THE RELATIONSHIP BETWEEN BODY COMPOSITION AND BONE IN PREADOLESCENT CHILDREN

BY

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THESIS

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ABSTRACT

The importance of optimizing peak bone mass early in life for the prevention of fractures throughout the lifespan and more debilitating diseases such as osteoporosis is well known today. However, more research is necessary to understand the importance of various determinants of bone health in youth. The purpose of this study was to assess the associations between body composition (lean vs. fat mass) and bone mineral density (BMD) in children 8-9 years of age. A total of 103 Black and White participants (48 females and 55 males) between the ages of 8-9 years old and of all body composition levels, representative of a Midwestern county, were included in this study. All subjects were assessed for bone and body composition via dual-energy X-ray absorptiometry (DXA). Correlations and linear regression analyses were used to analyze these data. Lean soft tissue (LST) was found to be significantly and positively related to BMD in both male and female children. Regression analyses revealed LST and race were the only independent predictors of bone BMD at the whole body (LST ß=0.812, p=0.006; Race ß=0.234, p=0.003) hip (Race ß=0.178, p=0.016) and lumbar spine (Race ß=0.211, p=0.010) sites. It was concluded that, a) LST is a major determinant of bone health in preadolescent children and b) Black children have greater BMD than White children.

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Chapter 1

Introduction

Statement of the Problem

Bone development and maintaining bone is a lifelong process that begins at birth and continues through childhood and into adulthood (National Osteoporosis Foundation, 2009). Attainment of peak bone mass early in life is critical in the prevention of bone fractures and ultimately more severe bone conditions, such as osteoporosis, later in life. In the second half of the twentieth century, distal forearm fractures in children have increased substantially in several nations, including the United States (Jones G, 2003). In addition, osteoporosis affects approximately 10 million people in the United States (Ondrak KS & Morgan DW, 2007). Thus, bone mineral density (BMD) and content (BMC) during childhood is of high public health importance, relating to the occurrence of fractures in childhood and early adulthood and osteoporosis later in life (Ondrak KS & Morgan DW, 2007). Understanding the factors that affect bone health status in childhood will ultimately impact guide prevention initiatives of more debilitating bone diseases, like osteoporosis, in late adulthood.

Childhood Bone Health

Childhood and adolescence is the most critical period of bone accrual because this is the time when peak bone mass is achieved, an important factor in future fracture risk. The period of the most rapid gain in bone mineral is referred to as peak bone mineral

accrual (Khan K, et al, 2001). Research has indicated that girls will generally reach this peak earlier than boys due to differences in puberty; however, peak bone mass will be lower and to a lesser magnitude in females. The two years surrounding the age of peak bone mass are critical years of bone development as well and account for ~26 % of adult total body bone mineral accrual (Khan K, et al., 2001).

Essentially, bone mass late in life depends on peak bone mass achievement during growth and/or the rate of age-related bone loss after attainment of peak bone mass (Cashman K, 2007). Optimizing peak bone mass during childhood and adolescence can prevent common adult skeletal disorders and protect against fractures (Heaney RP, et al, 2000). The most serious and common skeletal disease is osteoporosis which is traditionally known as an adult's disease. Osteoporosis is characterized by a loss of bone mass and deterioration of bone tissue (National Osteoporosis Foundation, 2008). It is estimated that 10 million individuals already have the disease and that 34 million more have low bone mass which indicates an increased risk for osteoporosis (National Osteoporosis Foundation, 2008). Osteoporosis often leads to fractures of the hip, spine, wrist and pelvis which are associated with lower quality of life and decreased function in older individuals (National Osteoporosis Foundation, 2008).

While children likely do not experience the effects of osteoporosis in childhood, they are susceptible to fractures. Specifically, forearm fractures are common in children and observed most commonly at the age of peak growth spurt (Goulding A, et al, 1998). Forearm fractures in children have been linked to low BMD which supports the literature of less dense bones being more susceptible to fracturing (Goulding A, Jones IE, Taylor

RW, Williams SM, Manning PJ, 2001). Furthermore, fracture risk is also associated with high BMI and high adiposity (Goulding A, et al., 2001). With rising rates of childhood obesity, bone health concerns emerge as another potential complication of unhealthy weight status, although the relation between weight status in general and body composition specifically to bone health status is not adequately characterized.

Childhood Obesity

Obesity in childhood, just as in adults, occurs from an imbalance in energy intake versus expenditure but defining obesity in children can be difficult. A variety of methods, including body mass index (BMI), waist circumference and body fat percentage, indicate various classifications for obese children. The Centers for Disease Control (CDC) and Prevention define a child as "at risk for overweight" when their BMI falls in the 85^{th}-95^{th} percentile for age and sex and "overweight" with a BMI greater than the 95^{th} percentile. Those children with BMI's exceeding the 99^{th} percentile are referred to as having "extreme pediatric obesity" (CDC, 2008).

Childhood obesity has become a major public health concern as it is associated with a child's risk for chronic disease at the present age and also co-morbidities later in life. A relationship between obesity and skeletal health in children has also been suggested. While it is commonly known that weight on bone is "bone loading," current research finds that excess weight can put a child at increased fracture risk (Goulding A, Taylor RW, Jones IE, McAuley KA, Manning PJ & Williams SM, 2000). For example, it has been reported that overweight and obese children, aged 3-19 years, have lower bone area and bone mass for their body weight than children with healthy body weight

(Goulding A, et al, 2000). This mismatch between bone mass and body mass could increase a child's risk of bone fractures during childhood and to other bone diseases later in life. Behaviors to manage weight in childhood through modifiable factors, such as physical activity, may help prevent or attenuate the damage caused by excess weight.

