Weight-Bearing Exercise in Youth and Its Effect on Bone Mineral Density in Adulthood

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Abstract

This paper explores the importance of developing peak bone mass through weight-bearing exercise in children in attempt to reduce the risk of bone fractures later in life. Within this paper are four clinical trials that are used to express the positive relationship between weight-bearing exercise and developing bone mass, as well as, one clinical trial on weight-bearing exercise and its effect on decreasing fracture incidence. Using these clinical trials, this paper examines the direct relationship of weight-bearing exercise to develop peak bone mass in children, to reduce the risk of bone fractures later in life. Along with the clinical trials, this paper explains why osteoporosis is a major public health issue. Additionally, this paper describes a myriad of additional ways to develop peak bone mass and the importance of doing so, as well as, the many different factors that cause osteoporosis.

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**Introduction**

Osteoporosis has been defined as, “a systemic skeletal disease characterized by low bone mass and architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fractures" (Hawker, 1996). When all of these 3 factors come together resulting in a low trauma fracture, the diagnosis of osteoporosis is given. Osteoporosis and low bone density represent a significant health concern in the United States and throughout the world. According to the National Osteoporosis Foundation, an estimated 10 million people living in the United States today have “osteoporosis” (“Learn What Osteoporosis is,” n.d.). Another estimated 34 million are at risk for having low bone density (known as “Osteopenia”). In total, half of all women over 50 in the United States, fall into the category of having osteopenia or osteoporosis. In addition, 6% of men over 50 have osteoporosis and another 33-47% have osteopenia (“Learn What Osteoporosis is,” n.d.). Each year, an estimated 1.5 million individuals suffer a fracture due to such bone diseases. The lifetime risk of fracture shows that over 53% of women 50 years and older, and over 20% of men 50 years and older will experience a fracture, making this a major public health issue (“Learn What Osteoporosis is,” n.d.). All humans are at risk for osteoporosis, however, Caucasians are reported to have lower bone density than other ethnic groups, yet, none of us are immune to modern day bone weakening (“Learn What Osteoporosis is,” n.d.). Though this is a major global public health issue, there are a myriad of factors that can decrease the incidence of osteoporotic fractures significantly. Developing peak bone mass through weight-bearing exercise in childhood is a major factor that helps to decrease the fracture incidence later in life.

**Background on Osteoporosis**

**Causes of Osteoporosis**

There are a many factors that are known to contribute to the development of bone. Nutrition and eating patterns are important, exposure to sunlight and vitamin D levels are also very important as well as, endocrine issues and healthy hormonal status. Lifestyle factors also play a role in bone development, as does exercise (Looker & Frenk, 2015). These are all very important when we consider optimal bone development. One of the most outstanding causal factors, however, is the failure to develop peak bone mass during the adolescent and teen years. Roughly half of the adult bone mass is laid down during the teen years and up to 25% is formed during the puberty spurt, puberty growth spurt (Loud & Gordon, 2006). Childhood and teenage years are a very important time for bone development. Bone mass attained in early life is thought to be the most important modifiable determinant of lifelong skeletal health. The higher the peak bone mass in youth, the lower rate of osteoporosis and needless fracture as one ages (Loud & Gordon, 2006).

