Health implications of overweight and obesity in children and adolescents

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Overweight and obesity has been associated with a wide range of health and psychosocial problems that impact negatively on quality and length of life. The exact relationship between obesity and premature mortality is controversial but there are strong and clear associations between increasing weight and risk of most major chronic diseases. Obesity is now the most common chronic disorder of childhood, and may adversely affect a child's health with immediate medical and psychosocial consequences. However the more significant risk in children and adolescents who are obese is the tendency for obesity to persist in adulthood leading to greater potential for the early development of chronic disease and reduced life expectancy.

The validity of adverse health implications in relation to excessive body fat in childhood and adolescence has come into question in recent years, with warnings that exaggeration of risk may lead to potential increases in eating disorders or body image problems [1, 2]. However, a substantial body of research exists demonstrating that both overweight and obesity can have profound effects on the health of a child or adolescent [3, 4].

Childhood obesity is a multisystem disease with significant immediate and long-term medical and psychosocial complications, which were previously associated with onset in adulthood. Ethnic origin, cultural background, genetic susceptibility, environmental factors and socioeconomic status contribute to the risk of developing obesity-related complications. Furthermore, childhood overweight and obesity tracks into adolescence and adulthood. A recent systematic review found that persistence of overweight and obesity was greater with increasing weight status and age [5]. For overweight children (under 12 years of age), the risk of becoming an overweight adult ranged from two- to tenfold compared with normal weight children. For obese children the relative risk for becoming an obese adult was in the higher range. Similarly, for overweight/obese adolescents (aged 12 to 18 years), the risks of becoming overweight/obese as an adult was higher than in younger children, with between 24%–90% of overweight adolescents becoming overweight/obese adults. Risk of

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Persistence of obesity is also greater if at least one parent of the child or adolescent is obese [6]. Obesity early on in life is a predictor of later morbidity and mortality [6]. Given that obesity during adolescence increases the risk for chronic disease and premature death in adulthood, independently of adult obesity, forecasts of potential decline in life expectancy of current and future generations are perturbing and plausible [7, 8].

The following gives an overview of clinically important medical and psychosocial complications associated with childhood and adolescent overweight and obesity. Table 1 provides a summary of these complications.

Table 1. Potential obesity-associated complications among children and adolescents

<table>
<thead>
<tr>
<th>System</th>
<th>Health problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychosocial</td>
<td>Social isolation and discrimination, decreased self-esteem, learning difficulties, body image disorder, bulimia</td>
</tr>
<tr>
<td></td>
<td>Medium and long term: poorer social and economic 'success', bulimia</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Obstructive sleep apnoea, asthma, poor exercise tolerance</td>
</tr>
<tr>
<td>Orthopaedic</td>
<td>Back pain, slipped femoral capital epiphyses, tibia vara, ankle sprains, flat feet</td>
</tr>
<tr>
<td>Hepatobiliary</td>
<td>Non-alcoholic fatty liver disease, gallstones, gastro-oesophageal reflux</td>
</tr>
<tr>
<td>Reproductive</td>
<td>Polycystic ovary syndrome, menstrual abnormalities</td>
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<tr>
<td>Cardiovascular</td>
<td>Hypertension, adverse lipid profile (low HDL cholesterol, high triglycerides, high LDL cholesterol), raised inflammatory markers</td>
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<tr>
<td></td>
<td>Medium and long term: increased risk of hypertension and adverse lipid profile in adulthood, increased risk of coronary artery disease in adulthood, left ventricular hypertrophy</td>
</tr>
<tr>
<td>Endocrine</td>
<td>Hyperinsulinaemia, insulin resistance, impaired glucose tolerance, impaired fasting glucose, type 2 diabetes mellitus</td>
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<td></td>
<td>Medium and long term: increased risk of type 2 diabetes mellitus and metabolic syndrome in adulthood</td>
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<tr>
<td>Neurological</td>
<td>Benign intracranial hypertension</td>
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<tr>
<td>Skin</td>
<td>Acanthosis nigricans, striae, intertrigo</td>
</tr>
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Psychosocial impact

