Indian Journal of Pediatrics (December 2021) 88(12):1222–1234
https://doi.org/10.1007/s12098-021-03913-3

REVIEW ARTICLE

Management of Obesity and Its Complications in Children and Adolescents

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Received: 11 May 2021 / Accepted: 22 July 2021 / Published online: 5 October 2021

Abstract
Pediatric overweight/obesity has assumed epidemic proportions in India. It is associated with several significant complications and tracks into adulthood. The mainstay of management is a holistic lifestyle modification that must be adopted by the family as a whole. It involves dietary changes, regular physical activity, and behavioral changes that favor a healthy way of life. Regular follow-up, and attention to keeping up the motivation of the child and family achieves good results. In the present paper, a stepwise approach to prevention and management of childhood obesity is presented along with the recommendations for screening and management of associated complications and the role of pharmacotherapy and bariatric surgery.

Keywords Obesity · Overweight · Lifestyle modification · Bariatric surgery

Introduction

Obesity is defined as excessive fat accumulation that is detrimental to health and well-being. It is the result of positive energy balance due to excess caloric intake, and/or inadequate physical activity; and is influenced by various genetic, behavioral and environmental factors. The global prevalence of childhood obesity has increased eightfold in the 5–19 y age group and doubled in the 2–4 y age group in the past four decades [1]. Simultaneously, the prevalence of undernutrition has remained mostly steady, the result being that the proportion of children/adolescents with normal weight has declined [1]. India is currently placed third after China and United States in the global burden of pediatric obesity [1]. Pooled data from 52 Indian studies show that the prevalence of overweight/obesity has increased from 16.3% in 2001–2005 to 19.3% in studies after 2010 [2].

The children/adolescents with overweight/obesity are at risk of having several complications. Insulin resistance is present in one-third and non-alcoholic fatty liver disease (NAFLD) in two-thirds of such adolescents, with a fivefold higher risk of hypertension [3–5]. Other complications include behavioral and psychological issues, orthopedic problems, and sleep apnea [6, 7]. Up to three-fourth of children with overweight/obesity remain so in adulthood [8].

The foundations of healthy lifestyle are laid in childhood, and therefore, interventions aimed at prevention and management of obesity are also the most rewarding at this age. In this paper the key strategies for prevention and management of nutritional (exogenous) obesity in children and adolescents will be discussed.

Stepwise Approach to Prevention and Management of Overweight and Obesity

Prevention and management of obesity constitute a continuum of efforts aimed at reducing the imbalance between energy intake and output at one end to creating a negative energy balance at the other end. The American Academy of Pediatrics in its 2007 guidelines has suggested a stepwise approach to prevention and management of obesity [7]. The authors follow and recommend a similar approach contextualized to their setting. The interventions are scaled up from level 1 to 4 depending on the severity of obesity and its complications, and the response. Level 1 interventions are directed towards prevention of obesity in children who currently have a normal weight, and towards management of children with overweight but with no complications.

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These focus on modifications in diet and lifestyle. Level 2 interventions for children with obesity or with overweight and complications such as mild hypertension, dyslipidemia, fatty liver etc. encompass the same strategies but are more structured, and closely supervised. If concerted efforts over 3 to 6 mo do not yield satisfactory improvement, they are scaled to level 3, with more intensive, comprehensive multidisciplinary care. Those with poor response, morbid obesity or significant comorbidities need further scaling up to level 4 that includes pharmacotherapy and bariatric surgery. While the key strategies remain fundamentally the same, their intensity increase at each successive level, visits to healthcare provider become frequent, and the family's committed involvement assumes greater importance.

Level 1: Prevention of Overweight/Obesity and Management of Overweight Without Complications

'Prevention is better than cure' holds particularly true for pediatric obesity and so, the key strategies need to be instituted early and continued through childhood and adolescence (Box 1). Any infant or child who is crossing percentile lines needs close observation and monitoring.

