Perspective

Childhood obesity and type 2 diabetes in India

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ABSTRACT

India is witnessing an increase in the burden of childhood obesity, especially among the upper socioeconomic strata and in urban areas. Emerging literature suggests a link between childhood obesity and the diabetes epidemic in India. Asian-Indian children and adolescents are increasingly susceptible to a high percentage of body fat and abdominal adiposity. Further, they are exposed to an obesogenic environment, created by rapid urbanization and nutrition transition in India. Obese children have a higher risk of developing abnormalities that are recognized as precursors to diabetes, such as subclinical inflammation, insulin resistance and metabolic syndrome, which often track to adulthood. A review of the literature suggests the need for more longitudinal studies to improve understanding of the long-term consequences of childhood obesity in India. A life-course approach with a combination of population- and risk-based strategies is warranted, to prevent childhood obesity and curtail its consequences in adulthood.

Key words: childhood obesity, diabetes, insulin resistance, metabolic syndrome, tracking

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BACKGROUND

The global tsunami of noncommunicable diseases (NCDs) has swept across all age groups, including children and adolescents. However, the young age group affected by NCDs is often underrecognized. NCDs are responsible for approximately 1.2 million deaths worldwide each year in the age group below 20 years.[1] Children and adolescents are affected by a wide range of NCDs, such as cancer, diabetes (both type 1 and type 2), chronic respiratory diseases, congenital heart diseases, etc. Most of the behavioural risk factors for NCDs (tobacco use, unhealthy diet, lack of physical activity, etc.) start during childhood and often lead to intermediate risk factors such as obesity, hypertension and dyslipidaemia early in life, even in childhood and adolescence.

The growing body of literature on the developmental origin of chronic disease suggest a life-course approach for tackling risk factors.[2] Childhood obesity is one of the prominent risk factors with serious health implications across the lifespan. Obese children and adolescents are more likely to be obese as adults. Further, they are at a higher risk for developing chronic diseases, such as cardiovascular diseases, diabetes, musculoskeletal disorders and cancers, at a younger age.[3] Studies from high-income countries have demonstrated that childhood obesity is also associated with premature mortality and disability in adulthood.[4] However, such data from low- and middle-income countries are scarce.

Many studies have shown a strong relationship between fetal undernutrition, early-life exposure to obesity and type 2 diabetes.[2] This is particularly relevant for countries in the World Health Organization (WHO) South-East Asia Region, including India, where there is a double burden of childhood under- and overnutrition.[5] The coexistence of severe malnutrition and childhood obesity could have a pivotal role in the exponential increase in prevalence of diabetes among Indians. Further, body composition and fat distribution, which are influenced by both genetic and environmental factors, may contribute to the pathophysiology of diabetes in the Indian context. This review aims to summarize the available literature from India on the burden and consequences of childhood obesity and its link with type 2 diabetes in children and adults.

THE GLOBAL BURDEN OF CHILDHOOD OBESITY

Globally, the prevalence of overweight and obesity among children and adolescents increased by 47.1% between 1980 and 2013.[6] Such a rapid increase led to a high burden of overweight and obesity (23.8% of boys and 22.6% of girls) in high-income countries in 2013. Low- and middle-income countries also experienced a substantial increase, with a rise from 8% in 1980 to 13% in 2013, with no difference between the sexes.[6] Low- and middle-income countries, including those in South-East Asia, had the highest increase in prevalence of childhood obesity in the past two decades.

THE BURDEN OF CHILDHOOD OBESITY IN INDIA

With a rapid demographic and socioeconomic transition, India is becoming the epicentre of epidemics of both adult and childhood obesity, especially in urban populations. Although the age-standardized rates are low, in absolute terms India is the country with the third-highest level of obesity in the world. Over the years, epidemiological studies have reported a consistent increase in the prevalence of childhood overweight and obesity in the subcontinent. A systematic analysis conducted as part of the Global Burden of Disease study 2013 reported that 5.3% of males and 5.2% of females aged under 20 years in India were overweight. The overall prevalence of obesity among males and females in the above age category was 2.3% and 2.5% respectively.[6]

The rates of childhood obesity vary significantly across India. Studies suggest a definite socioeconomic gradient in the burden of childhood obesity in the country, with higher prevalence in urban areas and in the upper economic strata. A cross-sectional study of schoolchildren from north India aged 5–18 years estimated a significant difference in the prevalence of childhood obesity between lower and upper socioeconomic strata.[7] However, recent studies from the rural population predict a higher prevalence in lower socioeconomic strata in the near future.