The Impact of Body Composition on Childhood Bone Health

Any factor that influences peak bone mass during the growth periods of childhood, will affect later fracture risk (Cashman K, 2007). There are factors that can be modified, such as diet, physical activity and body composition, and factors that cannot be modified, such as sex, age, genetics and ethnicity (Cashman K, 2007). Understanding the role of modifiable factors in childhood will help in identifying strategies to maximize bone mass during growth to reduce risk of osteoporosis later in life (Cashman K, 2007). Although it is acknowledged that bone health status is influenced by several factors, the focus of this study will be on total body weight and body composition.

Body weight and body composition [Fat mass (FM) and lean soft tissue (LST)] are other modifiable factors of interest that affect bone development (Khan K, 2001). It is well known that adult obesity appears to have a protective effect on bone due to the increased load causing higher bone mineral density (BMD) and decreased frailty (Bakker I, Twisk JWR, Mechelen WV & Kemper HCG, 2003). The effect of weight status on bone health in children is not as well defined. Overweight children appear to have higher BMD due to the increase in mechanical load from weight (Rocher E, Chappard C, Jaffre C, Benhamou CL & Courteix D, 2008). In contrast, it is suggested that an obese child's skeleton is not optimal to support the excess body weight (Rocher E, et al., 2008). This

may explain findings of obese children being more susceptible to fractures (Goulding A, et al, 2001). It does appear that children with higher FM appear to have lower bone mass and bone area; however, the independent relation from LST and weight is unclear (Rocher E, et al., 2008). This paradigm follows adult studies which suggest that FM is poorly correlated to bone mass (Bakker I, et al, 2003).

Importance of Study

The importance of optimizing peak mass early in life has become an integral component in the prevention of, not only fractures in youth, but also more chronic complications, like osteoporosis late in life. While there are multiple factors impacting bone development in youth, weight status and body composition have moved to the forefront with the epidemic of childhood obesity in the past decade. Evaluating the body composition profile of today's youth will further contribute to the literature on the impact of weight and body composition on bone.

It is established that Black adults have superior skeletal muscle mass and greater peak bone mass compared to Whites (Aloia JF, Vaswani A, Mikhail M & Flaster ER, 1999). Racial differences in children have just recently emerged as well indicating Black children have greater BMD of the whole body, hip and radius compared to their non-Black counterparts (Kalkwarf HJ,et al, 2007). In addition, Black children have been found to have higher weight and height than non-Blacks (Kalkwarf HJ, et al, 2007). The potential racial differences being explored in this study, along with the bone and body composition data, will add to the existing body of literature that will aid the formation of appropriate behavioral interventions for bone status to enhance health across the lifespan.

Study Aim and Hypothesis

The primary aim of this study is to assess the associations between body composition (LST and fat mass) and BMD in Black and White children 8-9 years of age. It is hypothesized that children with greater LST will have higher BMD and BMC of the whole body, hip and lumbar spine.

Chapter 2

Literature Review

This literature review is organized into five sections. The first section covers an overview of preadolescent bone development & growth. The next section discusses the literature relevant to the assessment of bone development and body composition in preadolescents using DXA technology. In the third section, literature concerning the theoretical interaction of body composition (total body weight, fat mass and lean soft tissue) on preadolescent bone health is discussed. The final section discusses the clinical application of body composition on bone health by indicating a relationship to fracture risk in childhood.

Overview of Bone Development during Childhood

With the aging population, the importance of bone mineral accrual during childhood and adolescence has become even more critical to maximize bone mass, particularly during growth and maturation. Previous work has demonstrated that optimizing bone mass, during preadolescence, will prevent non-traumatic fractures in late life. This review will focus on bone development and opportunity for accrual before the onset of puberty.

While bone development occurs throughout the lifespan, actual bone growth occurs over a relatively short period of one's lifespan (Barr SI & McKay HA, 1998). The two major growth spurts occur from one to four years of age and during puberty with peak BMD achieved between the late teen years and the third decade of life. These

growth spurts coincide similarly with gains observed in BMD as part of maturation (Ondrak KS & Morgan DW, 2007).

The two primary types of bone tissue, cortical (compact bone) and cancellous (trabecular bone), respond differently during periods of maturation. During the preadolescent stage, cortical bone growth is significantly and positively impacted by age and anthropometric measures of weight, height, body mass, fat and muscle (Goodman MS & Loro ML, et al, 1994). However, trabecular bone does not undergo these types of changes until the later stages of puberty (Goodman MS & Loro ML, et al, 1994). This suggests that the impact that body composition, physical activity and hormonal changes have on cortical and trabecular tissue may differ during growth and development.

In addition, bones in different locations of the body respond differently during growth (Ondrak KS & Morgan DW, 2007). BMD of the peripheral bones (arms and legs) increases linearly until late adolescence while axial (spinal column and ribs) BMD increases are accelerated during puberty (Goodman MS, et al, 1994). Because peripheral bone is primarily composed of cortical bone, this reinforces the finding that increases in cortical bone BMD may be of importance prior to puberty.