Box 1 Key strategies for prevention of obesity and management of overweight without complications in children [9–11]

Individual and family level

1. Intake of balanced diet, foods rich in fibre content, limited intake of high-calorie foods and sugar sweetened beverages. Having regular meals and increasing intake of water
2. Vigorous physical activity for 20–60 min at least 5 d per week
3. Parents to adopt facilitatory rather than coercive feeding style
4. Adequate sleep duration
5. Balance unavoidable technology-related screen time with increased opportunities for physical activity
6. Involvement of entire family in adopting healthy lifestyle

School, community and national level

7. Schools and communities to create environments that promote healthy food and encourage physical activity such as walking and climbing stairs
8. Encourage and promote breast-feeding and home-based complementary foods
9. Guidance to parents, carers, teachers regarding healthy body size and healthy lifestyle including sleep
10. Monitoring of weight gain in mothers in antenatal period and appropriate nutrition for prospective mothers
11. Regulation of marketing of commercially available complementary foods to limit intake of high proportions of fat, sugar and salt by infants.
12. School curriculum to include nutrition and health education components and regular physical activities
13. Develop comprehensive care facilities for management of children with overweight/obesity
14. Integrated national policies and programmes that promote intersectoral coordination to reduce the obesogenic environment (parks, safe roads for cycling, greater production and promotion of millets, legumes and seasonal fruits and vegetables at lower price, etc.)

Healthy Diet

Optimal Nutrition During the First 1000 Days Including Antenatal Period A balanced diet for the mother, avoidance of excessive gestational weight gain and exclusive breast-feeding for first 6 mo prevent development of obesity [12]. Complementary, home based foods introduced thereafter should include fruits and vegetables [9]. Importantly, preterm babies, term babies who are either small or large for gestational age (SGA or LGA), and infants born to mothers with pre-existing or gestational diabetes are at increased risk for later development of higher adiposity and insulin resistance [13, 14]. Continued breast-feeding till 2 y, and avoidance of excessive weight gain in infancy are especially important in these babies.

Balanced Diet The child should have a balanced diet with generous proportions of salads and vegetables [9]. Force feeding and overfeeding should be avoided, so that the child learns to understand his/ her satiety cues [10]. Frequent snacking should be discouraged as snacks contain more fat, sugar and calories [11]. Juice drinks, flavored sweetened milk and yogurts, chocolate-coated cereals etc. that are commonly marketed as 'healthy foods' are laden with sugar. World Health Organization (WHO) has recommended keeping the intake of sugar to less than 5 to 10% of daily caloric intake [15].

Fibre-Rich Foods Fibre-rich foods include whole grains, lentils, nuts, fruits and vegetables. An "age + 5" rule for dietary fibre is recommended [16]. A 5 y old should consume 10 g per day of dietary fibre and by 15 y it should approach adult values of 20–25 g/d.

Regular Meals Children and adolescents with overweight often skip breakfast causing irresistible craving (especially for foods with high fat, sugar and salt (HFSS)) and overindulgence at the next meal [17]. A regular meal pattern is associated with greater insulin sensitivity and subjective appetite changes that favor metabolic health [18].

Healthy Habits The family should have meals together, avoiding distractions like watching television or reading [10].

Physical Activity

Children should optimally have 60 min of moderate to vigorous physical activity, at least 5 d per week, to decrease the risk of developing obesity [11]. In completely sedentary children, incremental goals can be set beginning with 20 min daily or in two or more bursts. A simple way to classify an activity as moderate is that during which it is possible to talk but difficult to sing, while vigorous is that during which it is difficult to talk [11]. A linear relationship was observed between duration of physical activity and reduction in weight; each metabolic equivalent hour per week being associated with a decrease in BMI by 0.13 kg/m^2 [19]. While most activities should be aerobic, resistance exercises that strengthen muscles and bones should also be included at least thrice a week.

Everyday activities, such as, increased use of stairs, cycling and walking, and helping with household chores should be encouraged. Schools and communities can play a positive role by planning environments that demand and facilitate movement [11]. Enjoyable activities such as dancing, playing or joining a sports academy improve compliance and regularity.

Sleep Duration

School-age children and adolescents should sleep for 8 to 11 h a day and in quiet surroundings without use of electronic media [20]. Insufficient sleep affects dietary intake and metabolism and can lead to obesity . Reduced sleep has been associated with reduced serum leptin, increased ghrelin and reduced glucose utilization [21].

Screen Time

Spending long hours in front of the television, computer etc. not only promotes sedentary lifestyle but is also associated with increased snacking, exposure to commercials of junk foods and sweetened beverages, and reduced sleep [22].