BODY FAT COMPOSITION IN INDIAN CHILDREN AND ADOLESCENTS

For any given body mass index (BMI), adults in South-East Asia tend to have high body fat, particularly abdominal fat, compared to other ethnic groups.[8] This typical body fat composition increases the risk of insulin resistance at a lower BMI compared to other ethnic groups. A similar difference in body composition has been seen in Asian-Indian children living in Europe and the United States of America (USA). Despite small abdominal viscera and low muscle mass, Indian neonates preserve body fat during their intrauterine development and are relatively obese at birth compared to Caucasians.[9] Studies showed that this "thin–fat phenotype" persists in postnatal life and results in a significant difference in the body fat content of Indian children compared to other ethnic groups.[10,11]

Very few studies from India have reported the body fat composition of children and adolescents. A study from north India, which compared the percentage body fat of Indian children aged 7–17 years with data from NHANES (National Health and Nutrition Examination Survey – USA) and the New York Pediatric Rosetta Study, found that Indian children accumulate more body fat during the peripubertal years in comparison with US children.[12] Those in the highest percentile of BMI have a higher percentage body fat than their American counterparts. However, thinner children are likely to have a lower percentage body fat than their age- and sex-matched counterparts. Comparison of two cross-sectional studies from India and Germany also reported similar findings.[13] Despite the emerging evidence of high body fat among Indian children and adolescents, its prenatal and postnatal determinants are not well studied.

BODY FAT DISTRIBUTION IN INDIAN CHILDREN AND ADOLESCENTS

The pathogenesis of diabetes is influenced not only by the quantity of fat stored but also by its location. Excessive visceral fat, as indicated by abdominal obesity, is one of the strong predictors of insulin resistance, subclinical inflammation and diabetes in Asian-Indian adults.[14] It is now evident that children and adolescents of Indian origin are also susceptible to abdominal obesity. A study of migrant populations in the United Kingdom of Great Britain and Northern Ireland (UK) concluded that Indian children tend to deposit more fat on the trunk and less on the upper limbs compared with their Caucasian counterparts[15] Epidemiological studies showed a substantial burden of abdominal obesity among children in India. In 2011, a large multi-city study reported that 4.5% of urban children in India aged 8–18 years were centrally obese.[16] The prevalence ranged from 2.1% in Agra to 9.1% in metropolitan Delhi. Based on these data, the authors projected that 3.16 million urban boys and 5.39 million urban girls in India would have abdominal obesity.

CHILDHOOD OBESITY AND THE PATHOGENESIS OF DIABETES: EVIDENCE FROM INDIA

Subclinical inflammation

Inflammation is a key component of the link between obesity and diabetes. Longitudinal studies have established that obesity-associated chronic low-grade inflammation precedes and predicts diabetes.[17] In obese children and adolescents, C-reactive protein (CRP) was the most consistent and the strongest association observed with inflammatory markers.[17] Low levels of adiponectin, which are associated with insulin resistance and inflammation, have also have been observed in children and adolescents with obesity. A multi-ethnic study conducted in the UK showed 104% higher CRP levels in south Asian children as compared with their Caucasian counterparts.[18] A study of healthy adolescents and young adults aged 14–25 years from north India observed elevated levels of CRP among 21.8% of overweight subjects and 24.5% of subjects with a high percentage of body fat. Similar results were reported from studies in other parts of the country.[19] It is clear from the review that more longitudinal studies are required to improve understanding of the long-term health risk of chronic low-grade inflammation among obese Indian children.