Assessment of Bone Density and Body Composition in Preadolescents

Dual energy x-Ray absorptiometry (DXA) is used to assess bone health in the adult population and is widely known as the gold standard, its use in children is not well established. Cross-sectional studies of children ages 3-19 have illustrated a relationship between lower BMD and increased fracture risk, especially fractures involving the upper limbs (Goulding A, et al, 2001 & 2005). BMD was determined using DXA technology in

these studies. With the increase of fractures in children over the past three decades, DXA results may be one of many important tools in prevention and/or treatment of low BMD both early and late in life. Results must be interpreted differently in children than in adults. T-scores, which compare the subject to peak bone mass (PBM), is not applicable in children, as they have not yet achieved PBM. Instead Z-scores, which compare the subject to their peers of chronological age, should be used to determine BMD in children (Bogunovic L, Doyle SM & Vogiatzi MG, 2009). The International Society for Clinical Densitometry defines low BMC or low BMD in pediatrics as a BMC or areal BMD Z-scores $\leq$ -2.0, adjusted for age, sex and body size. In addition, the terms osteoporosis and osteopenia should not appear on a DXA report. Instead the term "low bone mass for chronological age" is used. The 2007 Position Statement also suggests when evaluating pediatric bones, DXA results alone should not be the only diagnostic tool for determining risk or incidence of osteoporosis. Despite these restrictions and limitations, DXA continues to be the standard technique for the assessment of BMD in the pediatric population (Bogunovic L, et al, 2009).

DXA has also been shown to provide accurate assessment of body weight distribution and a more accurate measure of body composition than other methods such as skin folds or bioelectrical impedance (Elberg J, et al, 2004). DXA has the capability to quantify total body fat percentage, total fat mass and total fat free mass of children and adults. DXA can be advantageous as it provides more detail to the regional distribution of the body composition content of an individual.

The Effect of Body Composition on Bone Mineral Density

It is well known that total body weight (TBW) can have a mechanical loading effect on bone similar to exercise in adults, if the individual is ambulatory (Barker I, et al, 2003). The effect of body weight on bone in children is not as clear. In 2008, Rocher et al showed that obese children (M and F aged 9-12 years) seemed to have denser bones than non-obese controls (Rocher E, et al, 2008). This suggests that the mechanical loading effect is similar in adults and children. However, the research team found the bone mass to total body weight ratio was significantly lower in obese children than the non-obese controls, suggesting obese children have weaker bones despite a higher BMD (Rocher E, et al, 2008), at least as expressed in relation to being able to handle body weight imposed stress

This same finding was, not only observed by Goulding et al in 2000, but the research team also found that overweight children had an increased occurrence of forearm fractures (Goulding A, et al, 2000 & 2001). These findings follow along the trend lines of increasing childhood obesity rates and increasing childhood forearm fracture rates observed over the past 30 years, thus indicating a relationship between rising obesity and poor bone health (Khosla S, et al, 2003). An obese child's skeleton may not be sufficient to support the excess weight and a child's body composition (Fat Mass and Lean Mass), versus TBW alone, may be a more important contributing factor in overall bone strength (Rocher E, et al, 2008). Alternatively overweight children may have a reduced motor skill ability and physical functional ability thereby increasing the risk that they will suffer a fall, a working paradigm that remains untested.

Fat mass (FM) and lean soft tissue (LST). Results regarding the effect of FM versus LST in children are equivocal. The few studies that have been conducted suggest that obese children have greater bone mass (Leonard MB, Shults J, Wilson BA, Tershakovec AM & Zemel BS, 2004), less bone mass (Goulding A, Taylor RW, Jones IE, Manning PJ & Williams SM, 2002) or no difference in obese versus normal-weight control children (Manzoni P, et al, 1996). The difference in the findings are undoubtedly impacted by the researchers' adjustments for a variety of parameters necessary in children such as height, weight, body composition and sexual maturation.

Leonard and colleagues assessed 132 non-overweight (BMI $<85^{th}$ percentile) and 103 overweight (BMI $\geq 95^{th}$ percentile) children and adolescents (ages 4-20 years) to determine the effect of obesity on bone accrual during growth (Leonard MB, et al, 2002). They examined whole body and vertebral bone mineral content (BMC) using DXA. Bone area, areal bone mineral density (BMD) and fat and lean mass were also measured. They found similar results to other studies that obese children were taller (144.0 cm ±14.4), had advanced maturation and more lean mass (27.9 kg ±9.2) for height than the non-obese controls (136.8 cm ±20.4, 22.4 kg ±9.6). Their main finding was that obese children were found to have greater bone density. Obese subjects had greater vertebral areal BMD (obese =0.685g/cm^2 ±0.138, non-obese = 0.619 g/cm^2 ±0.159) for height, greater volumetric BMD (obese = 0.100g/cm^3 ±0.014, non-obese = 0.093g/cm^3±0.013) and greater vertebral BMC (obese = 33.1g ±12.4, non-obese = 29.5 g ±16.5) for bone area after adjusting for maturation and sex. Whole body bone area (obese =1372 cm^2 ±406, non-obese = 975 cm^2 ±457) and BMC for age and height (obese =1095g ±502, non-obese = 732 g/cm^2 ±510) were also significantly greater in the obese than non-obese controls.

It appears from this study that obesity may strengthen bone parameters even after adjusting for height, maturation and sex. Of importance, while the researchers acknowledge their findings, they continue to conclude that the increase in bone strength may not be sufficient to overcome the excessive force put on a bone when an obese child falls resulting in increased fracture risk (Leonard MB et al, 2004).

Contradictory to the above study, Goulding and colleagues found childhood obesity to be associated with poorer bone status in 2002. The following study examined the increases in spinal BMC and area of overweight and obese children and adolescents to determine whether children with excess weight have sufficient compensatory increases in bone. DXA was used to measure vertebral area and BMC of lumbar vertebrae L2-L4 in 202 boys and 160 girls, aged 3-19 years. Children were classified as healthy weight (group 1), overweight (group 2) and obese (group 3) using BMI for age. They also confirmed higher adiposity with higher BMI. Group 3 had FM ranging from 14.2-38.5 kg for girls and 14.0-39.6 kg in boys. It was reported that overweight and obese children with higher fat percentage had lower vertebral BMC for bone area, height, weight and maturation. Overweight girls had 8% less-, obese girls had 12% less and obese boys had 13% less- BMC in the lumbar spine for bone area, height, weight and maturation compared to normal weight, sex matched controls (Goulding A et al, 2002). While the results of this study differ from Leonard et al, both groups conclude that the bone strength of obese and overweight children may not be sufficient for the mechanical strain placed on it due to the excess weight.