Family Involvement

For all lifestyle modifications to have a lasting effect, they should be incorporated in the daily practices of the family as a whole. Parents have to serve as role models for healthy eating, regular activity and reduced screen time. For adolescents, parents should maintain a positive engagement, praise each effort, and motivate them positively instead of nagging or criticizing them. Involving them in meal planning encourages their adherence to the modifications.

Role of Schools

Schools can play a positive role by regulating the food and drinks available on their campuses, and including physical activity as a scoring subject.

Table 1 Goals of weight loss/ maintenance in pediatric overweight/obesity (adapted from Ref. 23)

2–5 y	6–11 y	≥ 12 y
Maintain weight till BMI falls below 85th percentile for age	Overweight - Maintain weight till BMI falls below the overweight centile (23 adult equivalent) Obesity - Slow weight loss of 0.5–2 kg per month depending on the severity of obesity, targeting about 10% reduction in weight	Overweight - Weight maintenance (or gradual loss) till BMI falls below the overweight centile (23 adult equivalent) Obesity - Loss of up to 1 kg per week targeting 10% weight reduction

Level 2: Structured Weight Loss Programme for Children with Obesity, or with Overweight with Complications

The key management strategies are the same as mentioned under the heading of level 1 interventions, with the difference that they are more structured, goal-oriented and more closely supervised. The management plan should be based on the child's age, BMI and presence of complications (Tables 1 and 2). It should be further individualized as per their motivation to lose weight, readiness for physical activity, and availability of family support. Younger children may rebel if sudden changes are introduced, and need a more gradual approach, while older adolescents are keen to see positive results and could follow a more intense regime. Setting incremental goals, motivating the child, targeting the whole family for behavior change, and incentivising with praise and rewards constitutes a holistic approach. The intervention may be divided into active and maintenance phases. The active phase can be of 2–3 mo duration depending on the target weight loss (Table 1). For example, in an adolescent weighing 100 kg, the target weight loss is 10 kg over 10 wk (1 kg/wk); hence this constitutes the active phase. Giving a timeline helps the child and family adopt and stick to the behavioral changes more easily. For example, children will be more likely to agree to not eating their favorite pizzas or ice-creams, and joining a sports program for a few months rather than *always*. As the child and family start seeing the benefits of healthy eating and regular activity, they become more receptive to the idea of following these modifications regularly. After an initial success, there is often weight regain. Preventing it requires regular follow-up counselling through in-person visits and phone/video-calls to keep up the child's enthusiasm. A multidisciplinary team of a pediatrician, dietician, physical instructor and psychologist is ideal. Besides taking care of the emotional and psychological issues associated with obesity, the psychologist could use cognitive behavior therapy to bring about motivation and improve self-esteem [24]. Improvement in BMI is associated with improved metabolic outcomes, delay in onset of type 2 diabetes mellitus (T2DM) and improved cardiovascular fitness [25]. In the context of the current COVID-19 pandemic, management of obesity takes further significance as sedentariness has led to increased obesity, and obesity is a risk factor for developing severe manifestations of COVID.

Additional Principles of Management Beyond Those Discussed in Level 1

Diet A structured daily plan for meals and snacks is advised based on a balanced macronutrient diet. Traffic light diet is a useful and practical approach. (Box 2) [23]. For each meal suggest filling half the plate with salad and vegetables, one-fourth with protein and one- fourth with carbohydrate. Dwell more on what the child should eat, rather than only listing foods to be avoided. Controlling the portion size should be made a habit. The protein content in the diet must be sufficient and of high quality to prevent loss of muscle mass. Saturated fats in diet can be reduced in children older than 2 y. Processed foods must be limited and sugar sweetened beverages eliminated completely. Though calculation of total caloric intake is not needed as a routine exercise, a 24 h dietary recall or food frequency helps to identify the main problem areas in the child's diet and her likes and dislikes.

