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Metabolic Dysfunction Associated with Paediatric Obesity

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ABSTRACT

Paediatric obesity has become a major issue of global concern in the area of public health, with multifactorial interactions between genetic, environmental, and behavioural factors. Caloric overeating, inappropriate diet, sedentary lifestyles, and disturbance in the metabolism of the body are the main contributors to excessive adiposity among children and adolescents. Metabolic complications, which result, namely, insulin resistance, dyslipidaemia, hypertension, NAFLD, and premature onset of metabolic syndrome, substantially increase the likelihood of cardiometabolic disease throughout life. Management requires a multidisciplinary strategy that incorporates nutritional counselling, encouragement of physical activity, behavioural change, and family interventions. Poor diet and lack of physical activity have central roles in the development of diseases too. Sustained behavioural support, culturally sensitive interventions, and stringent policy evaluation should be of priority in future studies to reflect the establishment of effective public health interventions.

Keywords: Obesity, Children, Metabolic disease, diabetes

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Introduction

Paediatric obesity has become a leading health concern of the twenty-first century, and its incidence is increasing at an alarming rate both in the developed world and the developing world. Once considered mainly an adult issue, obesity and the metabolic consequences that accompany it are today being diagnosed more often in early childhood and adolescence, an indication of a dramatic change in disease prevalence and health impact on the community. This tendency is the expression of a multifaceted interplay of biological, behavioural, and environmental determinants, including the overconsumption of calories, poor diet quality, sedentary lifestyle, and the influence of sociocultural factors that determine health behaviours at a young age [1][8]. Children are therefore being exposed to insulin resistance (IR), dyslipidaemia, hypertension, and non-alcoholic fatty liver disease (NAFLD) at an earlier age, significantly increasing the risk of metabolic disorders [2]. The nutritional environment in which children grow has dramatically changed. Eating patterns that are typified by excessive intake of ultra-processed meals, high concentrations of sugar-sweetened beverages, and calorie-dense snacks, in contrast to increased dietary intake of fruits, vegetables, and whole grains, make a significant contribution to the excessive weight gain and metabolic disturbances [21][22]. Alongside all these eating difficulties is a sharp drop in physical activity, which is driven by the culture of inactivity, the use of digital screens, urbanisation, and limited access to safe recreational areas. Taken together, these lifestyle patterns negatively affect metabolic flexibility, interrupt glucose and lipid homeostasis, and predetermine early dysfunction of metabolism in children [3]. Although behavioural interventions are essential, they usually have a small effect when used alone, and the degree of effectiveness differs according to the socioeconomic and cultural backgrounds. Similarly, policy-oriented solutions like school nutrition policies, food advertising policies, and taxes on unhealthy foods have promise, but require more effective evaluation systems and longitudinal studies to determine the actual effect on paediatric metabolic health [14]. To fill these gaps, it is necessary to work out holistic evidence-based strategies to enhance nutrition, decrease the risk of obesity, and maintain a healthier metabolic process during childhood and adolescence [4][20].

Causes of childhood obesity

Genetics, environment, nutrition, physical inactivity, and socioeconomic status all contribute to childhood obesity [5]. Not getting enough sleep is a risk factor for childhood obesity and is becoming more common among kids [6]. Dietary behaviours contribute to childhood obesity as well. Excessive saturated fatty acids and trans-fat consumption and insufficient mono-unsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) can cause weight gain, lipid metabolism, and cardiometabolic health issues [23]. Screen time and inactivity are major risk factors for childhood obesity and metabolic disease [7].

Metabolic Complications of Obesity in Children

Diabetes Mellitus

In recent decades, type 2 diabetes has become more common in children and adolescents globally. The major pathophysiology here is IR, poor glucose tolerance, and hyperinsulinemia [24]. A high fasting glucose or a poor oral glucose tolerance test (OGTT) suggests prediabetes. Obese children are four times more likely to acquire T2DM [9].