**Importance of Developing Peak Bone Mass**

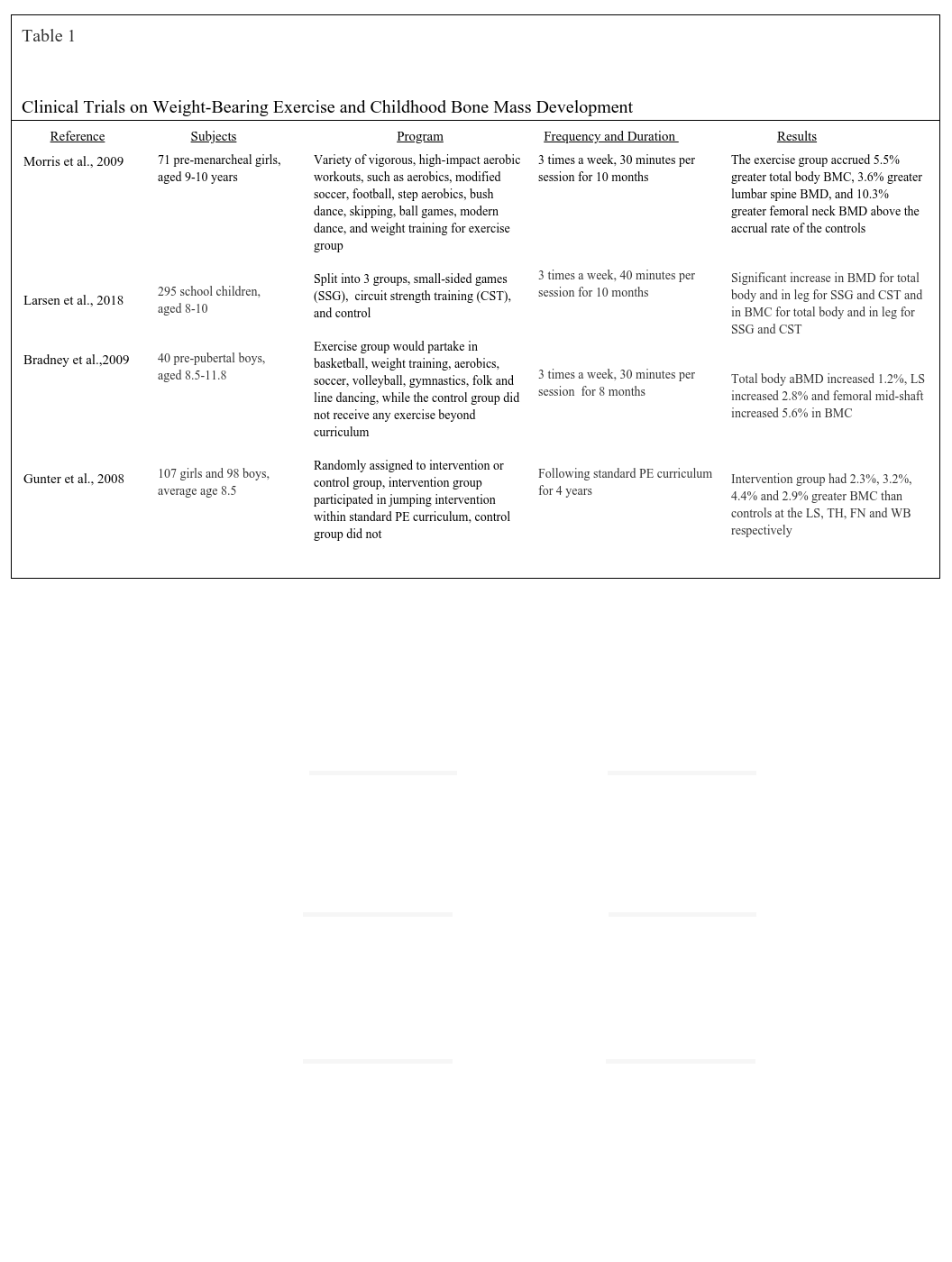
Developing peak bone mass is extremely important for a variety of reasons. A 5-10% increase in peak bone mass in young adolescents can translate into a 50% reduction in risk of fractures in older years (Brody, 1994). These reductions can add up to extraordinary financial, emotional, and physical savings. Additionally, a theory suggests that the effect of increasing childhood bone mass by 10% would delay postmenopausal osteoporosis by approximately 13 years. However, there is not enough sufficient data in order to prove this theory. (Loud & Gordon, 2006).

