Research Article

The Repercussions of Obesity on the Musculoskeletal System of Pediatric Patients

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Abstract

Nutrition is one of the most important factors in the growth and development of children and adolescents. According to the World Health Organization, obesity has become a worldwide epidemic and constitutes a major concern in view of the high rates of overweight and obese individuals documented both in developed countries and in the developing world. Obesity in infancy increases the risk of obesity in adulthood and results in health issues such as osteoarthritis and chronic back pain that in addition to occurring in adults may already be present in infancy. Orthopedic disorders of infancy such as slipped capital femoral epiphysis, cervical spine disorders, Blount’s disease and an increased risk of fractures may be related to weight. Overweight children have a greater prevalence of fractures and musculoskeletal discomfort and a greater risk of falls from low heights compared to children of normal weight. In view of the increasing prevalence of child obesity and the importance of understanding its repercussions on the various organs and systems including the musculoskeletal system, a literature review was performed to describe the orthopedic and musculoskeletal manifestations related to obesity in infancy, emphasizing the need for pediatricians to recognize, evaluate and adequately treat these patients.

ABBREVIATIONS

WHO: World Health Organization; SCFE: Slipped Capital Femoral Epiphysis

INTRODUCTION

The constant processes of growth and development that begin at birth and extend until adolescence are a characteristic of the pediatric patient. A variety of factors related to the individual and his/her environment may affect these processes; however, nutrition constitutes one of the most significant. According to the World Health Organization (WHO), in recent years obesity has come to be considered a genuine worldwide epidemic that is reflected in a growing concern over the increasing incidence of overweight and obese adults, the prevalence of which ranges from 10% to 40% in developed countries and has more recently also become an issue in the developing world [1]. It is estimated that, worldwide, overweight affects around 22 million children, 15.5 million of whom are of school age [2].

Obesity in infancy increases the likelihood of obesity in adult life and has been viewed as a predictor of a multitude of health problems in adults such as cardiovascular disease, type 2 diabetes mellitus, respiratory problems such as sleep apnea, liver dysfunction, cholelithiasis, polycystic ovaries and musculoskeletal disorders such as chronic osteoarthritis and back pain [3-5]. It has been suggested that some orthopedic problems exclusive to infancy such as slipped capital femoral
epiphysis (SCFE), cervical spine disorders, Blount’s disease and a greater risk of fracture may be related to weight [6-9].

A study carried out in the National Institute of Child Health and Human Development found a greater prevalence of fractures and musculoskeletal discomfort in overweight children compared to children of normal weight, the most common complaint being knee pain (21.4% in overweight children and 16.7% in children of normal weight) [9]. Overweight children were also more likely to report problems with joint mobility compared to children of normal weight [10].

As a result of difficulties with mobility and balance, overweight children are at a greater risk of falls from low heights and as a consequence of the greater force exerted on their bones during these falls, they are more susceptible to fractures [11].

In view of the increasing prevalence of child obesity and the growing interest in understanding the repercussions of this condition on the various organs and systems of the body including the musculoskeletal system, a literature review was performed with the objective of describing the orthopedic and musculoskeletal disorders related to child obesity, emphasizing the need for pediatricians to recognize the complaints and adequately evaluate and treat these patients.

Cervical spine disorders in children

During growth, the increase in bone mineral content in overweight and obese children is disproportional to their excess weight [12]. Obese children have around 12-13% less bone mineral content compared to children of normal weight [12]. The developing spine may be more flexible than the mature spine due to the absence of vertebral ossification, which only begins at around 11 years of age; however, the overload and consequent pain are a concern and their etiology may be related to bone geometry, lower back pain being less common in men, who have larger and consequently stronger vertebrae than those of women [13-15]. Since obesity is a complex trait which is both due to genetics (internal) as well as behavior/environment (external), and that the external factor can be controlled, clinicians should be active in implementing primary prevention strategies and emphasizing the dangers of excess weight in childhood and adolescence, since this would enable patients to reduce impact and stress on the spine and avoid possible complications.