Insulin resistance

Childhood obesity is strongly associated with insulin resistance, which is considered as a forerunner of type 2 diabetes. Asian-Indian individuals are susceptible to insulin resistance from their early infancy.[20-] Further, insulin resistance syndrome has been reported in children as young as 8 years in India.[21] A study on post-pubertal children in India reported a high prevalence of insulin resistance among children with adverse truncal body fat patterning, abdominal adiposity and excess body fat.[22] A study conducted among adolescents aged

14–19 years reported that 64% of the obese adolescents in India had fasting hyperinsulinaemia, a surrogate marker of insulin resistance.[23] Another study conducted by the current authors' group on Indian adolescents aged 10–17 years found that insulin resistance, measured in terms of values from the homeostatic model assessment of beta-cell function and insulin resistance (HOMA-IR), increased progressively from normal-weight to obese adolescents in both sexes.[24] Early detection of insulin resistance among children is vital in the prevention of metabolic syndrome and diabetes.

Metabolic syndrome

Metabolic syndrome is defined as a cluster of glucose intolerance, hypertension, dyslipidaemia and central obesity, with insulin resistance as the source of pathogenesis.[25] Obese children and adolescents with insulin resistance are at increased risk of metabolic syndrome.[26] There is a paucity of information from India on metabolic syndrome among children and adolescents. Comparison between studies is difficult, as they have used different criteria for diagnosis. Using the ATP III (Adult Treatment Panel III) criteria, a study from north India estimated an overall prevalence of metabolic syndrome of 4.2% among adolescents aged 12–17 years. The prevalence was almost nine times higher among obese individuals (36.6%).[27] Recently, the authors estimated the prevalence of metabolic syndrome among Indian adolescents aged 10–18 years, using ATP III and International Diabetes Federation (IDF) criteria. The overall prevalence was 4.3% and 3.0% respectively. The prevalence was much higher among obese adolescents, at 49% (ATP III) and 46.4% (IDF).[28] Despite the high prevalence of metabolic syndrome among obese adolescents, its role in the incidence of diabetes has not been confirmed through longitudinal studies.

TRACKING OF CHILDHOOD OBESITY

In life-course epidemiology, the concept of persistence or relative stability of risk factors over time is often referred to as tracking. Current evidence from high-income countries supports the tracking of childhood obesity, as well as obesity-related behaviours, to adulthood.[29] Overweight children have at least two times higher risk of becoming overweight adults compared to normal-weight children.[29] Persistence of overweight is greater in those with a high level of obesity.[29] However, such data from low- and middle-income countries are limited. Data from the New Delhi Birth Cohort Study suggest that higher BMI and greater BMI gain in late childhood and adolescence are associated with increased adult adiposity and central adiposity.[30] A recent longitudinal study from Pune, India, found a significant positive correlation between the BMI of children at 8 and 21 years. Those in the highest quartile of BMI at 8 years had a relative risk of 2.87 of remaining in the same quartile at 21 years of age.[31] Apart from BMI, waist circumference and skinfold thickness also showed a similar pattern of tracking.[31]

Data are emerging from India on the long-term consequences of childhood obesity tracking. An analysis from the New Delhi Birth Cohort Study showed that rapid weight gain in childhood and adolescence is associated with a higher prevalence of glucose intolerance and metabolic syndrome in adulthood.[32] More longitudinal studies are needed to improve understanding of the pattern and determinants of childhood obesity tracking in India.

PREDIABETES AND TYPE 2 DIABETES AMONG CHILDREN AND ADOLESCENTS IN INDIA

Globally, there has been an increase in the burden of prediabetes among children and adolescents.[33] In a recent population-based study conducted in south India, the overall prevalence of dysglycaemia was 3.7%, which increased to 12.7% in girls with abdominal obesity.[34] In the authors' recent study, the prevalence of impaired fasting glucose and impaired glucose tolerance among obese adolescents was 6.5% and 5.5% respectively.[28]

Population-based data on type 2 diabetes among children and adolescents are unavailable from India. However migrant studies from high-income countries have demonstrated a high prevalence of type 2 diabetes among south Asian adolescents.[35] Isolated clinic-based studies from India report a consistent increase in the proportion of individuals with type 2 diabetes among adolescents. A clinic-based study from Chennai reported that 30.4% of individuals diagnosed with diabetes at a young age (<25 years) who were registered at their centre during 1992–1995 had type 2 diabetes.[36] This increased to 49.1% during 2006–2009.[36] Out of the total 5546 patients recruited (between 2000 and 2011) by the large clinical registry of youth-onset diabetes funded by the Indian Council of Medical Research, 25.3% were diagnosed as having type 2 diabetes (unpublished data). However, results from these clinic-based studies should be interpreted with caution, as they could be influenced by referral bias.