The most prevalent of obesity-related complications are related to psychosocial consequences, with risk being greater in girls compared to boys, and increasing with age [6]. Childhood obesity is highly stigmatised, with affected children being seen by other children as young as four years, as lazy, unhygienic and socially incompetent [9]. Peer-
relationship problems are more prevalent in overweight and obese children, adolescents and even preschool-aged children [10]. Low self-esteem, anxiety and depression, and social isolation are more common in overweight and obese children and adolescents who may also suffer high levels of teasing and bullying [9]. Weight-based teasing may further contribute to negative psychosocial behaviour, including disordered eating, depression and suicidal ideation [11]. Overweight school-aged children are more likely to be bullied than normal-weight peers with obese children even more so [12, 13]. Bullying may take the form of physical aggression (overt bully) or what is termed relational bullying (eg withdrawing friendship or spreading lies). Bullying reportedly reduces throughout adolescence but whether this also occurs in relation to overweight/obesity is undetermined, though Janssen and colleagues report an association between weight status and peer victimisation in 11 to 14 year olds but not in 15 to 16 year olds [13]. Differentiation in relation to bullying, gender and weight is also unclear. There is a suggestion however that overweight/obese boys tend to suffer overt bullying whereas overweight/obese girls are victims of relational bullying [14]. Furthermore, presumably because of increased size in relation to peers thus enabling physical dominance, obese boys are more likely to be overt bullies [12].

Overweight and obese children tend to have reduced athletic ability, potentially leading to exclusion from physical activities and contributing to a vicious cycle of reduced opportunity to improve gross motor skills, further exclusion and inactivity [15]. Similarly, weight status may have a negative influence on academic achievement. Poorer school performance may result from a combination of factors. An increase in absenteeism has been noted in overweight and obese children compared with normal-weight peers, and reduced school attendance is associated with negative academic outcomes [16]. Absenteeism may be as a result of obesity-related ill-health or from school avoidance, which may be secondary to victimisation. Furthermore, difficulties with concentration secondary to sleep deprivation from obstructive sleep apnoea (see below) may also contribute to poor academic performance.

Many obese children have good self-esteem with few or no psychological issues. However, a systematic review of cross-sectional, longitudinal and intervention studies found strong evidence of a negative impact on global self-esteem and quality of life in obese children and adolescents compared with healthy-weight peers, with no clear differences in age groups [17]. Moreover, in the severely obese treatment-seeking child, the psychosocial impact of obesity can be profound, with studies indicating a significant reduction in health-related quality of life, with impairment equating to that of a child diagnosed with cancer [15, 17]. In addition, the psychosocial problems may persist into adulthood, particularly for obese adolescent girls. Longitudinal data indicate young obese women are less likely to marry, have fewer years of higher education, and have higher rates of poverty with lower levels of income compared with normal weight peers [18].

Obstructive sleep apnoea (OSA)

Obesity is a major risk factor for sleep-disordered breathing, particularly obstructive sleep apnoea (OSA), a condition characterised by recurrent prolonged episodes of partial and/
or complete upper-airway obstruction resulting in disruption of normal breathing and sleep patterns. The prevalence of OSA in the normal paediatric population is around 2%; however in children and adolescents with obesity the prevalence is significantly higher, ranging from 13% to 59%, depending on diagnostic criteria, age, ethnicity and pubertal status [19, 20]. For every 1 kg/m² increment in body mass index beyond the mean for age and sex, the risk of OSA appears to increase by 12% [21]. The underlying mechanisms for this increased risk are unknown. It is not simply related to enlargement (hypertrophy) of the tonsils, as, even after adeno-tonsillectomy (first line treatment in OSA in children and adolescents), residual OSA persists in around 50% of obese children compared with only 10%–20% of non-obese children [22].

Untreated OSA is associated with attention and behavioural problems (found in up to 58% of obese children, compared with 10% of the general paediatric population [23]), cognitive impairment and poor school performance, in part as a result of disturbed sleep and even recurrent low level hypoxia. Furthermore, OSA has been associated with cardio-metabolic complications, such as hypertension, ventricular hypertrophy, insulin resistance and abnormal blood lipid profile. The common pathway appears to be induction of chronic inflammation, the process beginning in childhood and persisting into adulthood, particularly if the OSA is left untreated [24].