Table 2 Age-based management plan for overweight/obesity [10, 11, 26]

Age group	Diet	Activity	Behaviors
< 2 y	Breast-feeding Complementary feeding at 6 mo No sugar sweetened beverages, fast food or juice	Allow as much activity as possible Parents encouraged to interact as much as possible	Sleep up to 18 h per day No media use except for occasional video chats
2–5 y	3 meals, 1–2 snacks/d, carbohydrates 45%–65%, proteins 5%–20%, fats 30%–40% (< 8% saturated), include fibre, free sugars < 10% of total daily energy intake Do not offer fast food or sugar sweetened beverages Age appropriate portion size, do not force feed	Encourage as much age appropriate activities as possible	Good meal hygiene-regular ameals at the table, without media Praise for trying new foods Parents should model the eating behavior Routine sleep pattern Minimum screen time
5–9 y	Same as for 2–5 y olds Include servings of protein (3/d), dairy (1–2/d), nonstarchy vegetables (4-5/d), fruit (1.5–2/d) Dessert only on special occasions	1 h of moderate to vigorous physical activity including organized sports activities should be fun. Everyday activities that promote fitness	Same as for 2–5 y olds No TV in bedroom Sleep 11–14 h a day Praise for trying new foods Parents should not be overcontrolling
Older children	Same as for 5–9 y olds with involvement of the child in meal planning, avoid skipping meals Reduction of daily caloric intake by 500 kcal (from usual intake)	Same as for 5–9 y olds	Since increasingly eating out - Discuss with child about limiting non-nutritious foods Sleep hygiene, 9 to 11 h per day Limit nonacademic screen time to 1–2 h per day Recognize and manage psychosocial comorbidities

Box 2 Key interventions for treatment of obesity in children [10, 11, 23, 27]

1. *Dietary interventions*
   - Traffic light approach - Green foods to be eaten often, yellow foods to be taken in moderation and red foods to be eaten sparingly.
     - Green (low energy, high nutrient foods) - Fruits and vegetables
     - Yellow (moderate energy foods) - Grains
     - Red (high energy, low nutrient foods) - Sweets, sweetened beverages, fried foods
   - Reduced saturated dietary fat
   - Structured and timely meals with appropriate portion size
   - Increase water intake - At least 2–3 L per day
2. *Physical activity*
   - Reduction of inactivity
   - 60 min of moderate to vigorous physical activity in a day
3. *Behavioral interventions*
   - Education to family about importance of healthy diet and activity
   - Mindful eating, avoid distractions, avoid grazing
   - Stimulus control within home
   - Keep physical activity and food log
   - Developing a routine for exercise
   - Frequent self weighing at home
   - Sleep hygiene (adequate duration and without electronic devices)
   - Promote healthy family environment
   - Parental training in lifestyle modification
   - Role modeling of desirable behaviors by parents
   - Counseling on regular basis
   - Positive reinforcements, praise and rewards
   - Recognize and manage psychosocial comorbidities (depression, anxiety etc)
   - Limitation of non academic screen time

Healthier options and cooking methods (like steaming) can be suggested for snacks. The caloric values of the usual serving size of popular snacks should be emphasized together with the physical activity needed to burn such calories. For example, the calories in 1 *samosa* or 1 slice of pizza need 30 min of running or 45 min of cycling. Reduction in caloric intake by 30%–40% of usual intake has been suggested (though most dietary recalls do not reveal the actual caloric excesses), typically creating a deficit of 500 kcal/d in adolescents with fewer than 30% calories from fats [26]. One must remember that the recommended daily allowance (RDA) for calories is based on the assumption of an active lifestyle, and lower intake would be needed for those with a more sedentary lifestyle. Incorporating higher amounts of vegetables, fruits, whole grains, poultry, fish and nuts as DASH (dietary approaches to stop hypertension) diet is associated with a decreased risk of developing metabolic syndrome [28].

Mindful eating is a healthy concept where one is consciously aware of what one is eating and focuses on the food only. Eating with others at set times and places,

thinking about the food being eaten, eating slowly and being aware of body cues of fullness are part of mindful eating [27].

Physical Activity Physical activity (at least 60 min of moderate to vigorous activity)must be supervised keeping a *log*.

Behavior Screen time must be further reduced, preferably to less than an hour a day. Parental supervision is important. Rewarding each small achievement boosts motivation.

Frequent Follow-Up The health care visits must be at least once a month and include screening for co-morbidities.