Obesity is an important determinant of type 2 diabetes among south Asian adolescents in the UK.[35] A case-control study by the present authors' research group in Delhi found significantly higher measures of generalized and regional obesity, hypertriglyceridaemia and hypercholesterolaemia in children and young adults with diabetes as compared to young people who did not have diabetes.[37] Longitudinal studies are needed to establish the causal relationship between childhood obesity and young-onset type 2 diabetes.

CONCLUSION

Current literature suggests a high burden of generalized obesity among Indian children and adolescents, with a definite socioeconomic gradient. Asian-Indian children are increasingly susceptible to unfavourable body composition, as well as regional adiposity. The conventional BMI criteria for obesity are inadequate to identify these differences in body fat composition or distribution. Hence, ethnicity-specific, metabolically relevant cut-off values should be considered while diagnosing obesity and adiposity. Emerging literature suggests tracking of childhood obesity and body fat patterning

to adulthood. Obese Indian children have a high burden of subclinical inflammation, insulin resistance and metabolic syndrome at a younger age than their non-obese counterparts. Clinic-based studies from India, and migrant studies from high-income countries, report an increase in the proportion of type 2 diabetes among adolescents. The age at presentation of type 2 diabetes is also declining in India. All these point towards a direct link between childhood obesity and the diabetes epidemic in India.

Review of the literature has emphasized the importance of future research to understand the relationship between childhood obesity and diabetes. More epidemiological studies are required to estimate the burden and consequences of childhood obesity in India. Secular trends in the incidence of obesity among children and adolescents also need to be studied. The effect of early-life factors, as well as environmental determinants of both generalized and abdominal obesity among Indian children, is largely unknown. Longitudinal studies are essential to understand the long-term health impact of childhood obesity tracking. Further, there is an urgent need to address the lack in the evidence base for management of established obesity and coexisting metabolic abnormalities such as insulin resistance and metabolic syndrome among children and adolescents.

Available evidence on the natural history of type 2 diabetes in India suggests the need for a life-course approach in the prevention and control of childhood obesity. A comprehensive multilevel, multicomponent obesity-prevention strategy addressing a wide range of issues, starting from maternal and childhood undernutrition, and including sociodemographic and environmental factors, is a necessity in India. Conventional childhood obesity programmes are school based and do not address most of the upstream determinants of obesity. Since the seeds of childhood obesity are sown in the domestic environment, culturally specific family- and community-level intervention would have more impact. These community-level interventions should be complemented with an environment that supports physical activity and healthy diet. Population-wide policies, such as restriction of marketing unhealthy foods and beverages to children, nutrition labelling, taxes and subsidies, are required to create such an enabling environment. The Ensemble, Prévenons l'Obésité des Enfants (EPODE) [Together Let's Prevent Childhood Obesity] programme in Europe,[38] The Pacific Obesity Prevention in Communities (OPIC) project[39] and the Romp & Chomp programme in Australia[40] are examples of such community-level interventions that can be adapted to Indian settings.

Opportunistic screening of obese children for metabolic syndrome and insulin resistance would help to prevent the long-term health consequences of these disorders. Parents and health professionals should be empowered with cost-effective tools to identify high-risk children. Moreover, children and adolescents should be given due importance when designing national NCD-prevention and management programmes. It is high time to build the sea walls of prevention, as the tides of childhood obesity are approaching the shore.

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How to cite this article: Praveen PA, Tandon N. Childhood obesity and type 2 diabetes in India. WHO South-East Asia J Public Health 2016; 5(1): 17–21.

Source of Support: Nil. **Conflict of Interest:** None declared. **Authorship:** Both authors were involved in the planning of the manuscript. PA prepared the first draft and NT was responsible for the revision.