In addition to studies indicating obesity having a negative and positive effect on bone, there is also evidence to show obesity having no effect on bone development.

Manzoni and colleagues assessed 115 healthy children aged 5-18 years grouped according to their relative body weight (RBW) calculated with Tanner growth charts (obese n = 65; RBW > 120% and normal-weight n = 50 RBW = 80-120%). DXA technology was used to evaluate the influence of body composition on total BMC (TBMC) and regional BMC (RBMC) in obese and normal-weight children. Obese children (n = 30 M, 35 F) were found to be taller (148.0 cm±15.5), have higher RBW (160% ±23), BMI (28.5 kg/m^2±4.8), body fat percentage (44.7%±7.3), LST (32.8 kg ±10.3) and TBMC (1927 g±670) than the normal weight controls (n = 28 M, 22 F; Ht: 143.5 cm±15.1; RBW: 101% ±12; BMI: 17.6 kg/m^2 ±2.6; body fat percentage: 23.9 kg ±9.7%; TBMC: 1478 g±491). Obese subjects RBMC was also higher at the arms (182 g±81), trunk (560 g±223) and legs (787.6 g±341) compared to the normal-weight controls (arms: 151 g±65; trunk: 43 g±169; legs: 539.5 g±230.7). These clinical characteristics demonstrate similarities with the studies completed by both Leonard and colleagues and Goulding and colleagues. These results were, however, before correcting for age, sex and body composition variables. After correcting for these confounding variables, there were no differences observed in TBMC and RBMC in obese versus normal-weight control. It was also determined that in the complete sample of obese and normal-weight children TBMC showed a significant and direct correlation with LST (r = 0.91 and 0.94) and FM (r = 0.68 and 0.54). However, the strongest determinants of TBMC were found to be height and LST (Manzoni P et al, 1996). The important conclusion from this research is that while obese and normal-weight children may both appear to have similar BMC, the body composition variable most influential will likely vary with regard to the strength of the bone.

The above finding was more recently demonstrated by Rocher and colleagues in 2008. As mentioned previously, Rocher and colleagues found that TBW should not be the only variable considered when evaluating bone health in children. In their 2008 research, they looked at preadolescent children aged 9 to 12 years categorized into obese (n = 20; 9 boys, 11 girls) and normal-weight (n = 23; 14 boys, 9 girls) as defined by the BMI for age charts. They used DXA technology to evaluate body composition, BMC, bone area and BMD for the whole body and lumbar spine (L1-L4). Again, obese children were taller (147.78 cm±8.38), had higher TBW (61.46 kg±12.34), fat mass percentage (39.72 %±6.08), FM (24.45 kg±7.08), LST (35.50 kg±6.53) and BMI (28.02 kg/m^2±4.47) than the normal weight controls (Ht: 144.98 cm±9.31; TBW: 35.37 kg±7.49; fat percentage: 19.74 % ±5.44; FM: 7.1 kg±3.09; LST: 26.56 kg±4.92; BMI: 16.66 kg/m^2 ±1.79). The importance of the results of this study were, not only that the ratio of bone mass to TBW was significantly lower in obese children, but also that LST is significantly related to bone mass. When adjusting for TBW, normal-weight controls were found to have significantly higher whole body BMD (0.958 g/cm^2), whole body BMC (1510.24 g) and whole body bone area (1560.83 cm^2) than obese children (WBBMD: 0.876 g/cm^2; WBBMC: 1190.98 g; whole body bone area: 1358.43 cm^2). After adjusting for LST, normal-weight controls were found to have significantly higher whole body BMD (WBBMD: 0.949 g/cm^2), higher whole body BMC (WBBMC: 1433.33 g) and higher whole body BMAD (WBBMAD: 0.097 g/cm^3) compared to the obese children (WBBMD: 0.886 g/cm^2; WBBMC: 1279.43 g; WBBMAD: 0.088 g/cm^3). There were no significant relationships shown when adjusting for FM (Rocher et al 2008). These results

strongly suggest a major role of TBW and LST in bone strength and development in children.

The Effect of Body Composition on Fracture Risk in Preadolescents

As previously stated, osteoporosis is the main debilitating bone ailment affecting older adults but the risk for this disease process starts during the growth periods. Children with lower bone mass may have the potential to be more at risk for fractures which ultimately makes them more at risk for osteoporosis as they age. The literature in the previous section suggests a relationship between body composition and bone mass but there is also research indicating that there is a clinical application to fracture risk.

In 2001, Goulding and colleagues suggested that low bone density, high BMI and high adiposity all increase fracture risk in young boys. Specifically, they evaluated the effects on forearm fracture incidence as it has been found to be the most prevalent fracture in children of this age (Goulding A, Grant AM & Williams SM, 2005). Researchers evaluated 100 children with fractures and 100 fracture-free children aged 3 to 19 years of age. Weight, height, BMI, BMD and body composition were measured for all subjects. Again, DXA technology was used to analyze bone and body composition.