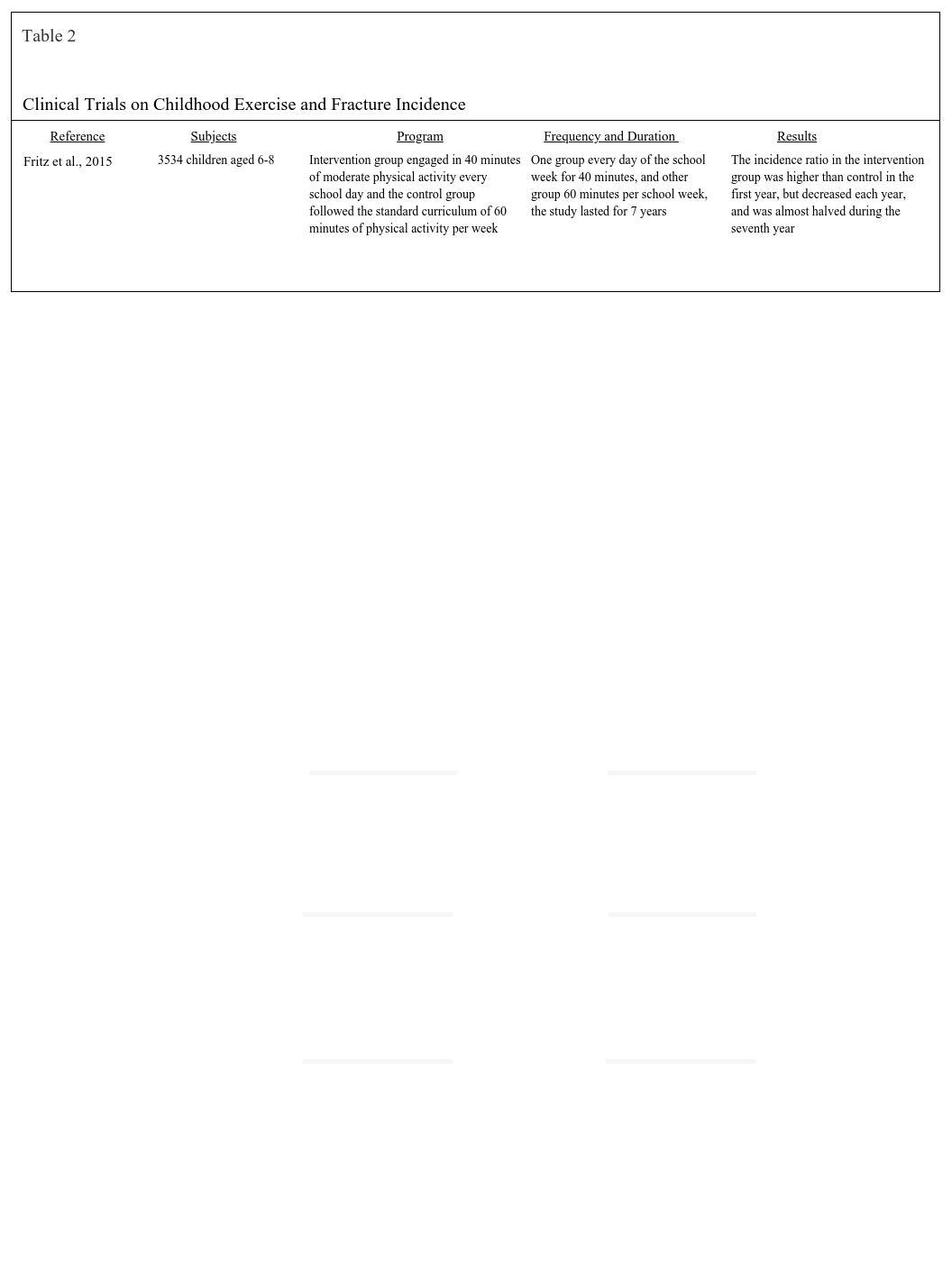
**Enhancing Peak Bone Mass in Children**

The development of greater bone mass in children will greatly decrease the adult incidence of osteoporosis and certainly reduce needless fractures. One of the key factors in maximizing childhood peak bone mass relates to the osteogenic-loading of bone which comes in the form of weight-bearing exercise (Brown, 2000). The objective of this paper is to review the literature on weight-bearing exercise in childhood and its impact on bone mineral density. Weight bearing exercise forces one to work against gravity. It is related to exercises that put load on the bone in multiples of body weight either through impact such as jumping or through the tendons in the muscles pulling on the bone, causing it to bend (Loud & Gordon, 2006). The bone mineral density (BMD) is greater in gymnasts at the hip and spine, runners at the femoral neck, rowers at the lumbar spine and tennis players have a higher radial BMD in dominant arm. High-impact activities and sports, jumping sports (gymnastics, volleyball, and karate) or odd-impact sports (soccer, basketball) are associated with higher BMD and enhanced bone geometry (Loud & Gordon, 2006).

