Print ISSN: 2321-6379
Online ISSN: 2321-595X
DOI: 10.17354/ijss/2018/16

Original Article

A Study on Environmental Factors and Comorbid Conditions Associated with Obesity in 5–15 Years Age Group

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Abstract

Background: Obesity among children is emerging as one of the most serious public health concerns in the recent times. The prevalence of obesity is increasing worldwide over the past three decades. Obesity affects nearly every organ system and often causes serious comorbid disease entities such as hypertension, dyslipidemia, insulin resistance, dysglycemia, fatty liver disease, and psychosocial problems in children. The options of pharmacotherapy as a treatment choice of pediatric obesity are very limited. Hence, establishing a comprehensive management program that emphasizes appropriate nutrition, exercise, and behavioral modification are essential. Role of a pediatrician should expand beyond his clinical setting to the community to educate both the children and their parents for prevention and early treatment of obesity.

Aim of the Study: The aim of the study was to study the environmental factors and comorbid conditions obesity in the pediatric age group.

Materials and Methods: Children aged between 5 and 15 years with obesity were included in the study environmental factors and comorbid conditions were observed and analyzed. All the parents of the children were in eliciting the clinical history and demographic details. All the children were subjected to necessary laboratory tests and ultrasound examinations to understand the base line health status and screen them for underlying comorbid conditions. Wherever clinical features of comorbid conditions are present further investigations were done to get a final diagnosis and treat the children. All the data were anise using standard statistical methods.

Observations and Results: A total of 36054 children registered in the outpatient department of the hospital during the study period of 2 years. Children aged between 5 and 15 years were 3812 (10.57%); children aged between 5 and 10 were 2147 (56.32%), and 1665 were aged between 10 and 15 years (43.67%). 131 (3.43%) children among the 3812 were identified to be obese according to the Indian Academy of Pediatrics 2015 growth charts. Among the 131 children 69 (52.67%) were in the age group of 5–10 years and the remaining 62 (47.32%) in the age group of 10–15 years. There were 66 (50.38%) females and 65 were males (49.61%). The overall mean age (5–15 years) was 08.22 ± 2.4. The mean age of children aged between 5 and 10 years was 7.10 ± 1.75. The mean age of children aged between 10 and 15 years was 12.87 ± 2.68. Among the males, the mean age was 08.50 ± 2.1 and 09.20 ± 1.8 in females. 42/131 (35.11%) children were found to have comorbid conditions more than one comorbid disease was observed in the children of this study group. Males were 25 (59.52%) and females were 17 (40.47%). Psychiatric illnesses were observed in 20/42 children (47.61%) and sleep apnea in 05/42 (11.90%). Other comorbid conditions were hypertension in 15 (35.71%), cardiovascular diseases (CVD) in 2 (4.76%), renal dysfunction in 5 (11.90%), asthma in 19 (45.23%), diabetes mellitus in 4 (09.52%), and thyroid dysfunction in 2 (4.76%) children. Dyslipidemia was observed in 02 (4.76%) and musculoskeletal disorders in 6 (14.28%) children.

Conclusions: Obesity constitutes a complex multifactorial disease associated with a wide spectrum of comorbidities due to a deleterious adipose tissue related metabolic profile and increased physical burdens imposed on various body sites. The common comorbidities were hypertension, sleep apnea, eating disorders, and psychiatric diseases. Even in children who are metabolically healthy multiple parameters and the risk of long-term adverse outcomes such as risk of CVD, osteoarthritis, disability, and psychological comorbidity need to be considered.

Key words: Children, Obesity, Overweight, Physical activity

Access this article online

www.ijss-sn.com

Month of Submission : 11-2017
Month of Peer Review : 12-2017
Month of Acceptance : 12-2017
Month of Publishing : 01-2018

INTRODUCTION

Overweight is excess body weight for a particular height whereas obesity is excess body fat.[1] The above conditions occur primarily due to excess calorie intake or insufficient physical activity or both. Simultaneously when various genetic, behavioral, and environmental factors play a role