Fracture incidence was reported with 97 boys breaking a single forearm while 3 broke both. Most fractures were associated with non-traumatic accidents such as falls from play equipment, biking, running or ball sports. It is also important to note that 42% of the children with forearm fractures had previously broken a bone. Anthropometric data indicated that children with fractures were heavier (48.1 kg) and had a higher BMI (20.21 kg/m^2) compared to fracture free children (Wt: 45.9 kg, BMI: 19.03 kg/m^2). Body composition results showed that these children also had less LST (34.38 kg), more fat

mass (11.44 kg) and a higher percent body fat (21.85 %) compared to the control children (LST: 35.27 kg, FM: 8.28 kg, fat percentage: 17.30 %). Bone measurements revealed that aBMD was significantly lower in fractured children than controls at every site except the hip trochanter region for age-adjusted data (WB aBMD: .964 g/cm^2 versus .985 g/cm^2; Ultra-distal radius a BMD: .301 g/cm^2 versus .316 g/cm^2; L2-L4 aBMD: .813 g/cm^2 versus .875 g/cm^2). These parameters were also statistically significant after adjusting for age and weight suggesting a link between weight, body composition and bone. While this particular study was conducted only in boys, Goulding and colleagues demonstrated similar relationships in girls of the same age in 1998 (Goulding A, et al, 1998). After multiple studies, this research team has concluded that overweight children, have a mismatch between bone mineral accrual and weight gain, largely due to increased excess adiposity, leading to an increased risk of fracture (Goulding A, et al, 2001).

Summary

Currently, the interactive association between body composition and bone health in children remains controversial. There is conflicting evidence illustrating the interaction of weight, FM and LST on bone during preadolescence. As in adults, research has shown that conventional measures of bone health, BMD and BMC, may be greater in overweight and obese children when evaluating the data based on height, maturation and sex (Leonard MB et al, 2004). On the contrary, poorer bone health has also been observed in preadolescent children when adjusting the data for weight (Goulding A et al, 2002). More important might be that LST has been found to be an important predictor of bone strength, while total weight has been shown to not have a direct effect on bone (Manzoni P et al, 1996 & Rocher et al 2008). Further research into

the interaction of TBW, FM and LST and bone status in children will provide additional insight into preventative strategies in childhood that may decrease fracture incidence in youth and ultimately osteoporosis in late adulthood.

Chapter 3

Methods

This study was part of a larger randomized controlled trial funded by the National Institutes of Health. The purpose of the present cross-sectional study was to assess the relations among body composition and bone health in children. A description of the procedures is as follows.

Experimental Design and Procedures

All participants were recruited from Champaign County, Illinois. Parents were sent flyers containing an overview of the project and contact information. The schools included information on the project in school newsletters and information sessions were held at two schools within the district. Voluntary participation was insured by having parents of the children contact the research team. The following inclusion criteria was used for screening participants in the parent study: Parent/guardian consent, assent of participant, 8-9 years of age, capable of performing exercise based on the Physical Activity Readiness Questionnaire (PAR-Q), absence of school-identified learning disability, IQ>85, Tanner Scales score ≤ 2, ADHD Rating Scale score > 85% and normal or corrected to normal vision.

Legal guardians completed the health history questionnaire containing questions regarding current medications, vision and previous diagnoses of cognitive or physical disability. Guardians also completed the PAR-Q, the ADHD Rating Scale IV, the pubertal self-assessment questionnaire and gave consent to have the school provide

information regarding any school identified learning disability. The participants completed the IQ test.

After passing all screening from the parent study, participants visited the Bone and Body Composition Laboratory in Freer Hall for about 1 hour to complete testing procedures. Before beginning testing procedures, participants and their legal guardians were oriented to the study and asked to sign an additional informed consent and assent for the bone and body composition measurements (Appendix A). A summary of testing procedures is shown in Figure 1.

