The Edmonton Obesity Staging System for Pediatrics: A proposed clinical staging system for paediatric obesity

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Traditionally, clinical recommendations for assessing and managing paediatric obesity have relied on anthropometric measures, such as body mass index (BMI), BMI percentile and/or BMI z-score, to monitor health risks and determine weight management success. However, anthropometric measures do not always accurately and reliably identify children and youth with obesity-related health risks or comorbidities. The authors propose a new clinical staging system (the Edmonton Obesity Staging System for Pediatrics, EOSS-P), adapted from the adult-oriented EOSS. The EOSS-P is used to stratify patients according to severity of obesity-related comorbidities and barriers to weight management into four graded categories (0 to 3) within four main health domains: metabolic, mechanical, mental health and social milieu (the 4Ms). The EOSS-P is based on common clinical assessments that are widely available and routinely completed by clinicians, and has the potential to provide clinical and prognostic information to help evaluate and inform the management of paediatric obesity.

Key Words: Canada; Child; Health risk; Obesity; Treatment

Obesity has both direct and indirect effects on health and well-being, which can vary considerably among individuals based on independent and synergistic genetic, biological, developmental and psychosocial influences (1). It is clear that some individuals are disproportionately burdened by comorbidities linked with obesity (2) and some face greater barriers to weight management. These observations reinforce the complexity of obesity and the long-standing position that there are different types of obesity (obesities) with varying etiologies and health consequences (3). Given this heterogeneity, obesity should not only be defined according to degree of adiposity or excess weight, but also on the basis of a more detailed assessment of obesity-related comorbidities and barriers to successful weight management.

Herein, we propose an evidence-informed paediatric clinical obesity staging system that builds on an existing model for adults (4). The staging system captures the severity of disease, as well as factors that complicate management, within four domains of health most commonly encountered in obesity – metabolic, mechanical, mental health and social milieu (the 4Ms) (Figure 1). This assessment tool can help support improved clinical and administrative decisions regarding the allocation of resources (ie, human, financial, time) for obesity management, and provide a platform for future research and clinical care designed to individualize therapeutic options. Given the evidence supporting the presence of many types of obesity with different etiologies and consequences (5,6), an expanded understanding of paediatric obesity...
may improve on the current but incomplete practice that focuses primarily on anthropometric assessment.

**OBESITY STAGING SYSTEMS FOR ADULTS**

The Edmonton Obesity Staging System (EOSS) classifies adults with obesity into five graded categories (0 to 4), which incorporate obesity-related comorbidities and functional status into the assessment (4). One of the strengths of EOSS is that it outlines the metabolic, mechanical, mental health risk factors that should be assessed according to clinical practice guidelines to determine both health risks and an approach to management. The predictive validity of the EOSS was evaluated using the National Health and Human Nutrition Examination Surveys datasets, which found that EOSS stage was predictive of mortality, independent of body mass index (BMI), with clear separation of survival curves (7). Individuals categorized at EOSS stages 0 and 1 were not at increased risk for all-cause mortality compared with normal weight individuals (2), whereas those rated as EOSS stages 2 and 3 had an increased relative risk for all-cause mortality, suggesting that obesity-related comorbidities, and not weight status in isolation, increase risk for mortality (2). In this manner, the EOSS provides prognostic information that can assist clinicians in tailoring interventions based on the stage of obesity – providing those at higher stages with the most intensive treatment (or earlier treatment) compared with those at lower risk (lower EOSS stage). For individuals with EOSS stages 0 and 1, a reasonable target is weight maintenance and the promotion of health behaviours, while those at EOSS stages 2 and 3 require greater resources to address the medical and/or mental health risk factors identified, in addition to supporting health behaviour modifications. Based on this evidence (2,7), our aim was to develop a paediatric-specific clinical staging system for obesity adapted from the EOSS for adults.