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in their pathogenesis both the conditions are enhanced. Childhood obesity is the precursor of metabolic syndrome, poor physical health, mental disorders, respiratory problems, and glucose intolerance which can also track into adulthood.[2] In India, we have a unique problem wherein at one end of the spectrum we find obesity in children and adolescents while at the other end malnutrition and underweight. The International Association for the Study of Obesity and International Obesity Task Force estimate that 200 million school children are either overweight or obese.[3] The trend in India is that there is rise in the prevalence of obesity[3] while it has stabilized in western developed nations.[4] It continues to rise in developing countries like India which are in final stages of nutritional stabilization. The third National Family Health Survey of India revealed increasing obesity in north Indian states more than other parts of the country.[5] Obesity is a condition with multiple factors playing their role in its causation and usually described as a phenotype of numerous pathologies.[6,7] Obesity is excess of body fat or adiposity in an individual defined by body mass index (BMI): Body weight divided by height in meters squared (BMI: Kg m^2). Even though BMI does not correlate with adiposity as it does not quantify total body adiposity and does not distinguish between fat and muscle but on a population level, however, BMI does seem to track trends in adiposity as opposed to muscularity.[8-10] In the pediatric age group, gender-specific BMI-for-age percentile curves are used to define overweight and obesity. Children and adolescents with a BMI over the 85th but < the 95th percentile for age and gender are considered overweight and those with a BMI > the 95th percentile are considered obese. Children and adolescents with a BMI > the 99th percentile are considered severely obese.[7-9] The International Obesity Task Force has developed an international standard growth chart which enables comparison of prevalence globally.[10] The WHO estimates after an analysis of 450 nationally representative surveys from 144 countries showed the prevalence of children below age 5-year-old with a BMI >+2 standard deviation (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.[11] There is strong evidence that childhood obesity leads to adult obesity and its related comorbidities.[9] In a Longitudinal Study of Adolescent Health in USA nearly 40% of obese adolescents became severely obese by 30 years of age (BMI >40 Kg/m^2), when compared to 5% among the normal weight adolescents.[12,13] In another study among native Indians of Arizona Children with highest quartile of childhood BMI had double the incidence of death from endogenous causes in adult life.[14] There is lack of national representative data on obesity in children from India with its widely varying geographical, social, and cultural norms[15]. Here an attempt is made to understand the clinical prevalence of obesity in children attending a tertiary teaching hospital and to observe the comorbidities associated with obesity.

Type of Study

This was a prospective cross-sectional cohort study.

Period of Study

The study period was from November 2015 to October 2017.

Institute of Study

This study was conducted at the Department of Paediatrics, Malabar Medical College Hospital and Research Institute, Modakkallur, Kozhikode, Kerala.

MATERIALS AND METHODS

An institutional Ethical Committee clearance certificate to conduct a prospective cross-sectional cohort study in the Department of Pediatrics of Malabar Medical College Hospital and Research Institute, Modakkallur, Kozhikode, Kerala, a tertiary teaching hospital was obtained. Ethical Committee cleared consent letter was used before commencing the study. The total numbers of children visiting the outpatient department (OPD) were screened for overweight and obesity. Revised Indian Academy of Pediatrics 2015 growth charts for height, weight, and BMI for 5–15-year-old Indian children[16] was used to identify the obese children. All the children identified as obese were subjected to (a) history taking: (1) Food eating habits (regular breakfast, snacking habits, and eating with family meal-time routines). (2) Daily physical activity (sports, walking to school, helping household chores, and playing). (3) Time spent on television, video games, computer, and cell phones. (4) History of body dissatisfaction, depression, loss of control of eating, impaired social relationships, and decrease weight-related quality of life. (5) Binge eating disorder, excessive concern of weight, strict dieting and followed by binge eating. (b) Physical examination: A thorough physical examination was done with a focus to identify endocrinal, developmental, familial, and genetic causes. (1) Vital signs were assessed (both systolic and diastolic blood pressures [SBP and DBP]). SBP and DBP were defined as high when they were ≥ the 90th percentile, according to the task force on high BP in children and adolescents.[17] (2) The height, weight and BMI, and waist circumference (WC) were calculated based on the weight and squared stature in cm. (3) Endocrinal disorders were looked for examined for goiter, Insulin resistance (Acanthosis nigricans), polycystic ovary syndrome (hirsutism and excessive acne), and Cushing syndrome (violaceous striae and moon face). (4) Reproductive system premature puberty (age <7 years in girls and <9 years in boys); apparent micropenis (but normal penis may be hidden in fat), undescended testis/micropenis