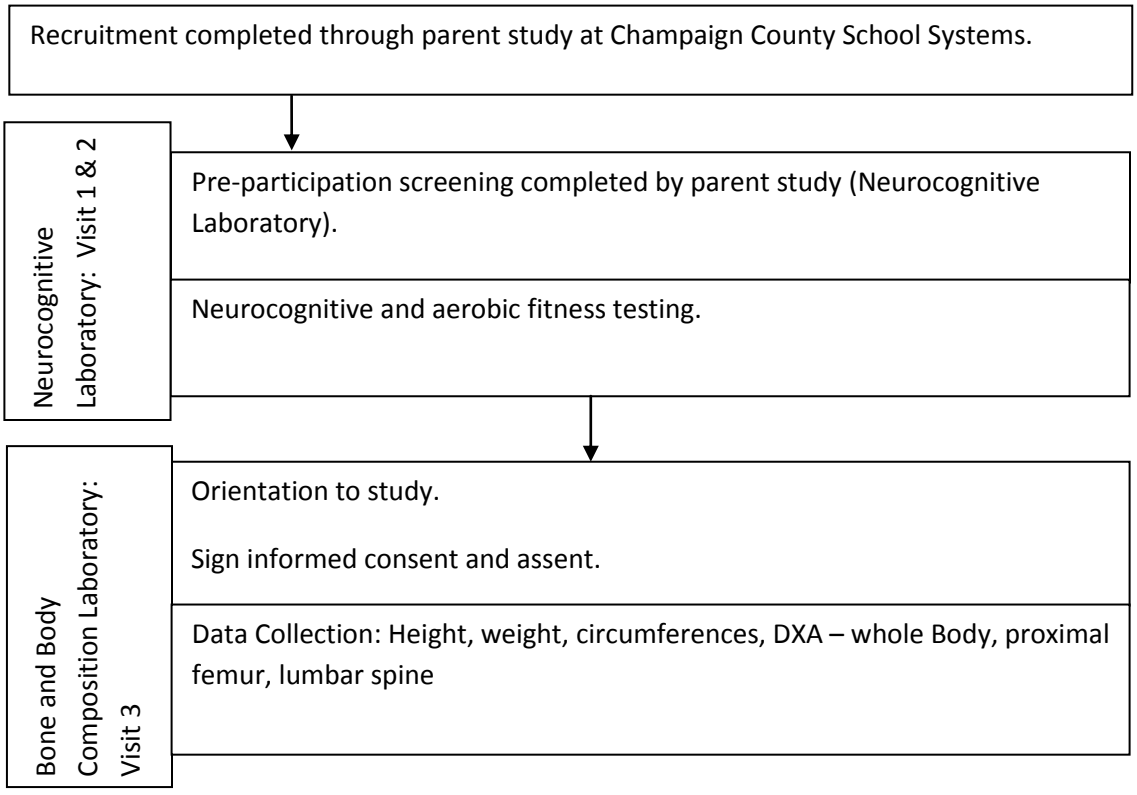

Figure 1. A flow chart of testing procedures.

Subjects

A total of 123 participants (53 females and 70 males) between the ages of 8-9 years old of a variety of races and body composition levels were recruited for this study. All participants included in the study passed screening inclusion criteria stated above and as assessed by the participants legal guardian. As the recruited sample was very balanced with regard to Black and White children, for this study, results from 103 children of Black and White races were analyzed.

To protect the privacy of the participants, each was assigned a study ID to use for their forms and data collection sheets. Names were kept confidential. Each child received a $10 cash incentive for participation in the study. The study was approved by the University of Illinois Institutional Review Board.

Primary Outcomes

The primary outcomes were assessed though multiple valid measures.

Anthropometric measures. Barefoot standing height was measured to the nearest 0.1 cm with a stadiometer (Seca 242, Hamburg, Germany). Body weight was measured on a calibrated balance scale (Tanita, Model BWB-627A) with participants wearing shorts and a t-shirt. The average of three trials was used for data analysis.

Waist circumference. Waist circumference was used to further assess the child's degree of central adiposity. Waist circumference was measured as the minimum circumference between the top of the iliac crest and the distal end of the rib cage along

the midaxillary line and at the umbilicus. Hip circumference was measured as the maximal girth of the hips region (buttocks).

Body composition and bone mineral density. Bone mineral content (BMC), density (BMD) and whole-body (WB) and regional soft tissue composition was assessed using Dual Energy X-Ray Absorptiometry (DXA) (Hologic QDR 4500A, Bedford, MA). BMC and BMD of the lumbar spine and non-dominant proximal femur were also measured for bone health. Participants were instructed to wear or change into clothing containing no metal. His/her height and weight was measured prior to the DXA scan. All scans were analyzed by one research assistant and quality controlled by a second assistant on the research team.

Statistical Analysis

Statistical analysis was performed using SPSS statisical software, version 17.0 for Windows. The data was inspected for normality, using Shapiro –Wilks test. Weight, FM, BMI, LST and percent fat were non-normally distributed and were attempted to be normalized by log10 and Ln transformations. Normality was not established and therefore data was further analyzed using non-parametric tests.

Descriptive statistics were generated for demographics and all bone and body composition variables. Descriptives were separated by Black and White race within sex to compare data by groups. Significant differences of the descriptive data between groups were found using Mann Whitney U independent t-tests. Spearman Rho

correlation tests were performed to demonstrate significant relationships between body composition and bone variables by race within gender.

To determine independent predictors of BMD and BMC, linear regression was utilized. Variables of interest included age, pubertal timing, sex, race, weight, height, BMI, whole body fat, whole body lean tissue and relative fat (percent fat). Regression analysis was computed for whole body BMD and BMC, lumbar spine BMD and BMC and hip BMD and BMC. The data were presented as mean ± SD. Group differences and relationships between variables were determined significant at $p<0.05$.

Chapter 4

Results

The purpose of this study was to examine the relationship between body composition variables and bone health, as assessed by BMD and BMC, in children aged 8-9 years. The predictive strength of body composition variables on bone health was also evaluated. As the recruited sample was diverse with respect to Black and White race, racial impacts on the aforementioned relations were also evaluated.

Subject demographic and body composition characteristics are presented in Table 1. Females had significantly higher weight, BMI, WC, FM, total mass and percent fat compared to males. Black females had higher weight, height, BMI, WC, FM and LST compared to White females; however, no racial differences were detected in boys except in LST.

Table 1. *Participant Body Composition and Demographic Characteristics*

	White Females (N=31)	Black Females (N=17)	White Males (N=31)	Black Males (N=24)	Total (N=103)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Pubertal Timing 1 / 2 (%) #	48.4 / 48.4	23.5 / 70.6	38.7 / 58.1	29.2 / 54.2	36.9 / 56.3
Age	8.96 ± 0.62	8.75 ± 0.47	8.72 ± 0.60	8.84 ± 0.57	8.82 ± .58
Weight (kg)**	38.32 ± 11.16	47.74 ±10.94*	34.96 ±12.20	41.05 ± 15.44	39.50 ± 13.09
Height (cm)	135.8 ± 7.27	141.26 ± 5.89*	135.29 ± 9.60	138.62 ± 9.20	137.21 ± 8.49
BMI (kg/m^2)**	20.59 ± 4.87	23.85 ± 5.11*	18.64 ± 4.25	20.97 ± 6.55	20.63 ± 5.38
Waist Circumference (cm)**	69.64 ± 11.07	77.18 ± 11.77*	64.70 ± 11.94	67.66 ± 15.27	68.94 ± 13.02
Whole Body Fat (kg)**	12.299 ± 5.94	16.161 ± 6.66*	86.40± 5.89	10.826 ± 8.37	11.49 ± 7.05
Whole Body Lean (kg)	24.992 ± 4.23	30.315± 4.59*	26.061 ± 6.75	29.461 ± 6.47*	27.23 ± 6.01
Whole Body Mass (kg)**	37.292 ± 9.50	46.476 ± 10.48*	34.701 ± 12.06	40.288 ± 14.43	38.72 ± 12.23
Whole Body Percent Fat (%)	31.4 ± 8.12**	33.47 ± 7.65**	22.95 ± 7.46	23.81 ± 9.53	27.43 ± 9.24

Data missing; N = 97

* Indicates significant racial difference within sex, $p<0.05$.

