LOWER EXTREMITY REVIEW – July 2012

Pediatric obesity weighs on growing bones, joints

Photo courtesy of Louis DeCaro, DPM.

Exercise is the standard prescription for obesity. But alterations to joint biomechanics, gait, and anatomical structure in overweight children and teens mean that physical activity comes with its own risks, which practitioners must factor into any clinical recommendations.

By Christina Hall Nettles

Overweight children are everywhere we look: in documentaries being bullied, in fashion magazines being celebrated or vilified, and in our clinics, complaining of pain in the foot, ankle, and knee.

In 2010, among children and adolescents aged 2 to 19 years, more than five million girls and about seven million boys were obese, defined as a body mass index (BMI) greater than or equal to the age- and gender-specific 95th percentiles of the 2000 Centers for Disease Control and Prevention growth charts.[1] Comparatively, obesity in adults is a BMI (weight divided by height [kg/m^2]) of 30 or greater.

Research has shown reducing sedentary behaviors lowers obesity in school-age children, and limiting television and videogame time to two hours or less in children aged 8 to 12 years has proven extremely effective, with lifestyle intervention successes especially notable in rural areas.[2]

When overweight children present with painful hip, knee, foot, or ankle conditions, however, clinicians must develop a treatment approach that addresses the injury or pain while acknowledging that conventional models for confronting obesity may actually complicate existing lower extremity issues.

“Underlying the complex medical and mechanical diagnoses in overweight children is the simple truth that the extra weight in obesity aggravates every joint, causing insidious biomechanical problems that are easy to ignore when focusing on diabetes or cardiovascular health,” said Chicago sports medicine podiatrist Robert A. Weil, DPM. He

hosts a weekly sports medicine radio show and a podcast, “Kids Beating Obesity,” that emphasizes a functional approach encouraging physical activity and strengthening.

“A belittled child is never going to perform well. But a self-motivated child will,” he said.

Weil and podcast cohost Rick Osbourne, a veteran physical educator and creator of the Pull Your Own Weight program, identified a group of 492 students in the second through fourth grades who could all perform at least one conventional pull-up. Osbourne found that all of the 202 girls and 98% of the 290 boys had BMI scores of less than 30.

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“In other words, the odds of kids who can perform pull ups being obese are almost zero,” Weil told *LER*. “With access to the right experiences, most [obese] kids can develop the ability to do pull ups in less than one school year. It’s simple and affordable. In that light, most kids can naturally immunize themselves against obesity by developing and maintaining—via good eating and exercise habits—the ability to physically pull their own weight.”

However, Weil acknowledges some physical activities have the potential to aggravate overweight children’s lower extremity issues, especially pain.

“Any running or jumping activities will have negative biomechanical effects on all foot, ankle, and knee areas—compounded by excess weight,” he said. “The pull-up concept, although initially concentrating on the upper body, then has a direct effect on stresses to lower extremity areas. If we can encourage children to develop their upper body strength with a goal of doing a single pull up, their fitness and their confidence will soar as ‘wear and tear’ and stress on their feet, legs, and back decrease.”

Flat feet, fat feet

The pediatric obesity issue that comes up most often among lower extremity practitioners may well be flexible flatfoot, though even the potential link between obesity and flexible flatfoot in children is controversial. For example, flexible flatfoot was diagnosed in 56% of obese children versus 27% of normal-weight children in a 2009 Taiwanese study.[3] But an Australian study of 140 children found body mass and flat feet were not correlated, and suggested

that differences in arch height assessment techniques and participant ethnicity may have contributed to the positive correlations reported in earlier studies.[4]

Some practitioners, such as Weil, who specializes in making custom foot orthoses for amateur and elite athletes, recommend custom sport-specific foot orthoses for almost all children involved in physical recreational activities to improve performance and reduce overuse injuries.

“Kids with flatfoot or collapsing of the arch who are told to increase activity, perhaps adding running or jumping, are going to complain because it hurts,” Weil said. “Orthotics can bring the foot into optimum biomechanical alignment. My goal is to capture the neutral position using materials with the right combination of strength and flexibility to achieve that balance.”

Some strict evidence-based medicine practitioners caution that early orthotic intervention may not show a greater benefit in children who are asymptomatic. In fact, a Hong Kong study that found obese children were significantly slower to respond to orthotic therapy: their Staheli arch index improvement was nearly 70% slower than nonobese children (see “Obesity impairs children’s response to orthotic therapy for flexible flatfoot”).