(Prader–Willi syndrome). (5) If headache was present fundoscopy was done for evidence of optic edema due to pseudotumor cerebri. (6) Respiratory system (asthma and sleep apnea). (7) Gastrointestinal disorders (hepatomegaly or abdominal pain (gastroesophageal reflux and nonalcoholic fatty liver). (8) Musculoskeletal problems (slipped capital femoral epiphysis and Blount disease). (9) Psychological disorders (binge eating, depression, and bulimia nervosa). (c) Laboratory testing: (1) In overweight children (BMI 85–94th percentile) were ordered fasting lipid-screening test, if risk factors coexisted measurement of serum levels of fasting glucose, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) was ordered. The risk factors included increased BP or hypertension, dyslipidemia and family history of diabetes. (2) In children with obesity (BMI ≥95th percentile) serum levels of fasting lipids, glucose, ALT, and AST were ordered. If the result of fasting glucose screen test is more than 126 mg/dL, counseling and repeating test was done. Glycated hemoglobin value of >40 mmol/mol (5.8%) was used for diagnosing impaired glucose tolerance (5.7–6.4% as prediabetes and >6.5% as diabetes). Fasting plasma glucose (FPG) levels are done to diagnose prediabetes in obese children (values of FPG from 100 to 125 mg/dL were diagnostic of prediabetes and more than 126 mg/dL used to confirm diabetes mellitus). 2 h plasma glucose levels (OGTT) 140–199 mg/dL were taken to diagnose prediabetes and >200 mg/dL as diabetes mellitus. If the undesirable lipid profile was found among the obese children and the total cholesterol level was on the borderline (170–200 mg/dl), the screen test was repeated and if found elevated (≥200 mg/dl), cardiac referral was undertaken. (3) In obese children with BMI (≥95 percentile) blood urea and nitrogen and creatinine levels were estimated to exclude renal dysfunction. (4) Thyroid dysfunction tests were ordered in children with BMI (≥95 percentile) thyroid-stimulating hormone levels were estimated. (d) Ultrasound abdomen: (1) To observe evidence of fatty liver was undertaken. Inclusion criteria: (1) Children aged between 5 and 15 years were included. (2) Children of both genders were included. (3) Children with BMI (≥85 percentile) were included. (4) Children with comorbid conditions such as hypertension, fatty liver, thyroid dysfunctions, and psychological disorders were included. Exclusion criteria: (1) Children below the age of 5 and above 18 years were excluded. (2) Children with acute medical or surgical diseases were excluded. (3) Children convalescing from cute diseases or surgeries were excluded. All the data were analyzed using standard statistical methods.

OBSERVATIONS AND RESULTS

The total numbers of children registered in the OPD of the hospital for various diseases during the study period of 2 years were 36054. Among these, the children aged between 5 and 15 years were 3812 (10.57%). The number of children aged between 5 and 10 were 2147 (56.32%). The remaining 1665 were aged between 10 and 15 years (43.67%). 131 (3.43%) children among the 3812 were identified to be obese according to the Indian Academy of Pediatrics 2015 growth charts[16] and included in this study. Among the 131 children 69 (52.67%) were in the age group of 5–10 years and the remaining 62 (47.32%) in the age group of 10–15 years. Among 131 children included in the study as obese, there were 66 (50.38%) females and 65 were males (49.61%). The overall mean age (5–15 years) was 08.22 ± 2.4. The mean age of children aged between 5 and 10 years was 7.10 ± 1.75. The mean age of children aged between 10 and 15 years was 12.87 ± 2.68. Among the males, the mean age was 08.50 ± 2.1 and 09.20 ± 1.8 in females. The anthropometric data, BMI, WC, and BP and laboratory values are shown in Table 1.

The 131 patients were grouped according to age groups in five categories and their mean height, weight, and their BMI was tabulated in Table 2.

Among the 131 children, 42 (35.11%) were found to have comorbid conditions and the incidence of each of the comorbid condition observed was tabulated in Table 3. More than one comorbid disease was observed in the children of this study group. Among 42 children males were 25 (59.52%) and females were 17 (40.47%). The most common comorbid disorder observed was psychiatric illnesses such as depression manifesting in the form of aggressive behavior, anger, and conduct problems; personality disorders such as low self-esteem, poor self-worth, and issues with socialization; cognitive impairment with poor school performance and altered eating behavior including binge eating, abnormal craving for food and habitual eating in 20/42 (47.61%) of the children. Asthma was observed in 19/42 (45.23%), hypertension in 15 (35.71%), musculoskeletal disorders in 06/42 (14.28%), sleep apnea was observed in 05/42 (11.90%), and renal diseases in 5 (11.90%) children. The next common comorbidities observed were diabetes in 04/42 (9.52%) cardiovascular diseases (CVD), dyslipidemia and hypothyroidism in two children each (4.76%), [Table 3].