**PROPOSED CLINICAL STAGING SYSTEM FOR PAEDIATRIC OBESITY**

The clinical staging system was developed by a group of clinicians and scientists representing, and affiliated with, secondary and tertiary level care centres for managing paediatric obesity across Canada. The original developer of the EOSS system (AMS) and a colleague with expertise in survey development and psychometrics (JL) also contributed clinical and research expertise. As a collective, consensus was achieved for which factors to include in the staging system, and the degree of impact these factors had on the health and well-being of children and youth with obesity. Consensus was reached through an iterative process, which included a series of e-mail communications, teleconferences and face-to-face meetings over a one-year period. Similar to the EOSS, the EOSS for Pediatrics (EOSS-P) is based on common clinical assessments, which include metabolic, mechanical, mental health and social milieu (the 4Ms) histories as well as routine diagnostic evaluations that are widely available and routinely completed (Table 1). The staging system identifies disease severity and potential barriers to
<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Stage 0</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic</td>
<td>No metabolic abnormalities</td>
<td>Hyperpension</td>
<td>T2D without diabetes-related complications</td>
<td>T2D with diabetes-related complications, hemoglobin A1c ≥8%</td>
</tr>
<tr>
<td></td>
<td>Acanthosis nigricans</td>
<td>Lipids at upper end of normal range</td>
<td>ALT: 1.5–2.0× normal</td>
<td>ALT: 2–3× normal</td>
</tr>
<tr>
<td></td>
<td>Impaired glucose tolerance (7.8 mmol/L – 11.0 mmol/L)</td>
<td>LDL-C or non-HDL-C: &gt;4.2 mmol/L</td>
<td>ALT: 2–3× normal</td>
<td>ALT: 3× normal</td>
</tr>
<tr>
<td></td>
<td>Impaired fasting glucose (6.1 mmol/L – 6.9 mmol/L)</td>
<td>HDL-C: &lt;0.80 mmol/L</td>
<td>Ultrasound: mild to moderate fatty infiltration of the liver</td>
<td>Liver dysfunction</td>
</tr>
<tr>
<td></td>
<td>Prehypertension</td>
<td>TG: &gt;4.0 mmol/L</td>
<td>Ultrasound: severe fatty infiltration of the liver</td>
<td>Cardiomegaly</td>
</tr>
<tr>
<td></td>
<td>Lipids at upper end of normal range</td>
<td>Lipids modestly elevated</td>
<td>Hyperpension</td>
<td>OSA requiring BiPAP or CPAP and supplementary oxygen/ pulmonary hypertension</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Mald OSA not requiring BiPAP or CPAP</td>
<td>Mild MSK pain that does not interfere with activities of daily living</td>
<td>MSK pain and/or complications limiting physical activity;</td>
<td>OSA requiring BiPAP or CPAP</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Mald MSK pain that does not interfere with activities of daily living</td>
<td>Dyspnea with physical activity not interfering with activities of daily living</td>
<td>Dyspnea causing moderate limitations in activities of daily living</td>
<td>OSA requiring BiPAP or CPAP</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Dyspnea with physical activity not interfering with activities of daily living</td>
<td>Dyspnea causing moderate limitations in activities of daily living</td>
<td>Dyspnea causing moderate limitations in activities of daily living</td>
<td>OSA requiring BiPAP or CPAP and supplementary oxygen/ pulmonary hypertension</td>
</tr>
<tr>
<td>Mental health</td>
<td>Mald depression or anxiety that does not interfere with functioning</td>
<td>Major depression or anxiety disorder</td>
<td>Gastroesophageal reflux disease</td>
<td>Uncontrolled psychopathology</td>
</tr>
<tr>
<td>Mental health</td>
<td>Mild body image preoccupation/concern</td>
<td>Significant body image disturbance</td>
<td>Uncontrolled psychopathology</td>
<td>Uncontrolled psychopathology</td>
</tr>
<tr>
<td>Mental health</td>
<td>Mild emotional binge eating (occasional)</td>
<td>Moderate binge eating (frequent)</td>
<td>Self/physical loading</td>
<td>Uncontrolled psychopathology</td>
</tr>
<tr>
<td>Mental health</td>
<td>Developmental delay with mild impact on weight management</td>
<td>Developmental delay with definite impact on weight management</td>
<td>Severe binge eating (daily)</td>
<td>Uncontrolled psychopathology</td>
</tr>
<tr>
<td>Social milieu</td>
<td>ADHD or learning disability</td>
<td>Moderate difficulty organizing household to support needs of child</td>
<td>Unable to monitor or discipline child</td>
<td>Severe financial limitations</td>
</tr>
<tr>
<td>Social milieu</td>
<td>Occasional bullying at school or at home</td>
<td>Significant bullying at school or at home; poor school attendance</td>
<td>Unable to organize household to support needs of child</td>
<td>Severe financial limitations</td>
</tr>
<tr>
<td></td>
<td>Minor problems in the relationships of the child with one or more family members</td>
<td>Severe problems with parent, siblings or other family members, frequent arguing, difficulty maintaining positive relationships</td>
<td>Unable to organize household to support needs of child</td>
<td>Severe financial limitations</td>
</tr>
<tr>
<td></td>
<td>Caregiver is generally knowledgeable of child’s needs/ strengths but may require information or support in parenting skills</td>
<td>Need for information on parenting skills; current lack of information interfering with ability to parent effectively</td>
<td>Unable to monitor or discipline child</td>
<td>Differing financial limitations</td>
</tr>
<tr>
<td></td>
<td>Caregiver has minimal difficulty organizing household to support needs of child</td>
<td>Moderate difficulty organizing household to support needs of child</td>
<td>Unable to organize household to support needs of child</td>
<td>Differing financial limitations</td>
</tr>
<tr>
<td></td>
<td>Caregiver is recovering from medical/physical, mental health and/or substance use problems</td>
<td>Medical/physical problems that interfere with parenting; has some mental health, substance use and/or development challenges that interfere with parenting</td>
<td>Medical/physical, mental health, substance use or development challenges that make it impossible for caregiver to parent effectively</td>
<td>Differing financial limitations</td>
</tr>
<tr>
<td>Financial</td>
<td>Mald financial limitations</td>
<td>Moderate financial limitations</td>
<td>Severe financial limitations</td>
<td>Differing financial limitations</td>
</tr>
</tbody>
</table>