Slipped capital femoral epiphysis or proximal femoral epiphysiolysis or adolescent tibia vara

Slipped capital femoral epiphysis (SCFE) is an abnormality in the usual anatomy between the head and neck of the femur [15-17]. Case studies of children with SCFE have suggested that increased body weight may be strongly associated with this disorder, and obesity rates in children with this pathology have been reported to be as high as 72% [15-17]. The relationship between obesity and SCFE is not exclusively due to the increased force exerted on the head of the femur by the stronger impact caused by increased body mass, but also because there is an increase in hip abduction in obese individuals and the force exerted on the capital femoral growth plate results in an increased risk of SCFE [14]. This also leads to the decreased femoral anteversion that occurs in obese individuals, femoral retroversion being associated with SCFE [12,18]. The severity of SCFE may be attenuated by controlling the patient’s weight, and clinicians need to use this knowledge to counsel patients on the importance of weight loss in preventing the occurrence of these complications and limiting the extent of the disease [15-21], which in most cases may require surgical treatment [21].

Blount’s disease

Blount’s disease is a growth disorder of the medial aspect of the proximal tibial epiphysis that leads to a varus deformity of the tibia [22,23,7]. It is more common in obese individuals and may occur as the infantile type (onset at 1-3 years of age), the juvenile type (onset at 4-10 years of age) or adolescent type (onset at 11 years of age or older) [24-26]. More than 90% of cases of the adolescent form of the disorder have been reported in obese individuals [27].

The disorder represents a mechanical response to pressure as a result of overload on the medial aspect of the epiphysis. The increase in the dynamic impact loading conditions related to changes in gait is added to the excess body weight and may result in sufficient force to alter the growth of the epiphysis and lead to the development of tibia vara [7,24]. The principal symptom of this disorder is a bowing of the legs and in the initial phase of the infantile type is often confused with physiological bowleggedness; however, whereas the latter condition tends to rectify itself as the child develops, Blount’s disease is progressive and may even lead to degenerative arthrosis [24].

In adolescents, gait disorders resulting from increased thigh perimeter due to obesity have been implicated in Blount’s disease; nevertheless, it is questionable whether obesity alone is responsible by affecting endochondral ossification, because other factors might contribute to incidence of Blount’s disease, there is suggestive evidence that individuals with African ancestry are more prone to Blount’s disease, pointing to genetic makeup as a key contributor, considering the low incidence of tibia vary in the general population and since Blount’s disease, although more common in obese patients, is not exclusively restricted to this group [27,28].

Fracture risk

The peak period for the incidence of fractures in children coincides with the rapid growth phase, since the metaphyseal/diaphyseal density ratio is lower during this period, and the dissociation between longitudinal growth and increased mineral content determines bone fragility and changes in bone quality and micro architecture [29]. Obesity at this time may increase the risk of bone fractures during falls, since the developing bone cannot cope adequately with the excess weight [30]. This weight/bone mass imbalance may lead to high levels of tension in the growing bones and articulations and may result in a joint lesion, contributing towards osteoarthritis [30]. It is useful to remember that lack of exercise may be a factor in the pathogenesis of obesity, contributing to the risk of fracture [31]. In addition to these factors, postural stability and balance have been suggested as possible problems in overweight and obese prepuberal boys and adolescents, and these conditions may also contribute towards a higher risk of fractures [32,33].
Abnormalities in the structure of the foot

Medial longitudinal arch height is a primary criterion for classifying the structure of the foot and is considered to represent a parameter by which to gauge the effective functioning of the feet and lower limbs [34]. It has yet to be fully clarified whether the larger dimensions of the foot reported in obese individuals represent splay-foot resulting from greater body mass or merely a consequence of an increase in the dimensions of the soft tissues because of the greater fat mass, or a combination of both [27]. Studies evaluating indirect measurements of medial arch height using electronic sensors show a smaller longitudinal arch typical of the obese individual, characterized by increased contact with the sensor in the case of obese patients with flat feet and foot pronation, increasing the potential for a musculoskeletal lesion; however, other studies in which direct clinical measurements were used failed to confirm this finding [25-27,35].

It is probable that the larger size of the foot may make it difficult for obese individuals to obtain comfortable shoes due to anthropometric modifications in the foot, including the configuration of the arch [36]. In fact, other factors such as plantar pressure and plantar surface vibration have also been shown to have an effect on the comfort levels of shoes and this may be an item of interest for future studies in obese individuals [26,37].

Changes in bone density

Over the past ten years, the prevalence of obesity and osteoporosis in public health issues has been growing. Obesity and osteoporosis are associated with significant morbidity and mortality and may be the result of deregulations of a common cell precursor [38].