**Indicates significant sex difference, $p<0.05$.

Bone measures are captured in Table 2. Females had significantly higher BMD of the lumbar spine and hip compared to males. Black children had higher BMC and BMD of the whole body, lumbar spine and hip compared to White children.

Table 2. *Participant Bone Characteristics*

		White Females (N=31)	Black Females (N=17)	White Males (N=31)	Black Males (N=24)	Total (N=103)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Whole Body	Total Area (cm2)	1294.44 ± 97.89	1376.62 ± 94.60*	1315.11 ± 194.86	1399.54 ± 159.54*	1338.71 ± 151.68
	Total BMC (g)	1032.53 ± 136.68	1175.39 ± 157.73*	1071.35 ± 263.47	1217.66 ± 204.99*	1110.93 ± 212.15
	Total BMD (g/cm2)	0.79 ± .06	0.85 ± .06*	0.80 ± .07	0.86 ± .06*	.82 ± .07
	Z - Score	.50 ± 1.17	.39 ± 1.03	.02 ± .87	.50 ± .89	.34 ± 1.01
Lumbar Spine	Total Area (cm2)	37.36 ± 3.40	37.23 ± 3.31	39.27 ± 4.63	39.40 ± 4.23	38.39 ± 4.06
	Total BMC (g)	23.39 ± 3.66	27.38 ± 5.05*	24.19 ± 5.89	26.19 ± 5.28	24.94 ± 5.17
	Total BMD (g/cm2)**	0.62 ± .07	0.73 ± .09*	0.61 ± .08	0.66 ± .09*	.64 ± .09
	Z - Score	.85 ± 1.18	.51 ± 1.41	.30 ± 1.18	1.07 ± 1.00*	.68 ± 1.20
Hip	Total Area (cm2)	23.21 ± 2.89	24.37± 2.79	23.70 ± 4.90	24.47 ± 3.52	23.84 ± 3.71
	Total BMC (g)	15.78 ± 3.14	18.87 ± 3.81*	17.75 ± 6.04	19.97 ± 4.93*	17.86 ± 4.89
	Total BMD (g/cm2)**	0.67 ± .07	0.76 ± .09*	0.73 ± .10	0.80 ± .11*	.74 ± .10
	Z - Score	.73 ± 1.21	.64 ± 1.53	.15 ± 1.13	.59 ± 1.46	.52 ± 1.31

* Indicates significant racial difference within sex, $p<0.05$.

**Indicates significant sex difference, $p<0.05$.

The associations between primary bone outcomes, especially BMD and body composition outcomes were similar among girls (Table 3) and boys (Table 4). Although all primary measures of body composition, namely lean mass, fat mass, and percent fat were related to bone area, BMC and BMD (all $p<0.05$), lean mass was the strongest predictor at all sites measured in both boys and girls regardless of race (all $p < 0.05$).

Table 3. *Relationship between Female Bone and Body Composition Variables by Race*

		White Females (N=31)				Black Females (N=17)			
		Fat Mass	Lean Mass	Total Mass	Percent Fat	Fat Mass	Lean Mass	Total Mass	Percent Fat
Whole	Area (cm2)	.133	.585**	.408*	.008	.228	.517*	.385	.098
Body	BMC (g)	.352	.657**	.574**	.251	.488*	.713**	.640**	.321
	BMD (g/cm2)	.522**	.592**	.638**	.475**	.507*	.659**	.605*	.343
	Z - Score	-.199	.037	-.121	-.223	-.272	-.006	-.221	-.375
Hip	Area (cm2)	.214	.626**	.468**	.051	.377	.527*	.419	.206
	BMC (g)	.470**	.727**	.673**	.343	.539*	.826**	.654**	.257
	BMD (g/cm2)	.680**	.656**	.752**	.614**	.664**	.863**	.765**	.419
	Z - Score	-.166	-.177	-.189	-.162	-.260	-.202	-.288	-.308
Lumbar	Area (cm2)	.268	.570**	.425*	.146	.167	.640**	.341	-.125
Spine	BMC (g)	.521**	.784**	.722**	.394*	.618**	.846**	.752**	.392
	BMD (g/cm2)	.593**	.677**	.744**	.502**	.659**	.728**	.723**	.498*
	Z - Score	-.176	.012	-.118	-.227	-.331	-.191	-.346	-.395

* Correlation is significant at the p<0.05 level (2-tailed)