Level 3: Multidisciplinary Intensive, Comprehensive, and Structured Weight Loss Programme

The scale of interventions in level 2 are upgraded with closer monitoring, appropriate documentation and supervision under a multidisciplinary team. Meals are planned to result in a negative energy balance. A few pilot studies have used protein-sparing modified fast, wherein carbohydrates are severely restricted but proteins are spared. It induces intense lipolysis and ketosis and hence, are not generally used in clinical practice in children and adolescents [29]. Physical activity is made more regular and tracked using logs or activity trackers. Weekly follow-up is advised for the initial 8 to 12 wk, and monthly thereafter, with telephonic reminders for further reinforcement. Short term goals are set. Group counseling and sharing experiences are very effective, as children and families learn from each other.

Level 4: Tertiary Care Intervention under Expert Multidisciplinary Team

The dietary interventions are made stricter with further reduction in total caloric intake. Meal replacements, i.e. meals with a fixed amount of food, typically as meal bars or liquid shakes with known caloric content, are a useful option especially as they reduce contact with problem foods [30]. The associated comorbidities (e.g., diabetes or hyperlipidemia) need to be taken into consideration in diet planning. Physical activity is monitored and exercise specialists involved when possible. Pharmacotherapy and bariatric surgery may be considered.

Anti-obesity Drugs

Orlistat is an Food and Drug Administration (FDA) approved drug for treatment of obesity in children older than 12 y [11]. It inhibits gastrointestinal lipases, decreases fat absorption by about 30% and reduces BMI by 0.7 to 1.7 kg/m^2. It needs to be taken with each meal, increases the tendency for flatus and causes fecal urgency and only 10% continue the drug beyond 6 mo. The absorption of fat soluble vitamins is also affected, and need supplementation.

Centrally acting anorexigenic agents that are catecholaminergic and dopaminergic stimulants are approved for use in adults but not yet recommended for children. Phentermine has recently received FDA approval for use in obesity though not in children younger than 16 y. Topiramate controls food craving but is not FDA approved for the treatment of obesity.

Glucagon-like peptide-1 analogue, liraglutide, has recently received regulatory approval for use in obesity and T2DM in children more than 12 y after recent trials documented its efficacy [31]. Exenatide, an incretin mimetic with similar action, has been found effective in reducing BMI in adolescents in small trials [32].

Pharmacotherapy for obesity is still for restricted use with limited efficacy. No medication has proven beneficial effect in reducing the long term cardiovascular risks associated with obesity.

Bariatric Surgery

Bariatric surgery may have to be undertaken in adolescents with BMI > 40 kg/m^2 or > 35 kg/m^2 with significant comorbidities including psychological distress related to obesity (but no underlying psychiatric illness and a stable supportive family) despite rigorous lifestyle modification. It is performed only when the adolescent has reached Tanner stage 4 or 5 [11]. The operative procedures include vertical sleeve gastrectomy or Roux-en Y gastric bypass surgery. In addition to anatomically reducing the caloric intake of the individual, they decrease levels of ghrelin and increase anorexigenic glucagon like peptide-1,thereby decreasing appetite and improving insulin sensitivity [33]. There is improvement in glucose homeostasis and reversal of type 2 diabetes, NAFLD and in cardiovascular risk factors such as dyslipidemia and hypertension [34]. However, as many as 15% may require additional operative procedure following the surgery for complications such as internal hernias, adhesions etc. [35]. Weight regain is a significant issue with median gain of 14% of lost weight at 5 y postsurgery [36].

Screening for and Management of Complications of Obesity

Screening

The complications could be asymptomatic or symptomatic and should be regularly screened for (Table 3). Excess fat deposition in the abdominal region is associated with insulin resistance and clustering of several cardiometabolic disorders, such as dyslipidemia, prediabetes and NAFLD.

Table 3 Screening for complications of pediatric overweight/obesity [11, 28, 37–39]

