The Biomechanical Implications of Obesity in K-12 Learners

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Few studies have targeted the musculoskeletal and mechanical implications of excessive weight.

It is not a primary purpose of the biomechanics specialization to "combat" disease, but rather to examine how people move and suggest alternatives to the movement pattern that will enable the performer to become a more skilled mover. As a result, the biomechanics literature concerning obese individuals is descriptive in nature and often anecdotal. There are few biomechanical studies that have examined obese individuals as primary subjects. What is known from the biomechanics perspective appears to be primarily musculoskeletal. However, some literature exists that identifies mechanical differences between overweight or obese individuals and "normal" movers. The following review is not exhaustive, but should provide readers with a starting point for further examination.

Musculoskeletal Concerns

Due to the complex nature of musculoskeletal diseases such as osteoarthritis, most of the biomechanical treatises on this subject seem to be anecdotal. To specify obesity as the cause for some of these musculoskeletal problems is a great stretch. What follows is a brief synopsis of biomechanically related explanations for problems that may be caused by obesity.

Osteoarthritis. Osteoarthritis (OA) is a degenerative disease of the musculoskeletal system that presents deterioration of the articular cartilage, joint space narrowing, mild hypertrophy of the bone, and eburnation (conversion of bone to a dense ivory-like substance; Martel-Pelletier, 2004). The causes of OA include factors such as genetics, hormone balance, age, gender, ethnicity, bone metabolism, nutrition, sport participation, injury, skeletal alignment, muscle weakness, joint laxity, joint proprioception, and obesity (Wearing, Hennig, Byrne, Steele, & Hills, 2006a, 2006b). Due to the complex nature for the onset of OA, it is very difficult to determine direct cause-and-effect relationships. It is hypothesized, however, that obesity can contribute to the development and progression of OA in the knee and hip (Felson, Goggins, Niu, Zhang, & Hunter, 2004). Under normal load (non-obese individuals), compressive loads for walking might be three to six times body weight. Obesity can create more loading and more persistent loading of the joints during locomotion when compared to the non-obese individual.

Syed and Davis (2000) found that decreased muscle strength relative to body weight in obese individuals may induce earlier fatigue in the knee, which has been shown to reduce shock attenuation, increase load rate, and increase knee motion variability. Messier (1994) reported that body mass index (BMI) was related to all loading factors of ground reaction forces for osteoarthritic individuals, except for the rate of loading. These two studies report different findings for load rate. Body mass index has also been found to be positively associated with joint space narrowing (Sharma, Lou, Cahue, & Dunlop, 2000). Stress distribution on the tibia as a result of varus malalignment will also focus a greater load on the medial compartment of the knee (Wearing et al., 2006a, 2006b). Each of these may accelerate the onset of OA.

Plantar Heel Pain. Plantar heel pain (i.e., heel spur syndrome, plantar fasciitis) is a relatively common disorder of the foot in which pain occurs where the plantar fascia inserts into the calcaneus. While the direct cause of this pain is difficult to pinpoint, Riddle, Pulisic, Pidcoe, and Johnson (2003) reported that obese individuals are five times more likely to have plantar heel pain. The cause of the high incidence of plantar heel pain in obese individuals is speculative, but the possibilities include lower arch structures, an increased magnitude of rearfoot pronation during walking, and increased rates of rearfoot pronation during walking, which have been observed in obese individuals (Messier & Pittala, 1988).

Obesity and Fracture. Obese children have been shown to have wrist and arm fractures twice as often as children of normal weight (Goulding, Cannan, Williams, Gold, & Lewis-Barned, 1998). This could be caused by an increase in mass, lower bone-mineral content, relatively lower cross-sectional area of the radius (Goulding, et al., 1998), a lifestyle that is not conducive to the promotion of bone gain (Weiler et al., 2000), less skill at falling or clumsiness (Petti, Cairella, & Tarsitani, 1997), decreased relative muscle strength, decreased balance, lower activity levels (Davidson, Goulding, & Chalmers, 2003), or carrying the weight of an adult on a child's skeletal structure (Goulding, Taylor, Jones, McAuley, & Manning, 1998). Also, obese children seem to be predisposed to an increased risk of hip fracture as they age (Maffeis & Tato, 2001).