The E OSS-P can be applied to all children and youth with obesity. Individuals are assigned whatever stage is the highest in which they present with any metabolic, mechanical, mental health or social milieu risk factors. ADHD Attention deficit hyperactivity disorder; ALT Alanine aminotranferase; BiPAP Bi-level positive airway pressure; CPAP Continuous positive airway pressure; HDL-C High-density lipoprotein cholesterol; LDL-C Low-density lipoprotein cholesterol; MSK Musculoskeletal; OSA Obstructive sleep apnea; PCOS Polycystic ovary syndrome; T2D Type 2 diabetes; TG Triglycerides
TABLE 2
The Edmonton Obesity Staging System for Pediatrics and stage-based management plan*

<table>
<thead>
<tr>
<th>Stage</th>
<th>Management plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Ongoing monitoring of obesity-related risk factors and healthy lifestyle/behavioural counselling by the primary health care provider at regular visits.</td>
</tr>
<tr>
<td>1</td>
<td>Ongoing monitoring of obesity-related risk factors and healthy lifestyle/behavioural counselling by primary health care provider in conjunction with dietitian/mental health provider depending on individual needs.</td>
</tr>
<tr>
<td>2</td>
<td>Referral to multidisciplinary paediatric obesity clinic for comprehensive assessment; receive more intensive, family-centred counselling and lifestyle/behavioural intervention; plan regular follow-up clinical appointments.</td>
</tr>
<tr>
<td>3</td>
<td>Referral to tertiary level, multidisciplinary paediatric obesity clinic for comprehensive assessment, which may include subspecialty care to manage comorbidities; receive more intensive, family-centred counselling and lifestyle/behavioural intervention; consider complementary, intensive therapeutic options (eg, bariatric surgery); plan regular follow-up clinical appointments.</td>
</tr>
</tbody>
</table>

*Persistence in stage 1, 2 or 3 over an extended period (eg, 12 months) should result in intensification of management strategy after the exclusion of nonmodifiable risk factors.

The Edmonton Obesity Staging System for Pediatrics (EOSS-P) is a tool that helps clinicians assess and manage children and youth with obesity. It is based on the presence and degree of four main domains (4Ms) that are impacted by obesity or impact weight management:

1. **Metabolic**
   - Metabolic complications of paediatric obesity include glucose dysregulation (including type 2 diabetes [T2D]) (8), dyslipidemia (9), the metabolic syndrome (10), nonalcoholic fatty liver disease (11), hypertension (9) and, in adolescent females, polycystic ovary syndrome (12). Metabolic complications are often asymptomatic and must be screened for to be identified. Screening should begin with obesity-related risk factors and continue at 10 years of age or at the onset of puberty, if this occurs earlier, for diabetes (13). Metabolic complications of obesity can improve significantly through changes in health behaviour with minimal change in BMI (14).