<table>
<tr><th>Complication</th><th>Age for screening</th><th>Symptoms</th><th>Tests and interpretation</th></tr>
<tr><td>Prediabetes</td><td>Clinical screen at first visit, lab screen for older than 10 y</td><td>Acanthosis nigricans</td><td>HbA1c 5.7 to 6.5%
Impaired fasting glucose-Fasting plasma glucose ≥ 100 but < 126 mg/dL
Impaired glucose tolerance - 2 h glucose ≥ 140 < 200 mg/dL</td></tr>
<tr><td>Diabetes</td><td>Older than 10 y</td><td>Polyuria, polydipsia, blurry vision, fungal vaginitis/discharge (girls), unexplained weight loss</td><td>HbA1c ≥ 6.5%
Fasting plasma glucose ≥ 126 mg/dL, 2 h plasma glucose ≥ 200 mg/dL during oral glucose tolerance test, in patient with classic symptoms of hyperglycemia, a random plasma glucose ≥ 200 mg/dL</td></tr>
<tr><td>Dyslipidemia</td><td>First visit then every 2 y</td><td></td><td>Fasting lipids
<table>
<tr><th>Lipid (mg/dL)</th><th>Acceptable</th><th>Borderline high</th><th>High</th></tr>
<tr><td>Triglycerides 0–9 y</td><td>< 75</td><td>75–99</td><td>≥ 100</td></tr>
<tr><td>TG 10-19 y</td><td>< 90</td><td>90–129</td><td>≥ 130</td></tr>
<tr><td>LDL cholesterol</td><td>< 110</td><td>110–129</td><td>≥ 130</td></tr>
<tr><td>Total cholesterol</td><td>< 170</td><td>170–199</td><td>≥ 200</td></tr>
<tr><td>HDL cholesterol</td><td>> 45</td><td>40–45 (borderline low)</td><td>< 40 (low)</td></tr>
<tr><td>Non–HDL cholesterol</td><td>< 120</td><td>120–144</td><td>≥ 145</td></tr>
</table></td></tr>
</table>

Waist circumference shows better correlation with risk of metabolic complications than BMI though is subject to error due to variations in the measurement technique. All children ≥ 3 y of age with obesity should have blood pressure (BP) checked at every health care encounter [37]. Potential secondary causes of HTN (e.g., chronic kidney disease) should be ruled out. All children with overweight/obesity should have a fasting lipid level estimation at first visit

Table 3 (continued)

<table>
<tr>
<td>Hypertension (HTN)</td>
<td>BP-for older than 3 y at every visit</td>
<td>Frequent headaches</td>
<td>BP categories and stages
<table>
<tr><th></th><th>1–13 y olds</th><th>≥ 13 y olds</th></tr>
<tr><td>Normal BP</td><td>< 90th percentile</td><td>< 120/< 80 mm Hg</td></tr>
<tr><td>Elevated BP</td><td>≥ 90th to < 95th percentile or 120/80 mm Hg to < 95th percentile (whichever is lower)</td><td>120/< 80 to 129/< 80 mm Hg</td></tr>
<tr><td>Stage 1 HTN</td><td>≥ 95th to < 95th percentile +12 mm Hg, or 130/80 to 139/89 mm Hg (whichever is lower)</td><td>130/80 to 139/89 mm Hg</td></tr>
<tr><td>Stage 2 HTN</td><td>≥ 95th percentile +12 mm Hg or ≥ 140/90 mm Hg (whichever is lower)</td><td>≥ 140/90 mm Hg</td></tr>
</table>
(as per age, gender and height specific charts)</td>
</tr>
<tr>
<td>Sleep apnea

Asthma</td>
<td>As per symptoms</td>
<td>Frequent headaches, habitual snoring, restless sleep, shortness of breath, wheezing</td>
<td>Nocturnal polysomnography, oximetry

Pulmonary function test, peak flow</td>
</tr>
<tr>
<td>NAFLD</td>
<td>LFT for older than 10 y</td>
<td>Gastrointestinal discomfort</td>
<td>ALT > 25 U/L (boys), >22U/L(girls), ultrasonography or Fibroscan</td>
</tr>
<tr>
<td>PCOS</td>
<td>As per symptoms</td>
<td>Acne, hirsutism</td>
<td>Free and total testosterone, sex hormone binding globulin</td>
</tr>
<tr>
<td>Psychological</td>
<td>As per symptoms</td>
<td>Depression, anxiety, nervousness, low self-esteem, worsening school performance</td>
<td>Child behavior checklist, children’s depression inventory under clinical psychologist consultation</td>
</tr>
</table>

and this should be repeated every 2 y if result is normal, every year if borderline and in 2 wk to 3 mo if abnormal. Liver function test and fasting plasma glucose or glycated hemoglobin (HbA1c) should be done as part of initial evaluation of those who are older than 10 y [38, 40]. Even mild elevation of liver enzymes may be associated with fatty

Table 3 (continued)