Osteoporosis is a disorder characterized by skeletal fragility and a reduction in bone quantity and quality [39]. Fractures in children have been associated with changes in body composition (such as increased adiposity) and bone structure, suggesting that they may represent early signs of skeletal deficiency [40]. Any process that affects the balance between bone formation and resorption may lead to a reduction in bone mass, an alteration in bone architecture and a greater propensity for fractures [38]. Osteoblasts and adipocytes originate from a single hematopoietic lineage and adipocytes secrete paracrine and endocrine factors that affect the functions and activities of neighboring cells. Some of these factors such as leptin, adiponectin, adipin and inflammatory cytokines may affect and alter bone remodeling [41].

There is a positive association between body weight and bone mass that may be attributed to several possible mechanisms: greater body weight increases the mechanical impact on the skeleton, the combination of fat mass with the bone-regulating hormones secreted by the pancreas (insulin, amylin, resistin and preptin) and bone-regulating factors secreted by the adipocytes (estrogen, leptin and adiponectin) [42]. The relationship between body weight and bone mineral density is complex and depends on the patient’s age, sex and ethnic group [38].

It is important to emphasize that body weight is composed of fat mass, muscle mass and bone mass; therefore, the correlation between body weight and bone mass does not necessarily reflect

the relationship between obesity and osteoporosis, bearing in mind that the definition of obesity is an excess fat mass in relation to total body weight [43].

A study carried out in Chinese and Caucasian cohorts found a negative correlation between fat mass and bone mass when the effect of the mechanical impact of body weight was statistically removed, the risk of osteoporosis, osteopenia and fractures being significantly higher in individuals with a higher percentage of body fat irrespective of body weight [44]. This finding has a significant clinical implication, since it would appear to suggest that treatment for obesity may increase bone mass, thus protecting the individual against osteoporosis [44].

Adult bone strength is a consequence of factors regulating the bone quality and density that was acquired during infancy and adolescence [45]. Although there is some evidence that excess weight is associated with better bone development in children and adolescents, child obesity was found to be related to a relatively lower bone mass when results are corrected for the effects of age maturation and size. Excess weight in children has also been related to a reduction in bone strength, greater stress and a higher risk of fracture [46-49]. Again, reduced physical activity in obese individuals may be relevant and the relative reduction in bone mass in obese children and adolescents may also be an effect of the lower levels of physical activity in this population [40,50,51].

Alterations in postural balance

Obesity may affect postural performance by altering the strength of the articulations required to stabilize the body [52,53]. Studies on postural balance in children are based on clinical measurements of stability and therefore offer sparse information on the association between child obesity and the regulation of anteroposterior and mediolateral balance [54]. Some authors propose that because the characteristics of the strength vectors remain relatively unaltered by adiposity, the decreased stability found in obese children is usually the result of the greater inertial properties of adipose tissue rather than damage to the postural control system [55]. In view of the association between obesity and physical inactivity, it remains unclear whether the additional mass associated with obesity results in reduced postural stability or whether the higher adiposity in the obese individual is a consequence of postural instability and reduced physical activity [53,56].

Alterations in muscle strength and potency

Although studies have frequently shown that obese children and adolescents have similar or greater absolute strength in the muscles of the trunk and upper limbs, absolute measurements of muscle strength do not take into account the increase in muscle strength that occurs with maturation and are confounders due to the concomitant increase in free fat mass that is frequently, but not always, associated with childhood obesity [57,58].

According to Riddiford et al., obese children are hampered in performing standing long jumps and in tasks involving vertical jumps [59]. When adjustments are made for body weight, obese adolescents are found to have less strength in the knee extensor and the flexor of the elbow joint [60] and low power in cycling,
jumping and stair-climbing activities [61] Nevertheless, despite probable hypertrophy in the lower limb muscles, obesity is characterized by a decrease in muscle strength [62,63]

When strength characteristics are evoked electrically, the differences in the intrinsic strength of obese adolescents and those of normal weight disappear [59,62], suggesting that in maximum voluntary contraction, the reduction in strength represents a decrease in motor unit activation that depends on various factors, among them, physical activity levels [64]. Therefore, a reduction in strength combined with childhood obesity may reflect a lower level of physical activity and muscle reconditioning together with the additional gain in mass associated with adiposity [55]. Evidence suggests that inadequate muscle strength, principally in the lower limbs, may limit the performance of routine tasks such as standing on one foot and may predispose the individual to a greater risk of fatigue and musculoskeletal lesions [65].