**Insulin resistance and type 2 diabetes mellitus**

Childhood obesity is associated with a number of metabolic complications, including insulin resistance (IR), a pre-diabetic state. The presence of insulin resistance increases the risk of developing type 2 diabetes mellitus and cardiovascular disease, and also appears to predict future cardiovascular risk [25]. The prevalence of insulin resistance is difficult to ascertain as there is no single simple reliable marker to determine a universal cut-point. Furthermore ethnicity and age (in particular pubertal status) influence insulin levels. However, studies using a simple blood marker of insulin resistance (homeostasis model of insulin resistance) have found a prevalence of IR ranging from 45%–80% in obese children, 10%–60% in overweight children and 2%–20% in normal-weight children [26]. Similarly, in the 2004 New South Wales Schools Physical Activity and Nutrition Study, in which fasting blood from randomly sampled 15-year-old school students was analysed, raised levels of fasting insulin (another marker of insulin resistance) were found in 68%, 30% and 7%, of obese, overweight and healthy-weight boys respectively, and in 44%, 42% and 11% of obese, overweight and healthy-weight girls respectively [27]. Increasing body mass index and deep abdominal fat are associated with increasing insulin resistance and there is a degree of heritability with an increased risk of developing insulin resistance in those with a strong family history of type 2 diabetes.

The number of cases of type 2 diabetes has been increasing in the paediatric population over the past couple of decades in parallel with the rise in paediatric obesity. The overall prevalence of children and adolescents with type 2 diabetes is 1%–4%, with rates being much higher in certain racial and ethnic groups, including Native American, African American, Hispanic, Indian sub-continent and Indigenous Australian populations, and
lower in northern European countries [28]. Type 2 diabetes in childhood can present with life-threatening ketoacidosis (around 10% of cases) or hyperglycaemic hyperosmolar non-ketotic syndrome (3.7% of cases) [29, 30]. The consequences of type 2 diabetes in young people may be more marked than in adults. Disease progression is normally related to decline in beta-cell function and altered insulin sensitivity. The decline in glycaemic control following initial diagnosis of type 2 diabetes tends to occur over a period of ten to 12 years in adults, but appears to evolve more rapidly in children, within two to four years of diagnosis, with those presenting in diabetic ketoacidosis manifesting greater and more rapid decline [31]. In addition, cardiovascular fitness is significantly impaired in comparison with obese youth who do not have type 2 diabetes.

Hypertension, cardiovascular disease and the metabolic syndrome

Obesity in childhood, and especially adolescence, is associated with the development of cardiovascular abnormalities, including atherosclerotic changes in the aorta and cardiac vasculature, and decreased arterial distensibility. Furthermore, obese children are more likely to develop such changes at an earlier age than normal-weight children [32, 33]. Both left ventricular hypertrophy and arterial hypertension are significantly more prevalent in obese children and adolescents, with the prevalence of hypertension increasing progressively with body mass index. Adolescents with obesity are three times more likely to be hypertensive than those in lower weight ranges [34, 35]. Arterial hypertension is a highly prevalent cardiovascular risk factor in young obese individuals and is predictive of sustained hypertension and end-organ damage in early adulthood [36]. In the previously mentioned 2004 NSW Schools Physical Activity and Nutrition Survey, high blood pressure was found in 37%, 36% and 14% of obese, overweight and healthy-weight boys, respectively, and in 22%, 7% and 5% of obese, overweight and healthy-weight girls, respectively [27].

The clustering of cardiovascular risk factors (insulin resistance, hypertension, abdominal obesity and dyslipidaemia – also termed the metabolic syndrome) are predictors of adult cardiovascular disease. Clustering of two or more cardiovascular risk factors is more prevalent in obese children and adolescents, and, depending on the definition used, 1.2%-22.6% of children and adolescents have the metabolic syndrome, with rates ranging from 30% up to 60% observed in those who are overweight or obese [36–38]. Moreover, mid-childhood obesity is associated with a sevenfold increased chance of developing cardiovascular disease risk factors in adolescence [39].

Dyslipidaemia

Dyslipidaemia, most commonly raised serum concentrations of low-density lipoprotein (LDL) cholesterol and triglycerides and reduced concentrations of high-density lipoprotein (HDL) cholesterol, occurs in overweight and obese children and adolescents, particularly those who have abdominal obesity. Up to 50% of obese adolescents may have some degree of dyslipidaemia [40, 41].
Paediatric obesity is associated with a spectrum of liver abnormalities known as non-alcoholic fatty liver disease (NAFLD). The disease ranges from simple fatty infiltration of the liver (hepatic steatosis), to fatty liver with inflammation and fibrosis (non-alcoholic steatohepatitis). NAFLD is the most common paediatric liver abnormality, related to the increasing childhood obesity epidemic and is associated with the metabolic syndrome (central obesity, hypertension, dyslipidemia and insulin resistance). The true prevalence and severity of NAFLD is unknown because of problems with standardisation of disease definition, diagnostic modalities and variations by ethnicity. However, prevalence ranges from 3%–77% in obese children and adolescents have been quoted [42]. Additionally, the natural history of paediatric NAFLD is not established as long-term studies are lacking. Current evidence suggests that a minority of adolescents with NAFLD develop progressive liver disease, leading to liver failure or transplantation, and this is most likely in patients with advanced fibrosis at baseline [43].