**Clinical Trials**

Presented in this paper, are a review of four clinical trials on weight-bearing exercise and childhood bone mass development and one clinical trial on childhood exercise and fracture incidence.





As discussed prior, developing peak bone mass during childhood is very important for the prevention of osteoporosis later in life. Attaining this vital peak bone mass through exercise has been studied globally. Researchers have proven the effects of weight-bearing exercise on bone mass development.

Table 1 shown above, discusses four clinical trials studying bone weight-bearing exercise and childhood bone mass development. In each of these trials, researchers found that weight-bearing exercise had increased bone mineral density and childhood bone mass development. This is to ensure that children attain their peak bone mass for success in stronger bones later in life.

According to researchers, Morris, Naughton, Gibbs, Carlson and Wark during a ten-month exercise intervention in premenarcheal girls, there are positive effects on bone and lean mass. This clinical trial studies 71 total girls ages 9 and 10 years old, who are enrolled in 4th and 5th grade. The 10-month study had the girls engage in 30 minutes of physical activity sessions, 3 times a week (Morris, Naughton, Gibbs, Carlson & Wark, 1997). The intervention group included a variety of vigorous, high-impact aerobic workouts, such as aerobics, modified soccer, step aerobics, bush dance, skipping, ball games, modern dance and weight training. The control group engaged in these 30 minutes of physical activity without any instruction. The study revealed that the exercise group was associated with greater bone mineral accrual, total body bone mineral content and bone mineral density, lumbar spine bone mineral density, proximal femur bone mineral density and femoral neck bone mineral density increases than the control group (Morris, et al., 1997).

An additional study investigates the positive effects on bone mineralization and muscular fitness after 10 months of intense school-based physical training. Researchers studied 295 total boys and girls ages 8 to 10 years old. The intervention group included 95 boys and girls who would engage in small-sided ball games (SSG). This consisted of mainly team sports, such as 3v3 football, 3v3 basketball and floor-hockey. The circuit strength training group (CST) included 83 boys and girls, of which engaged in 30 second all-out plyometric and strength exercises interspersed by 45 second rest periods (Larsen, et al., 2018). The remaining children, 116 boys and girls made up the control group. This study took place for 10 months where the children would engage in 40 minutes of their assigned activity 3 times per week. Researchers found that there was a significant increase in bone mineral density for total body and in the SSG and CST groups, and at the leg in SSG and CST. Additionally, the bone mineral content for total body in CST and at leg in SSG and CST was significantly greater compared to the control group (Larsen, et al., 2018).

In a controlled study, researchers studied moderate exercise during growth in prepubertal boys. This study included 40 boys, 20 in the intervention group and 20 in the control group, all ranging in age from 8.4 to 11.8 (Bradney, et al., 2009). Prior to the start of the study, the intervention group and control group were matched for age, standing and sitting height, weight, and baseline areas bone mineral density. For 8 months, the intervention group would engage in 30-minute sessions of weight-bearing physical education lessons, 3 times a week. The activities were supervised outside of school time, and included aerobics, soccer, volleyball, dance, gymnastics, basketball and weight training. The study indicated that the areal bone mineral density at lumbar spine had doubled compared to the control group (Bradney, et al., 2009).

Lastly, in a 4-year long study, researchers assessed the effects of jumping on skeletal development in pre and circum pubertal children. The study included 107 girls and 98 boys around 8.5 years old, who were randomly assigned to the intervention or control group. The intervention group included jumping in the standard physical education curriculum, while the control group did not include jumping. Researchers found that the intervention group had greater bone mineral density in various areas such as: lumbar spine 2.3% increase, total hip 3.2% increase, femoral neck 4.4% increase and whole body bone mineral density 2.9% increase (Gunter, et al., 2008).