In this study, obesity was defined as BMI > or = 95th percentile and overweight as BMI > or = 85th percentile. Pre-hypertension and hypertension were defined as systolic and/or diastolic BP > or = 90th percentile for age, gender, and height and BP > or = 95th percentile, respectively. In children with pre-hypertension or hypertension, repeated measurements were performed. The incidence of comorbid conditions among the 213 children with obesity were categorized according to percentile of BMI is shown tabulated in Table 4.

DISCUSSION

In adults the incidence of obesity has doubled worldwide since 1980, with more than 1.5 billion adults being overweight with BMI >25 kg/m^2 and among them at least 500 million are clinically obese with BMI >30 kg/m.[18,19] Alarming trends of weight gain are reported for children and adolescents, undermining the present and future health status of the pediatric population.[20,21] The WHO has declared obesity a global epidemic, further stressing that it remains an under-recognized problem of the public health agenda.[22,23] Depending on the degree and duration of weight gain, obesity can progressively cause and/or exacerbate a wide spectrum of comorbidities, including Type 2 diabetes mellitus (T2DM), hypertension, dyslipidemia, CVD, liver dysfunction, respiratory, and musculoskeletal disorders, subfertility, psychosocial problems, and certain types of cancer.[24] These chronic diseases are shown to have strong correlations with BMI and closely follow the prevalence patterns of excessive body weight in all studied populations.[24] The risk increases exponentially with increasing BMI over 30 kg/m^2, which is further associated with a graded increase in the relative risk of premature death, primarily from CVD.[25] In this study, hypertension, dyslipidemia, and CVD were observed in 35.71%, 04.76%, and 4.76% of the children, respectively. Fat accumulation intra-abdominally and subcutaneously around the abdomen (central, abdominal, visceral, android, upper body, or apple-shaped obesity) is associated with higher risk for metabolic and CVD, independent of BMI.[26] Certain populations of few ethnic origins, regardless of the country of residence, are predisposed to central obesity and more vulnerable to obesity-related complications.[27] Diagnosing obesity with BMI thresholds as low as 25 kg m^2 and WC (central obesity) >45 cm is a grave risk factor for cardiovascular complications.[28] In this study, the mean WC was 48.8 ± 8.5 [Table 1]. National surveys in the UK have shown that obesity is directly responsible for almost 7% of the overall morbidity and mortality.[29] Even though diabetes mellitus Type 1 account for the most of cases in the obese pediatric population, T2DM constitutes a rather recent phenomenon and, obese children and adolescents are now increasingly diagnosed with impaired glucose tolerance and T2DM.[30] The new term "diabesity" has been introduced following the documentation of diabetes mellitus Type 2 with obesity.[31] Accordingly, anthropometric

Table 1: The overall anthropometric and BP and laboratory values of the study subjects according to gender (*n*-131)

Observation	Total (*n*=131)	Male (*n*=64)	Female (*n*=67)	*P*
Age (years)-mean; SD	08.22±2.4	08.50±2.1	08.35±1.8	0.688
Weight (kg)-mean; SD	56.3±11.2	57.0±11.5	58.7±10.7	0.013
Height (cm)-mean; SD	136.30±11.6	137.25±09.8	134.1±12.1	0.418
BMI (kg/m^2)-mean; SD	30.59±1.3	30.48±1.7	32.79±1.9	0.017
WC (cm)-mean; SD	48.8±8.5	49.5±5.9	46.07±10.1	0.023
SBP (mmHg)-mean; SD	99.7±11.5	99.0±10.9	99.2±12.2	0.050
DBP (mmHg)-mean; SD	58.6±10.4	58.0±10.1	59.7±10.4	0.042
BMI>2 SD-mean; SD	33±5.0	34±2.6	34±7.6	0.012
WC>75th percentile-mean; SD	109±25.8	36±15.5	73±38.4	0.010
High SBP-mean; SD	11±2.6	4±1.7	7±3.7	0.206
High DBP-mean; SD	14±3.3	7±3.0	7±3.7	0.697
Triglyceride levels				
<150 mg/dL	162.34±6.35	164.40±3.20	161.50±40	0.031
>150 mg/dL	132.60±2.30	127.60±42	133.70±10	0.042
Reduced HDL-C				
<40 mg/dL	33.80±5.0	32.50±3.10	34.41±3.20	0.040
>40 mg/dL	44.15±7.20	42.30±2.80	47.60±3.60	0.050
FPG				
<100 mg/dL	85.50±4.30	86.30±4.30	88.45±6.30	0.033
>100 mgd/dL	112.40±6.24	115.0±6.70	113.40±2.38	0.028