Researchers from the University of Wollongong in New South Wales, Australia, recently found obese children have flat and fat feet, with lower arches than healthy weight cohorts.[5] The same group determined that additional medial midfoot fat padding in obese children reflected their excess mass but did not appear to be an adaptive response to cushion pressures associated with extra body mass. Further investigation is required to identify probable short- and long-term functional limitations resulting from increased pressures generated beneath the feet of obese children when walking, the group concluded.[6]

Lead author Diane Riddiford-Harland, PhD, noted that the developing feet of overweight and obese children may be at risk for pain, discomfort, or dysfunction due to the high plantar pressures generated by their excess body mass. She also has cited a need for interventions designed to reduce pressures generated beneath the feet of overweight and obese school-aged children while still encouraging them to participate in adequate levels of physical activity.

Flexion and gait

Overweight children tend to walk more slowly and with greater perceived exertion than their healthier cohorts, and may take fewer steps than their nonobese classmates or friends, said Sarah Shultz, PhD, ATC, a lecturer in exercise and sport science at Massey University in Wellington, New Zealand, and lead author of a recent review article on childhood obesity and walking.[7] Shultz’s research focuses on orthopedic complications and biomechanical implications of childhood obesity, working toward evidence-based exercise prescriptions that are metabolically effective and physically safe.

In a study published earlier this year in the *Journal of the American Podiatric Medical Association*, Shultz and colleagues found that 10 obese children demonstrated significantly less active ankle dorsiflexion at 90° of knee flexion than 10 nonobese children.[8] This limited ankle dorsiflexion, which may reflect dorsiflexor weakness, increases time spent in stance during gait, Shultz said.

“During swing, when foot activity is controlled by muscle, not contact forces, it may be too difficult for the obese child to maintain appropriate dorsiflexion. This would lead to an earlier occurrence of plantar flexion during swing phase,” she said.

Increased contact time during stance may also be related to postural control, Shultz said.

“Obese children are often linked with a decreased sense of balance or stability,” she said. “Because of this lack of dynamic stability, an obese child will try to proceed very quickly through swing phase and then slow down and spend as much time as possible in double-support stance phase. This explains the increased foot contact for a longer period of stance phase, the decreased time in swing phase, and simultaneous increased time in stance phase.”

Earlier research from the University of Queensland suggests that obese children walk with less knee and hip flexion than their normal-weight counterparts.[9]

“The lack of stability also causes individuals to hold themselves more rigidly, in an effort to gain better control over balance, which helps explain a lack of hip and knee flexion during walking,” Shultz said. “When this early plantar flexion is combined with a lack of hip and knee flexion, toe clearance is reduced, which can often lead to gait changes in the frontal plane as a way for the obese child to walk without dragging his feet.”

Shultz and colleagues have also found that overweight children have significantly higher peak joint moments at the hip, knee, and ankle during gait than normal-weight children.[10]

These increased joint moments would seem to underscore the perception that obese children have a higher risk of injury than nonobese children when participating in any activity that is weightbearing and requires movement of the whole body mass. But Shultz says it’s not that simple.

“Obese children have greater difficulty with walking and more complaints of musculoskeletal pain. That does not mean they will definitely injure themselves, and it should not be used as an excuse to avoid being physically active; it just means we need to know more about the biomechanics of obese children during exercise so that this injury risk can be diminished,” she said.

Similarly, in a 2010 study in *Gait & Posture*, researchers from East Carolina University in Greenville, NC, reported gait changes and observed differences in frontal plane kinematics during walking between obese and healthy-weight boys.[11]

“Boys who were overweight collapsed into hip adduction and knee valgus during stance and attempted to compensate with rearfoot inversion,” said lead author Amy Gross McMillan, PhD, PT, associate chair of the Department of Physical Therapy at East Carolina University.

The study raised concerns about whether these stressful movement strategies might affect maintenance of lower extremity structural integrity over time.

Knee flexion was a key component in a Chinese study comparing ankle and knee joint proprioception in boys aged 7 to 12 years with a BMI greater than 25 kg/m^2 to those with a BMI of about 16 kg/m^2. Researchers saw little difference in proprioception between the two groups during ankle movements or knee extension, but found that, during knee flexion, obese boys showed much poorer proprioception, which may be associated with decreased postural control.[12]

Musculoskeletal disorders

Obesity in children and adolescents has been linked to musculoskeletal disorders, including slipped capital femoral epiphysis (SCFE), tibia vara (Blount disease), and osteoarthritis.[13]

SCFE is more likely to occur in boys than girls, and in overweight patients. It typically occurs during adolescence and preadolescence, but clinicians are seeing SCFE more frequently in younger children and obese patients.[14-16]

Adolescent Blount disease may be linked with obesity because abnormal force pressures the medial tibial growth plate, decreasing growth and potentially causing varus deformity or significant malalignment that requires stapling or surgical intervention. Excess force or joint loading may also lead to osteoarthritis in overweight teens.