Dyslipidaemia

Approximately 8-20% of children in the general population have dyslipidaemia, whereas abnormal lipid readings in obese children can reach over 40%. Lipid problems are 2.8 times more likely in children with BMI > 90th percentile than in those with normal body weight. High FFA levels block insulin signalling, reducing glucose transport into muscle and causing IR [10].

Hypertension

Obesity is the leading cause of hypertension in children. Excessive leptin secretion from adipose tissue promotes systemic vasoconstriction, salt retention, nitric oxide production, and sympathetic nervous system activation, which raises blood pressure [11].

Non-alcoholic fatty liver disease

Abdominal obesity, insulin resistance and hypertension are characteristic symptoms of children with NAFLD, defined by hepatic steatosis. Cardiovascular disease (CVD), polycystic ovary syndrome (PCOS), and osteopenia are common in NAFLD children. Children and adolescents who gain weight are more likely to develop NAFLD and end-stage liver disease [13]. Therefore, we must investigate NAFLD in youngsters because it can have serious consequences. Weight control may help with this illness. Low-carb and low-glycaemic index diets may improve hepatic steatosis and fibrosis.

Metabolic Syndrome

Metabolic syndrome is defined as a mix of cardio-metabolic risk factors that are known to put a person at risk for both T2DM and CVD. It is thought that IR and/or central obesity start a variety of harmful pathways that raise metabolic risk and lead to the syndrome's full manifestation. Given the rising incidence of childhood metabolic syndrome, it is anticipated that both metabolic syndrome and cardio-metabolic abnormalities will become increasingly common in young people. However, there are still no clear guidelines regarding how to diagnose metabolic syndrome in young people, making it challenging to identify individuals who are impacted [12].

Cardiovascular Diseases

Higher BMI in adolescence is connected with the development of cardiomyopathy in adulthood and an up to 8-fold increase in the risk of dilated cardiomyopathy if BMI ≥ 35 kg/m2. Lipid metabolism, oxidative stress, and inflammation can promote cardiac fibrosis and systolic and diastolic dysfunction [15].

Polycystic Ovary Syndrome

Girls with obesity are more likely to develop PCOS. Most young adult females have PCOS, the primary cause of non-ovulatory infertility. Adolescent girls with PCOS are diagnosed by menstrual abnormalities and clinical or biochemical hyperandrogenism. Diagnostic challenges arise from overlapping characteristics such as irregular cycles, acne, and polycystic ovarian morphology with physiological changes during adolescence [16].

Management

Paediatric obesity treatment reduces adiposity, improves physical and psychological difficulties, and prevents chronic diseases.

Dietary intervention

Nutritional education and mild energy restriction are possible dietary therapies. Dietary education promotes local dietary guidelines, such as eating more vegetables and fruit, reducing energy-dense, nutrient-poor foods and sugary drinks, and making mealtime routines and family meals more common [17].

Physical activity

The most beneficial exercise treatments last 60 minutes or more, at least three days a week, for 12 weeks. Schools encourage physical exercise and reduce obesity risk in children and teens. School-based physical activity-only programs improved BMI, waist circumference in females, skin-fold thickness, and body fat [18].

Screen time and sedentary behaviours

A complete behavioural change approach must address sedentary behaviours like screen time, not just physical activity. Strong parental involvement, structural adjustments in the home environment (e.g., removing or replacing home or bedroom electronic game access), and e-monitoring of digital device time reduce screen time in the short term [19]. In young children, these therapies work better.

Behavioural support strategies

Setting goals, controlling the environment, and self-monitoring are common behaviour modification methods. Motivational interviewing techniques, such as reflective listening and collaborative decision making to motivate behaviour change, are considered good strategies in this evolving era of digitalization and artificial intelligence [27].

Conclusion

Paediatric obesity and related metabolic consequences are on the rise, propelled by poor food habits, lack of physical activity, and environmental factors. Despite the potential of behavioural interventions and legislative measures, their long-term efficacy and equitable execution are still constrained. An integrated strategy that combines enhanced nutrition, family-oriented assistance, and rigorously assessed public health policies is crucial for mitigating obesity risk and enhancing metabolic health outcomes in children.

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