Table 2, shows one clinical trial in childhood exercise and fracture incidence. This the first study showing an association between gradually diminished risk of fractures and years of increased physical activity. Researchers studied 3534 children aged 6 to 8 years old at the start of the study, for up to 7 years. 1339 of the children engaged in 40 minutes of moderate physical activity every school day (intervention group), and 2195 children engaged in the standard curriculum of 60 minutes of physical activity per school week (control group) (Fritz, et al., 2016). The study showed that the incident rate ratios of fractures decreased each year of physical activity in the intervention group. During the final year of the study, the incident rate ratios of fractures was almost halved. Additionally, the intervention group has a significantly greater gain in total spine areal bone mineral density (Fritz, et al., 2016).

**Health-Belief Model**

The topic of developing peak bone mass through weight-bearing exercise in childhood as a way to decrease fracture incidence later in life, is best expressed through the Health-Belief Model. The Health Belief Model attempts to explain and predict health behaviors by focusing on the attitudes and beliefs of individuals. A person is more likely to take a health-related action if that person feels the negative condition is avoidable, believes that he/she can take the recommended health action or if that person has a positive expectation that if taking the recommended action, he/she will avoid the negative health condition (“Explaining Health Behvaiors,” n.d.). This model is based on 6 concepts for changing health behaviors. Such concepts include perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action and self-efficacy. In the case of developing peak bone mass to reduce fracture incidence later in life, all 6 concepts could be applied to change the health behaviors.

For instance, the perceived threat and net benefits such as perceived susceptibility, perceived severity, perceived benefits and perceived barriers, a person is being accounted for on their “readiness to act.” Cues to action, indicates that a person is demonstrating readiness and stimulate overt behavior. Additionally, self-efficacy shows that a person has the confidence in the ability to successfully perform the action (“Explaining Health Behaviors,” n.d.).

In regards to this specific topic, perceived susceptibility would be how susceptible one is to an osteoporotic fracture later in life. Perceived severity would include those people who are serious about their bone health and decide to seek more information on how to do so. Perceived benefits and perceived barriers would include one’s incentives on osteoporotic fractures. Perceived threat would include losing a family member or loved one, or witnessing an osteoporotic fracture occur and the hardships that follow. Self-efficacy would include talking to family, friends or health professionals about osteoporosis or osteoporotic fractures. Lastly, the cues to action would include talking to health professionals and taking the next steps to prevent an osteoporotic fracture from occurring.

**Recommendations**

The prevalence of osteoporotic fractures is a major global issue. Studies have proven that achieving peak bone mass in adolescent years affects the rate of osteoporotic fractures later in life. Researchers have suggested weight-bearing exercise as a means of doing so. Implementing such exercise in physical education curriculum would enable children to achieve their peak bone mass before it is too late (Loud & Gordon, 2006). Additionally, educating adolescents on the importance of reaching their peak bone mass, and ways to do so. There are many other ways besides weight-bearing exercise and it is important for children and adults to be aware of the different factors associated with the development of bone mass. Pediatricians play a major role in helping optimize bone health. Implementing a more rigorous and aggressive protocol for children to ensure their development of peak bone mass would greatly affect the prevalence of osteoporotic fractures (Golden & Abrams, 2014). There are very few studies that measure bone mineral density and weight-bearing exercise. In order to implement a program permanently, there needs to be more research on weight-bearing activities and its association to bone mineral density in adolescents (Loud & Gordon, 2006).

**Conclusion**

Osteoporosis is a major public health issue worldwide. There are a variety of factors that contribute to the development of bone. A few major factors include nutritional and lifestyle choices, hormonal status and physical activity. More specifically, weight-bearing exercise is known to be an important factor in bone development in childhood. Engaging in weight-bearing exercise during adolescent years has a direct relationship to one’s risk of osteoporotic fractures later in life. Researchers have proven through various clinical trials that weight-bearing exercise directly contributes to the development of bone mass. Furthermore, it is important for individuals worldwide to take all the necessary precautions to help prevent osteoporotic fractures from occurring.

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