions, and there was wide heterogeneity in the results, which made it very difficult to identify the most effective intervention components but suggests that combined diet and physical activity school-based interventions may help prevent children from becoming overweight, and there was no evidence of any adverse effects.[81]

Only a few studies have tested obesity prevention strategies in older (13 to 18 years of age) school-aged children, and together they provide only weak evidence for effectiveness as assessed by a reduction in BMI (mean change in BMI *Z* score, −0.09; 95% confidence interval, −0.20 to

0.03).[81] Furthermore, at this age, children are potentially more sensitive to issues related to body image such as stigmatization, low self-esteem, and unhealthy dieting patterns, and none of the studies explicitly reported on the potential harms of intervention.[81]

Interventions in Infants and Preschool Children

There have been far fewer intervention studies in preschool-aged compared with school-aged children, although the limited evidence suggests that larger treatment effects may be achieved in this age group.[81] In particular, very early intervention during infancy could present a "window of opportunity" for obesity prevention because it is a period of developmental plasticity, rapid weight gain, and habit formation. Interventions in early life could potentially influence feeding patterns before they have been established and become more difficult to modify.[82]

Long-term follow-ups of earlier randomized, controlled trials in preterm and small-for-gestational-age infants have reported that standard versus nutrient-enriched formula milks prevent faster infancy weight gain and lead to lower adiposity and cardiovascular risk factors in adolescence.[83,84] The Special Turku Coronary Risk Factor Intervention Project (STRIP) trial showed that reduced saturated fat intake beginning at 7 months of age had beneficial effects on serum cholesterol levels and lowered blood pressure during adolescence, although in that study the active intervention was continued well beyond infancy and preschool age.[85]

Other trials of childhood obesity prevention during infancy are in progress. Two randomized, controlled trials are testing modified compositions of formula milk, and 8 are testing behavioral interventions to promote breastfeeding, longer sleep duration, physical activity, or healthy eating. For example, the multicenter European Childhood Obesity Project (ERNEST) randomized 1000 infants to high- or low-protein formula milks. Infants on the low-protein formula had lower weight gain, similar to the reference breastfed group.[86] The US Sleeping and Intake Methods Taught to Infants and Mothers Early in life (SLIMTIME) pilot trial taught parents soothing strategies to reduce feeding for "non–hunger-related fussiness," to prolong sleep duration, to delay introduction of solid food, and to increase the acceptance of healthy foods through repeated exposure and has reported promising results.[87]

In the slightly older preschool-aged group, recent systematic reviews[88,89] found an absence of effective interventions to prevent obesity. The first review[88] included only 3 studies that reported BMI as an outcome; the second review included 23 studies that reported BMI, diet, or physical activity as an outcome.[89] It is interesting to note that the second review found that parental involvement was important, that parents were receptive to intervention programs and in some cases made positive changes to diet and physical activity in young children.

Treatment

The US Preventive Services Task Force recently positively reviewed the evidence for lifestyle interventions in obese children.[90] In 13 trials comprising 1258 overweight or obese children and adolescents, they found adequate evidence for short-term (up to 12 months) improvements in BMI from moderate- to high-intensity (but not low intensity) comprehensive interventions that included dietary, physical activity, and behavioral counseling components in obese children and adolescents ≥6 years of age with only small risks of harm. It is notable that no studies were identified that targeted those <4 years of age. On the basis of these findings and the adequacy of BMI as an acceptable measure for identifying children and adolescents with excess weight, the US Preventive Services Task Force was bold enough to recommend routine screening for obesity in children >6 years of age.[90] The harms of screening were judged to be minimal; therefore, the net benefit of screening was judged to be at least moderate. However, how widely these recommendations are taken up will also depend on much-needed health economics analyses to demonstrate the cost-effectiveness of such strategies.

The disappointing side-effect profiles and withdrawal of appetite suppressant medications such as fluoxetine, rimonabant and sibutramine,[91] have left limited pharmacological options for weight management in obese adults, let alone in obese children in whom the longer treatment durations needed to avoid disease end points may lead to less favorable risk-to-benefit calculations. Orlistat, a gastric and pancreatic lipase inhibitor, modestly reduces BMI (by ≈ -0.24 Z scores) in children and adolescents but has an unacceptably high prevalence of gastrointestinal adverse effects, leading to frequent premature discontinuation in the absence of adequate dietetic support.[92]

Finally, there is limited evidence that the insulin-sensitizing agent metformin has moderate efficacy in obese in children, reducing BMI by on average 1.42 kg/m^2.[93] In small randomized trials of girls presenting with precocious pubarche and history of low birth weight, who tend to have high central adiposity and insulin resistance, low-dose metformin during the peripubertal years has been reported to have remarkable benefits both on reducing short-term symptoms of oligomenorrhoea and hirsutism and on long-term increases in lean body mass and height and reductions in adiposity and other markers of metabolic disease.[94] Similar trials of metformin in other groups of insulin-resistant children are warranted to confirm these potential reprogramming effects of insulin sensitization therapy during puberty.

Conclusions

The promising signs that the rates of increase in obesity in children and adolescents are starting to slow have been attributed to wider awareness of its adverse health effects.[26,95] However, turning the corner from plateau to steady decline in obesity rates will require informed and decisive actions, which, considering the complex causes and contributing factors of childhood obesity,[26] will need to involve multicomponent and multisector policy interventions. Increasing the understanding of the early developmental origins of obesity has led to a growing interest in the development and trials of interventions starting in early life, which have the potential for larger and longer-lasting benefits.

Disclosures

None.

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