Blount disease	As per symptoms	Knee pain, severe bowing of tibia	Appropriate radiographs
Musculoskeletal		Back pain, joint pain	
Slipped capital femoral epiphysis		Hip and knee pain, limp	
Pseudotumor cerebri	As per symptoms	Headache, vision changes, pailloedema	Cerebrospinal fluid opening pressure, Radiological imaging
Migraine		Headache	None

change and fibrosis [39]. Ultrasonography and evaluation of controlled attenuation parameter by Fibroscan are useful tests, especially for identification of moderate or severe hepatic steatosis [41]. Any symptoms suggestive of psychological, neurologic or orthopedic manifestations should prompt appropriate evaluation. Presence of one or more abnormalities should prompt detailed evaluation for others. Further, presence of certain coexisting conditions (Box 3) may increase the risk of cardiometabolic complications and these should be looked for. Calculation of homeostatic model of insulin resistance (HOMA-IR) is not recommended in clinical practice [42].

Box 3 Risk factors for cardiometabolic complications in children with overweight/obesity [28]

Central/Truncal obesity

Maternal gestational diabetes

Low birth weight

Accelerated weight gain with crossing of centiles in childhood

Infant feeding practices - Early weaning from breast milk

Early adiposity rebound

Family history of obesity, dyslipidemia, type 2 diabetes or early cardiovascular disease in 1st or 2nd degree relatives

Sedentary behavior, smoking

Asian Indian ethnicity

Treatment

The medications available for the treatment of complications are summarized in Box 4.

Box 4 Treatment of complications [11, 28, 37, 43]

Hypertension

- Weight loss, DASH diet, limit salt intake to < 1500 mg/d, at least 1 h per day of moderate to vigorous physical activity
- Those with symptomatic stage 2 hypertension, coexisting diabetes (type 1 or 2) or end organ damage such as left ventricular hypertrophy should be started on medication.
  Angiotensin converting enzyme inhibitors, e.g., Enalapril
  Angiotensin receptor blockers, e.g., Losartan
  Calcium channel blockers, e.g., Amlodipine

Dyslipidemia

- A diet with total fat at 25% to 30% of calories, saturated fat at < 10% of calories, and cholesterol intake at < 300 mg/d.
- Decisions for medication should be based on the average of results from at least 2 fasting lipid levels obtained at least 2 wk but no more than 3 mo apart.
- For older than 10 y - Use medication if after 6 mo trial of diet and lifestyle management-LDL-C ≥ 190 mg/dL/ non-HDL-C ≥ 145 mg/dL or LDL-C > 160 mg/dL with family history of early onset cardiovascular disease, or in presence of other risk factors (stage 2 HTN, smoking, diabetes).
- If baseline average LDL cholesterol level of ≥ 250 mg/dL or average triglyceride level of ≥ 500 mg/dL - Start medication, consult expert.
- Younger than 10 y - Do not use medication unless severe primary hyperlipidemia or associated serious morbidity.
- Medication - Statins, e.g., Atorvastatin (10–20 mg/d) with monitoring of creatine kinase and liver transaminases.

Insulin resistance and impaired glucose tolerance

- Metformin has been approved for treatment of type 2 diabetes in children 10 y and older and is useful in insulin resistant states such as polycystic ovary syndrome. Liraglutide has recently received approval for treatment of obesity and type 2 diabetes in children older than 12 y.

DASH Dietary approaches to stop hypertension; *HTN* Hypertension; *LDL-C* Low density lipoprotein cholesterol; *non-HDL-C* Non-high density lipoprotein cholesterol

Summary

The management of pediatric obesity should be based on a strong foundation of healthy diet and regular physical activity. Family involvement and role modeling by parents provide the crucial motivation. The pediatrician has the overall responsibility of guiding the family and the child, along with a dedicated multidisciplinary team. Pharmacotherapy has a limited role and bariatric surgery may be an option for those with severe obesity or significant complications, refractory to diet and lifestyle modification.

Authors' Contributions MM did the literature search, initial draft and revisions; VJ conceptualized and designed the manuscript, provided valuable experiential inputs, edited the manuscript. VJ is the guarantor for this paper.

Declarations

Consent for Publication The manuscript contains no identifying information pertaining to any individual. Both authors have approved the final draft and give their consent for publication.

Conflict of Interest None.

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