BMI: Body mass index, WC: Waist circumference, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SD: Standard deviation

Table 2: The age group wise gender and anthropometric data (*n*-131)

Age groups-years	Male-66	Female-65	Mean height		Mean weight		Mean BMI	
			Males	Females	Males	Females	M	F
05-07-(36) mean; SD	18	18	115.90±3.20	114.53±2.78	38.31±1.7	36.60±1.4	29.46	28.37
08-10-(33) mean; SD	19	14	132.23±2.80	131.20±2.35	54.10±2.6	54.05±2.3	31.09	31.60
11-13-(30) mean; SD	14	16	146.64±2.48	145.55±2.64	75.21±3.8	70.45±4.8	35.30	33.54
13-15-(32) mean; SD	15	17	159.66±3.65	155.33±2.90	89.32±4.5	80.0±3.10	35.44	33.33

SD: Standard deviation, BMI: Body mass index

indices of central obesity (e.g., WC and waist-to-height ratio) are utilized to better assess the risk for glucose intolerance and T2DM.[32] Liver constitutes 2–3% of the body weight and consumes 25–30% of oxygen in the body. Its function is essential for metabolic homeostasis and a dynamic relation exists between it and the adipose tissue in the body to regulate carbohydrate, protein, and fat metabolism. Insulin resistance developing sue to obesity may cause insulin resistance, hyperinsulinemia, hyperglycemia, and ectopic fat accumulation in the liver (fatty liver). Fatty liver may lead to impaired hepatic function and lead to a spectrum of abnormalities, ranging from elevation of circulating liver enzyme levels and steatosis to cirrhosis, liver failure, and even liver cancer.[33] Non-alcoholic steatohepatitis was introduced by Ludwig *et al.* to describe findings in 20 patients at the Mayo clinic exhibiting a non-alcohol related liver disease which was histologically similar to alcoholic hepatitis.[34] In this study, there were 17 children showed features of fatty in liver on ultrasound examination of the abdomen. Psychological disorders, such as depression, anxiety, and chronic stress, are risk factors for developing obesity, metabolic syndrome manifestations, and CVD.[34] They also can be comorbidities following obesity. In addition, evidence indicates that prolonged and/or intense stress can lead to subsequent weight gain. In this study, the incidence of psychological disorders including depression was 47.61%. Several mechanisms have been proposed to explain links between obesity and mental health in both directions, mainly focusing on over-activation of the hypothalamic-pituitary-adrenal axis and sympathetic nervous system, as well as on the role of health risk behaviors.[35] In the context of a multidisciplinary approach, clinicians should also take into consideration that several widely prescribed antidepressants and antipsychotic agents can induce weight gain (e.g., tricyclic antidepressants, paroxetine, mirtazapine, monoamine oxidase inhibitors, lithium, clozapine, olanzapine, and risperidone).[36] Childhood obesity may also be implicated with cancer and is suggested to have long-term consequences (e.g., increased risk of death from colon cancer), although further research is required on the associations between childhood and different cancers.[37] In this study, there were no cases of malignance reported. Increased body weight due to increase in weight may enhance biomechanical stress on joints resulting in knee osteoarthritis (OA), back pain, and restrictive lung disease. Obesity is a major risk factor for knee OA. Indeed, a recent systematic review by Blagojevich *et al.* reported obesity as one of the main factors consistently associated with knee OA (pooled odds ratio of 2.63, 95% confidence interval [CI]: 2.28–3.05).[38] A prospective population-based study in Finland with a follow-up of 22 years documented a strong association between BMI and risk of knee OA, with relative odds ratio of 7.0 (95% CI: 3.5–14.10; adjusted for age, gender, and other covariates) for obese persons compared to individuals with BMI <25 kg/m^2.[39] In this study, the musculoskeletal disorders were observed in 14.28% of the children. Obesity appears to also increase