Musculoskeletal complications

There is increased awareness that child and adolescent obesity may not only lead to major orthopaedic complications, such as slipped capital femoral epiphyses (where the developing head of the femur shifts backwards resulting in a weakened hip joint) and tibia vara (Blount disease, progressive bowing of the legs), but also a number of other issues involving the whole of the musculoskeletal system. Compared with normal-weight peers, obese children and adolescents have a higher incidence of musculoskeletal pain (eg back pain, lower limb pain especially knees and feet), and genu valgum (knocked knees), greater hinderance to lower limb functioning and gait, and increased risk of fractures (as obese children generally have reduced bone mass after adjusting for size and often vitamin D deficiency as well) [44]. Slipped capital femoral epiphyses, a debilitating condition of the hip joint requiring surgical intervention, is significantly associated with obesity: up to 80% of cases of slipped capital femoral epiphyses are associated with obesity. Unfortunately, weight loss does not resolve the condition, although it helps alleviate the severity and potential for developing bilateral disease. Likewise Blunts disease is strongly associated with increased weight whereby weight loss alleviates but does not resolve the condition [44].

Polycystic ovary syndrome

Obese adolescent girls are at risk of polycystic ovary syndrome (PCOS), a syndrome of elevated androgen levels and ovulatory dysfunction. The prevalence appears to be increasing. It is associated with obesity, insulin resistance, and other elements of the metabolic syndrome. It should be suspected in girls, with hirsutism or severe acne and/or menstrual irregularity, especially if they have obesity and insulin resistance [45]. There is mounting evidence that females with PCOS are at increased long-term risk of endometrial cancer (if PCOS is untreated), cardiovascular and metabolic complications later in adulthood. PCOS is also the most common cause for infertility.
Idiopathic intracranial hypertension

Idiopathic intracranial hypertension (also known as pseudotumour cerebri), is more prevalent in obese children and adolescents, although more so in obese adolescents rather than younger children [46]. It is a rare condition which can cause severe visual impairment or blindness and presents with headaches and a range of potential symptoms.

Skin problems

Obesity is associated with a number of skin manifestations, including acanthosis nigricans, in association with insulin resistance. Acanthosis nigricans appears as hyperpigmented, velvety-thickened skin most often seen on the neck, in the axillae, groin, knuckles or knees. It may be mistaken for a dirty neck and may be a cause of embarrassment in more marked cases. Treatment of the insulin resistance, either by weight loss or pharmacologically, results in reduction or resolution of the manifestation. Other skin complications associated with obesity include striae (stretch marks) and a tendency for fungal infections (intertrigo) in areas where moisture is trapped, such as in skin folds.

Other medical complications

The above list of obesity-associated complications is not exhaustive. Additional complications such as gastro-oesophageal reflux disease, constipation, daytime wetting and nocturnal enuresis (bedwetting), nutritional deficiencies, gallstone formation and bulimia are all problems that are either exacerbated by the association of obesity or have an increased prevalence in overweight and obese children and adolescents. Moreover, seemingly less major difficulties, such as an inability to attend to personal hygiene or reach to tie one’s shoelaces, can result from being obese and have a major impact on quality of life.

Conclusion

Childhood and adolescent obesity is a multifactorial, multisystem disease, the prevalence of which has been rising exponentially in recent decades. A considerable body of evidence exists highlighting the significant adverse health-related impacts of childhood and adolescent obesity. Recognised obesity-related complications range from psychosocial issues, these being the most prevalent, to medical ailments such as insulin resistance, hypertension and non-alcoholic fatty liver disease. Importantly, the adverse effects may not only have immediate implications but also can affect health in the longer term, independent of adult obesity. As childhood obesity tends to persist into adulthood, the risk of obesity-related morbidity and mortality is further increased. However, a reduction in total body fat has the potential to alleviate or resolve the adverse health outcomes, thus appropriate assessment and management of such children and adolescents is warranted.
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References