Obesity and injury

Pediatric emergency medicine physician Wendy Pomerantz, MD, and colleagues published a 2010 study in *Pediatrics* that found the ratio of lower extremity injuries to upper extremity injuries was higher in obese children than in nonobese children.[17] The authors also found that obesity and injury epidemics are rising in tandem and with disproportionate frequency among economically deprived and minority children.

“The most common lower body injuries were sprains,” said Pomerantz, a professor of clinical pediatrics in the Division of Emergency Medicine at Cincinnati Children’s Hospital. “Because obese patients have an increased body mass and force, they are more likely to twist or roll on a lower extremity and cause injury than nonobese children. The ankle bears the weight of the body. In obese children, it bears more weight, which may increase injury potential. In addition, obese people may have poor balance, which may result in more injuries.”

With study coauthor Michael Gittelman, MD, Pomerantz is codirector of the Injury Free Coalition for Kids in Greater Cincinnati, which works to reduce injuries by providing children with safe playgrounds and engaging them in supervised coordinated activities to minimize injury risk. She advises care for overweight children when beginning physical activities.

“Begin slowly, with low-impact activities to reduce the risk of injuries. Activities with less impact on lower extremities, such as swimming, should be encouraged,” she said.

After sprains or more serious ankle injuries in obese children, rehabilitation and follow up is critical. One study in *Archives of Pediatric and Adolescent Medicine* found that as BMI increased, so did long-term morbidity associated with ankle injuries. Six weeks after an ankle injury obese children (BMI in the 95th percentile or higher) demonstrated more persistent pain, swelling, or weakness and had a higher risk of reinjury than less overweight participants. More than 50% of obese children complained of pain, swelling, weakness, or reinjury six weeks following an ankle injury. Six months postinjury 46% of the obese children had persistent symptoms, compared with 29% of children with lower BMI.[18]

Although dual-energy x-ray absorptiometry scans indicate overweight children have greater bone density than their normal-weight counterparts, the heavier children are more likely to suffer fractures because they are likely to fall with greater force than normal weight children, some research suggests.[13]

Other studies have shown that obese children also suffer more morbidity following trauma and surgical procedures. A 2009 retrospective study of pediatric trauma patients found that 55% of obese children had extremity fractures compared with 40% of nonobese children and that 42% of obese children required orthopedic surgical intervention compared with 30% of healthy-weight children.

Further mirroring adult obesity trends, the overweight children were more likely to have elevated systolic blood pressure upon arrival and had a higher risk of complications, including a higher incidence of deep vein thrombosis and decubitus ulcers.[19]

Treatment plans

Preventing obesity and injury are key strategies for families, schools, and communities. Until these twin epidemics show significant declines, physical therapy may address both issues when the opportunity arises.

Gross-McMillan notes the key to a successful treatment plan is specificity, as well as individualization of a physical activity for each child or teen.

“As a physical therapist, my exam of the individual’s structure and movement leads to specific recommendations. This is sometimes as simple as explaining how to select a really supportive pair of athletic shoes, or perhaps recommending over-the-counter or custom orthotics to be worn while being active,” she said. “Then I listen to what that individual enjoys or has enjoyed and help them set goals, such as making a plan to improve the time or intensity of that favored activity. In all recommendations we consider individual musculoskeletal structure and movement patterns and avoid activities that would put excessive stress on growing and developing joints.”

For clinicians, Shultz noted, it is important to focus on strengthening exercises, particularly for the dynamic stabilizers of the knee and the ankle dorsiflexors.

“These are often exercises that an obese person can perform without cardiovascular strain or constant orthopedic impact,” she said. “Activities to increase balance and proprioception may also help improve physical activity function in obese children. Because of the difficulty that obese children have in activities that involve moving their body weight, it is important to recognize nonweight-bearing activities will lower the already increased impact on joints.”

Prevention and predisposition

Obesity prevention strategies are becoming more relevant as a growing body of research suggests the earliest environmental and genetic influences have a tremendous impact upon childhood obesity. Prenatal characteristics that may predispose children to early presentation of overweight include race, ethnicity, maternal smoking while pregnant, and prepregnancy obesity.[20] Prenatal exposure to endocrine-disrupting chemicals (such as pesticides and industrial pollutants) has also been linked to childhood obesity in the very young.[21]

Modeling healthy lifestyles in schools, communities, and homes and prospectively engaging socioeconomic populations at risk for both obesity and injury will improve short-term outcomes. But as obese children—including those who return to a healthy weight—develop anatomically, more research is needed to determine obesity’s long-term effects.

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