Table 3: The incidence of comorbid conditions in the study (*n*-42)

Comorbid conditions	Male	Female
Psychiatric illnesses including altered eating behavior-20 (47.61%)	09	11
Asthma-19 (45.23%)	12	07
Hypertension-15 (35.71%)		
Systolic-8	04	03
Diastolic-7	05	03
Musculoskeletal disorders-06 (14.28%)	04	02
Sleep apnea-05 (11.90%)	03	02
Dyslipidemia-2 (04.76%)	01	01
Hypothyroidism-02 (4.76%)	01	01
CVD-02 (04.76%)	01	01
Renal dysfunction-05 (11.90%)	03	02
Diabetes mellitus-04 (09.52%)		
Prediabetes	01	01
Type 2 diabetes		01

CVD: Cardiovascular diseases

Table 4: The incidence of comorbid diseases according to the percentile of their BMI (*n*-42)

Observations	>99th percentile-34 (15.96%)	95–99th percentile-49 (23%)	90–95th percentile-82 (38.49%)	85–90th percentile-48 (22.53%)
Male-25	10	06	05	04
Female-17	06	05	04	02
Hypertension-15	08	04	02	01
Diabetes-04	07	03	02	02
Hypothyroid-02	01	01	01	01
Dyslipidemia-02	02	01	00	01
Sleep apnea-05	02	01	01	00
Cardiovascular-02	01	01	00	00
Musculoskeletal-06	02	01	01	02
Asthma-20	08	06	03	03
Renal dysfunction-02	02	01	00	00
Psychiatric illnesses including altered eating behavior-20	08	06	03	03

BMI: Body mass index

the risk of hip and hand OA, although these associations are less consistent.[40] Increased body weight and fat accumulation in the abdomen and chest wall can have a significant impact on respiratory physiology leading to deterioration of pulmonary function, attributed primarily to increased mechanical pressure on the thoracic cage and trunk.[41] Obese children may exhibit reduction in lung volumes and respiratory compliance, as well as in respiratory efficiency.[42] In this study, 20 children (45.23%) had respiratory-related diseases like asthma as a comorbid condition. Morbid obesity is associated with decreased total lung capacity, expiratory reserve volume, and functional residual capacity, as a result of mass loading, splinting, and restricted decent of the diaphragm.[43] Obesity is further associated with a spectrum of distinct respiratory conditions including obstructive sleep apnea (OSA), obesity hypoventilation syndrome, asthma, and chronic obstructive pulmonary disease. OSA can lead to various clinical manifestations including snoring, choking episodes during sleep, nocturia, restless and un-refreshing sleep, daytime hypersomnolence, and impaired concentration.[44] In this study, there were 5 children (11.90%) with sleep apnea disorder. The long-term consequences of sleep apnea include are alterations in the central control of breathing, with episodes of central apnea due to progressive desensitization of respiratory centers to hypercapnia. These episodes are initially limited during sleep, but eventually can lead to the obesity hypoventilation syndrome (Pickwickian syndrome) which is characterized by obesity, sleep-disordered breathing, alveolar hypoventilation, chronic hypercapnia and hypoxia, hypersomnolence, right ventricular failure, and polycythemia.[45] Several studies have reported a consistent association between increased BMI and OSA risk with an extremely high OSA incidence among morbidly obese subjects.[46] The treating pediatrician must be recognizing obesity as a disease and appropriate weight loss treatments should be offered to the obese children. Weight management is crucial and should be promptly suggested to the parents and children even when they are otherwise healthy (e.g., metabolically healthy obese patients) to prevent and/or delay the onset of obesity-related complications.[47]

CONCLUSIONS

Obesity constitutes a complex multifactorial disease associated with a wide spectrum of comorbidities due to a deleterious adipose tissue related metabolic profile and increased physical burdens imposed on various body sites. The common comorbidities were hypertension, sleep apnea, eating disorders, and psychiatric diseases. Even in children who are metabolically healthy multiple paWWrameters and the risk of long-term adverse outcomes such as risk of CVD, OA, disability, and psychological comorbidity need to be considered.

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How to cite this article: Chungathu R, Shrinath G. A Study on Environmental Factors and Comorbid Conditions Associated with Obesity in 5–15 Years Age Group. Int J Sci Stud 2018;5(10):1-7.

Source of Support: Nil, Conflict of Interest: None declared.