Davidson, Goulding, and Chalmers (2003) found that in falling, the first peak impact force between non-obese and obese boys did not exhibit significant differences. However, the second peak impact force was significantly greater in obese boys. It was surmised that the second peak impact force was greater because this was when the body's weight was absorbed by the fall. Softer surfaces did not seem to disperse forces any better than hard surfaces. This could be due to the fact that the first peak impact depleted any cushioning effect the surface may have provided. They concluded that obese children are at greater risk of arm fracture, that this risk increased when the fall was shortened, and that the risk was the same for non-obese children when the surface was made softer.

Mechanical Concerns

The literature base for the mechanical concerns of biomechanics that deals specifically with obese populations is extremely limited. The tendency in biomechanics is to examine movement and movers, but, to date, very little emphasis has been placed upon the somatotype of the performer. Generally, emphasis is placed on efficiency and the most skillful execution of the movement. Balance and gait have been examined to some extent. Obviously, further investigations should be completed before any concrete conclusions can be made about obese movers.

Balance. Static balance between obese and non-obese individuals is not significantly different. Obese individuals, however, show greater instability than their non-obese counterparts during dynamic and one-foot balance trials (Goulding, Jones, Taylor, Piggot, & Taylor, 2003). McGraw, McClenaghan, Williams, Dickerson, and Ward (2000) compared balance parameters between obese and non-obese prepubescent boys and found that antero-posterior balance in these populations was comparable. However, obese boys showed greater medio-lateral instability. This was speculated to occur as the result of the larger size of the obese individual, which creates larger inertial qualities for the limbs and trunk. Relatively weaker muscle strength based on size could also play a role in the medio-lateral instability of the obese individual.

Gait. In a series of investigations, Hills and Parker (1993) found that obese children with slower walking speeds decreased their step lengths and step frequencies, and increased their time of single and double support phases. The findings of McGraw et al. (2000) support the data provided by Hills and Parker. McGraw et al. (2000) and Goulding et al. (2003) also found that obese children show more medio-lateral instability than their normal-weight counterparts.

Summary

As we can see, investigations aimed at explaining biomechanical variables in obese children are limited. In view of the multifaceted risk factors (one of which is obesity) that lead to OA, it is difficult to draw conclusions about how obesity affects the onset of OA from a biomechanical perspective. Mechanically, limited studies have been done on balance and gait, and further study is needed to better understand the limitations that obesity places on walking and standing, as well as on other movements.

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~~Battling the Bulge with the Bottom Line~~

~~Effective teachers know and teach exercise science and other factors that underlie a healthy, active lifestyle and battle hypokinetic diseases such as obesity. At the same time, they need to inform students rather than scare them, to inspire rather than preach, and to be inclusive rather than exclusive. They are not training athletes, but educating active, healthy citizens. Teachers should be careful with how they portray body composition. Everyone's body is different. Children need to be taught to accept their body, not *force* it into a certain percent body fat or BMI, or give up on it if it cannot achieve that measure. Students need to know that a person can have a higher percent body fat and still be healthy through a healthy diet and an active lifestyle, and that a person can have a lower percent body fat and still be unhealthy due to an unhealthy diet and a sedentary lifestyle.~~

~~The real focus *must* be on physical activity levels, nutrition, and lifestyle, and not just on percent body fat or weight. If teachers focus on percent body fat or BMI, they will send the wrong message to students about their body and how to care for it. Students need to know and be able to do what makes them healthy. Of course, they should know what a "healthy" body weight or composition is. However, the critical thing is to know how to eat healthy, what to do to improve health fitness, and that eating this way and doing these things *will* lead to better health, no matter what those "other numbers" say.~~

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