2. **Mechanical**
   - Biomechanical complications of paediatric obesity include sleep apnea (15), sleep disordered breathing (15), gastroesophageal reflux disease (16), and musculoskeletal pain and dysfunction (17-18). The presence of sleep apnea and/or sleep disordered breathing can exacerbate the metabolic complications of obesity (19), have deleterious neurobehavioural effects (20), and affect appetite and food intake (21). Biomechanical complications can be barriers to weight management and affect progression (22). If left inadequately treated, biomechanical complications of obesity can promote further weight gain.

3. **Mental**
   - Children and youth with obesity are at risk for social isolation and stigmatization (23). Childhood psychiatric disorders (eg, depression, anxiety), school difficulties, body dissatisfaction, dysregulated eating behaviours, teasing and bullying have all been linked to paediatric obesity (24,25). Children and youth with obesity have consistently reported lower health-related quality of life compared with normative samples (26,27). Mental health disorders, as well as some of the pharmacotherapeutic agents that are used to manage them, can complicate weight management, promote weight gain and affect progression (28).

4. **Social milieu**
   - An assessment of the family, school and neighbourhood milieu (the social milieu) is unique to the paediatric staging system and is important given the key role that parents, family members, schools and communities/neighbourhoods play in the health and wellbeing of children and youth (24). Social difficulties and family factors, such as poor parental health, maternal depression, poor family functioning, receipt of social assistance, lack of emotional support, single parenthood and maternal drug use, have been associated with childhood obesity (24). Exposure to greater levels of psychosocial stress has been associated with higher levels of self-reported illness and negative health outcomes (29). Parental involvement and support are integral to successful paediatric obesity management (30).

**SCORING AND INTERPRETING THE EOSS-P**

The EOSS-P can be applied to children with obesity who are ≥2 years of age. The staging system is a tool reliant on clinician ratings, which are based on common clinical assessments including medical history, clinical examination and routine investigations. The EOSS-P is based on the presence and degree of the 4Ms with four stages of increasing health risk severity (0, 1, 2 and 3). The 4Ms are distinct categories, and progression in one of the categories does not necessarily coincide with a concomitant increase in the others. Individuals are assigned the highest stage in which they present with any metabolic, mechanical, mental health or social milieu risk factors.

**CLINICAL MANAGEMENT ACCORDING TO EOSS-P STAGE**

The EOSS-P enables clinicians to both assess and address four main domains that are impacted by obesity or impact weight management. It identifies complications of obesity, as well as drivers of weight gain and barriers to weight management, and informs an individualized and meaningful approach to weight management (Table 2). For patients at stage 0, the management strategy will be to prevent progression to a higher stage through the reinforcement and support of positive health behaviours. For patients at stages 1, 2 or 3, the management strategies are designed to reverse modifiable risk factors and prevent progression to higher stages. Persistence or progression within stages 1, 2 or 3 over an extended period (eg, 12 months) should trigger intensification of the management strategy, with the exclusion of nonmodifiable factors (eg, developmental delay). Below are some case examples:

**Case 1: Stage 0**

AM is a 15-year-old boy with a BMI of 35 kg/m² (99th BMI percentile, BMI z-score of 2.40). He has no metabolic or mechanical complications of obesity. He is physically active and has no functional limitations. He has a positive body image. He lives with supportive parents and their relationship is healthy.

**Suggested management strategy:** For AM, the clinical focus includes helping him to maintain a healthy lifestyle and behavioural habits. He could be followed by his primary care provider (eg, paediatrician, family physician or nurse practitioner) with expertise in paediatric weight management.
Case 2: Stage 1
BC is a 10-year-old boy with a BMI of 34 kg/m² (99th BMI percentile, BMI z-score of 2.57). He has acanthosis nigricans on examination (stage 1, metabolic). He has no biomechanical complications of obesity (stage 0, mechanical). He has attention deficit hyperactivity disorder, a learning disability and is struggling at school (stage 1, mental health). He has been bullied about his weight (stage 1, milieu). **Overall stage: 1.**

**Suggested management strategy:** BC has metabolic complications of obesity including acanthosis nigricans. The presence of attention deficit hyperactivity disorder, a learning disability may complicate weight management. The weight-based bullying is likely a major stressor, negatively impacting his engagement in physical activity and serving as a barrier to weight management. He may benefit from a specialized team to address the underlying causes and complications of obesity, which includes (at a minimum) a consultation with a paediatrician. He may also benefit from a consultation with a psychologist or social worker to explore whether academic and/or social support is available to him at school.