Gait alterations

Obese children tend to walk slower compared to children of normal weight [62,63]. In addition to a concomitant decrease in the length and frequency of steps, the reduction in walking speed seen in obese children is characterized by longer single- and double-support phases, together with a shorter balance phase compared to children of normal weight [62,63,66-68]. These changes have been interpreted as representing an underlying instability in the obese individual, whose walking pace is slower and in whom there is a longer double-support phase to help maintain dynamic balance [62]. In view of these findings, it is speculated that obese children have a greater risk of falling and that their gait characteristics may be indicative of impaired postural stability [55]. On the other hand, the shorter balance phase seen in obese children may represent a shortening of the inverted pendulum model as a result of a relatively larger accumulation of mass in the thigh segment [55].

A faster than usual walking speed has been shown to have a higher energy cost in obese adolescents compared to thin adolescents matched for weight [69]. This higher metabolic cost has been partially attributed to a higher cost in ventilation and, with the additional gain in mass associated with adiposity [55]. Evidence suggests that the gait characteristics of obesity may contribute towards an improvement in osteoarthritis in young adults or older persons when added to other factors such as physiological bone degradation [77-79].

CONCLUSION

Childhood obesity can cause a number of problems for the health of children with consequences in adulthood, among them stands out type 2 diabetes mellitus, musculoskeletal problems, respiratory problems, liver dysfunction, heart disease, high blood pressure, cancer, low self-esteem, polycystic ovaries, among others. The consequences of childhood obesity on the development and function of the musculoskeletal system have received scant attention and require further investigation. Indirect evidence suggests that the alignment and structure of the hip, knee and foot may suffer the effects of overweight and obesity in childhood; however, the effect of these changes in the young adult remain to be fully clarified. The effect of childhood obesity on the structure of connective tissue has been well-defined; however, the effects on the skeletal system remain controversial and further studies are required to define the effects on the musculoskeletal structure in terms of mass, adiposity, anthropometry, metabolic effects and physical inactivity or combinations of these factors. Postural changes, continuous mild and severe trauma, tendonitis, arthritis, deformities of the hip, knee or foot and disorders of balance, among others, are common in overweight and obese children and adolescents. Children in general and obese children in particular are more likely to suffer lesions. Postural abnormalities such as genu valgum and scoliosis, lesions resulting from excessive use such as osteochondritis and epiphysitis, and severe trauma such as dislocation's, sprains and fractures, are some of the most common problems of the locomotor system resulting from physical activities and are more common in obese individuals. It is generally accepted that the principal priority in the treatment of obesity is to maintain the individual functionally mobile, bearing in mind that high body fat levels increase impact on the musculoskeletal system and may result in pain and discomfort and future limitations in mobility, hampering physical activity.

Overweight children and adolescents should be encouraged to participate in alternative forms of physical activity such as riding a bicycle or swimming that may potentially attenuate the effect and excessive gravity of their weight and the discomfort in their lower limb joints [29]. Efforts should be made to encourage healthcare providers to recognize the orthopedic complications resulting from excess weight so that early interventions may be
implemented. Physicians and physiotherapists should be fully aware of the articular and orthopedic consequences of obesity and clinicians should educate and warn children and their families of the health problems and their short and long term sequelae. Today, there is a growing tendency towards a sedentary lifestyle that promotes obesity coupled with a lack of public spaces for recreation and inadequate public safety that obliges children and adolescents to stay more and more at home, where the options of sedentary leisure activities include television, videogames and computers. Genetic factors and the formation of habits at an early age would appear to be important for the individual to adopt active behavior throughout life. Moreover, obese children are under emotional stress and disinclined to practice any form of physical activity that would require exposing their body, which is almost always a reason for ridicule. As a natural result, these children tend to avoid physical activity. Pediatricians should realize that children who reach this stage should be helped emotionally and these professionals play a fundamental role in identifying and adequately counseling these patients, stimulating them to lose weight and to participate in appropriate physical activity, providing them with detailed nutritional guidance and following them up at regular intervals.

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