Case 3: Stage 2
LM is a 13-year-old girl with a BMI of 32 kg/m² (98th BMI percentile, BMI z-score of 2.19), T2D and hypertension. Her most recent hemoglobin A1c value was 6.5% (stage 2, metabolic). She has no functional limitations or self-esteem issues (stage 0, mental health; stage 0, mechanical). Her parents are separated and significant conflict exists between her mother and father (stage 2, milieu). **Overall stage: 2.**

**Suggested management strategy:** LM has metabolic complications of obesity including T2D and hypertension. Her diabetes is adequately controlled. Family stressors may complicate weight and diabetes management. She and her family would benefit from a specialized interdisciplinary team to assess and address the complications of obesity as well as provide a comprehensive therapeutic care plan. She may also require support from the diabetes team. Her family situation can be a complicating factor; therefore, mental health assessment and support would be important.

Case 4: Stage 3
DM is a 16-year-old boy with a BMI of 54 kg/m² (99th BMI percentile, BMI z-score of 3.16), impaired glucose tolerance (stage 1, metabolic) and sleep disordered breathing requiring bilevel positive airway pressure therapy at maximal settings with need for supplemental oxygen (stage 3, mechanical). He struggles with adherence to his bilevel positive airway pressure therapy. He has knee pain that intermittently interferes with his ability to be active. He lives with his mother and two siblings (stage 0, mental health; stage 0, milieu). **Overall stage: 3.**

**Suggested management strategy:** DM has metabolic complications of obesity including impaired glucose tolerance, and mechanical complications including sleep apnea and musculoskeletal pain. His poorly managed sleep problems may promote further weight gain. He may require consultation with an endocrinologist and respirologist. He would benefit from an intensive, family-based paediatric weight management program that includes a comprehensive assessment, and a care plan completed by an interdisciplinary team with nutrition, physical activity and mental health components. If available, bariatric surgery may be considered after completing an interdisciplinary six-month presurgical intervention and if adequate family/social supports exist to enable success postsurgery.

As illustrated in these cases, using the EOSS-P can provide a better conceptualization of the severity of the condition, an identification of potential barriers and strengths for the child and family, and a more comprehensive evaluation of therapeutic needs than can be identified using BMI alone.

**LIMITATIONS AND FUTURE DIRECTIONS OF THE EOSS-P**

The EOSS-P has limitations that are important to acknowledge. First, similar to the EOSS for adults, some of the concepts that comprise the EOSS-P rely on clinical acumen for purposes of measurement. Both the mental health and social milieu risk factors can be subject to variation in clinical judgment and, as new data emerge, thresholds proposed for the metabolic cutoffs may differ from the current classification system. Like the EOSS for adults, the EOSS-P does not contain a measure of readiness to change, although it may be a useful prognostic indicator. Attempts were made to stay as consistent as possible with the adult version of the tool to ensure that it would be easily transferable across age groups. Children at higher stages are likely to have greater needs from the health care system. They would, therefore, benefit from access to intensive efforts at intervention, even in the precontemplation phase with support from an expert team to help identify and address barriers to movement across the stages of change. Finally, the tool needs to be evaluated for its reliability and validity in clinical practice. This progression from establishing to testing the staging system is consistent with the adult-based EOSS, which included the original development of the EOSS (4), followed by two independent validation studies that demonstrated the value of using the EOSS versus BMI to determine health risk (2,7). Our team members are currently leading research that will enable us to replicate this sequence of reports. We are advocating, here, for increased health care resources to be directed to children with the highest EOSS-P stage, although some may argue that given the treatment resistance often observed at these higher stages, resources directed at lower or middle stages of obesity may result in better outcomes and impact a greater number of children/families. We will need long-term studies to determine whether this is, in fact, true.

**CONCLUSION**

From a clinical viewpoint, current anthropometric classifications used in paediatric obesity are limited. The adaptation of the EOSS-P was designed to provide clinical and prognostic information to help evaluate and guide weight management. The EOSS-P can help clinicians identify children with obesity who are at increased risk and may benefit from more immediate, intensive therapy with treatment stratification according to the EOSS-P stage. The EOSS-P can also inform treatment guidelines, establish differential diagnoses and be used to more clearly describe populations used in research so that generalizability of the findings could be better understood.

Children with obesity are a heterogeneous group; therefore, applying the proposed clinical staging system can help prioritize and tailor family-centred health services depending on obesity-associated health risks, which vary across metabolic, mechanical, mental health and social milieu domains.

**DISCLOSURE:** The authors have no financial relationships or conflicts of interest to declare.
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