** Correlation is significant at the p<0.01 level (2-tailed)

Table 4. *Relationship between Male Bone and Body Composition Variables by Race*

		White Males (N=31)				Black Males (N=24)			
		Fat Mass	Lean Mass	Total Mass	Percent Fat	Fat Mass	Lean Mass	Total Mass	Percent Fat
Whole Body	Area (cm2)	.698**	.817**	.780**	.518**	.618**	.820**	.725**	.435*
	BMC (g)	.674**	.850**	.799**	.460**	.659**	.869**	.780**	.494*
	BMD (g/cm2)	.551**	.732**	.700**	.352	.477*	.715**	.616**	.333
	Z - Score	.409*	.396*	.442*	.374*	-.061	-.135	-.044	-.033
Hip	Area (cm2)	.548**	.706**	.656**	0.354	.205	.463*	.317	.043
	BMC (g)	.545**	.685**	.646**	.359*	.430*	.706**	.562**	.244
	BMD (g/cm2)	.368*	.470**	.458**	.242	.466*	.697**	.592**	0.3
	Z - Score	.033	-.009	.019	.085	.054	-.011	.058	.073
Lumbar Spine	Area (cm2)	.530**	.733**	.696**	.382*	.361	.481*	.405*	.196
	BMC (g)	.661**	.830**	.806**	.491**	.640**	.802**	.717**	.464*
	BMD (g/cm2)	.517**	.643**	.624**	.366*	.536**	.710**	.614**	.414*
	Z - Score	.175	.156	.185	.163	-.106	-.068	-.088	-.156

* Correlation is significant at the p<0.05 level (2-tailed)

** Correlation is significant at the p<0.01 level (2-tailed)

To further ascertain the primary predictor variable of whole body (Table 5), lumbar spine (Table 6) and proximal femur (Table 7) BMC and BMD in the complete sample, regression analyses were conducted. Race and lean mass were the only significant predictors of whole body BMC explaining 4.1% and 3.5% of the variance respectively. Similarly, race and lean mass explained 1.1% and 3.6% of the variance in BMD, respectively. At the lumbar spine site, lean mass explained 4.2% ($p<0.001$) of the variance in BMD while race explained 3.3% ($p=0.010$) of the variance in BMD. A similar pattern existed for the hip with lean mass explaining 3.1% ($p=0.002$) and race explained 2.4% of the BMD, respectively.

Table 5. *Independent Predictors of Whole Body BMD and BMC from Linear Regression Analyses*

	WB BMD			WB BMC		
	β Coefficient	P	R^2	β Coefficient	P	R^2
Constant		.089			.113	
Sex	.090	.319	.004	.084	.233	.004
Age	.135	.110	.011	.066	.313	.003
Pubertal Timing	.014	.849	.000	-.052	.343	.002
Weight	.568	.536	.002	1.379	.055	.010
Height	-.220	.523	.002	-.308	.250	.003
BMI	-.307	.645	.001	-1.366	.009	.018
Race	.234	.003	.041	.123	.040	.011
Whole Body Fat	-.654	.170	.008	-.147	.689	.000
Whole Body Lean	.812	.006	.035	.829	.000	.036
Whole Body Percent Fat	.388	.216	.007	.239	.324	.003
Total R^2			.627			.776

Table 6. *Independent Predictors of Lumbar Spine BMD and BMC from Linear Regression Analyses*

	Spine BMD			Spine BMC		
	β Coefficient	P	R^2	β Coefficient	P	R^2
Constant		.490			.973	
Sex	-.121	.203	.008	.036	.647	.001
Age	.006	.949	.000	-.014	.844	.000
Pubertal Timing	.073	.328	.005	.038	.527	.001
Weight	.107	.911	.000	.082	.917	.000
Height	.035	.922	.000	.118	.689	.001
BMI	-.178	.799	.000	-.654	.253	.004
Race	.211	.010	.033	.034	.606	.001
Whole Body Fat	.104	.834	.000	.132	.746	.000
Whole Body Lean	.492	.107	.013	.896	.000	.042
Whole Body Percent Fat	.129	.694	.001	.263	.327	.003
Total R^2			.589			.726

Table 7. *Independent Predictors of Hip BMD and BMC from Linear Regression Analyses*

	Hip BMD			Hip BMC		
	β Coefficient	P	R^2	β Coefficient	P	R^2
Constant		.024			.359	
Sex	.197	.024	.021	.084	.280	.004
Age	.108	.179	.007	.041	.567	.001
Pubertal Timing	.072	.288	.004	.100	.103	.009
Weight	1.733	.050	.016	1.318	.098	.009
Height	-.511	.121	.010	-.270	.364	.003
BMI	-1.034	.105	.011	-1.094	.059	.012
Race	.178	.016	.024	.012	.854	.000
Whole Body Fat	-.022	.961	.000	-.275	.501	.001
Whole Body Lean	.350	.205	.006	.773	.002	.031
Whole Body Percent Fat	-.170	.568	.001	.085	.753	.000
Total R^2			.661			.723

Chapter 5

Discussion

The aim of the present study was to examine the relationship between components of body composition including fat mass and lean mass on measures of bone health in children differing in sex and race. Our data indicates that multiple body composition variables demonstrated positive and significant relationships with bone health status in Black and White girls and boys. The major findings from this study are: 1) LST is the most influential predictor of BMD and BMC of the whole body, lumbar spine and hip in Black and White children aged 8-9 years and 2) race also may influence bone health with Black children having greater measures than White children.

Previous studies have shown that obese children have greater bone mass (Leonard MB, et al, 2004), less bone mass (Goulding A, et al, 2002) or no difference in obese versus normal-weight control children (Manzoni P, et al, 1996). Our data supports that LST in 8-9 year old children makes greater contribution to BMD and BMC of the whole body, hip and lumbar spine than FM. This finding has previously been shown in both children and adults (Rocher E, et al, 2008 & Bakker I, et al, 2003). While the present study does indicate the importance of LST on bone in children, it does not suggest that obese children have poorer bone health as earlier studies have demonstrated (Goulding A, et al, 2002). Our data show positive and significant correlations between both FM and LST on BMD and BMC in both races and sexes, which seems to support research indicating obese children may have superior bone status (Leonard MB, et al, 2004) or at the very least suggests that FM does not necessarily have detrimental effects on BMD

and BMC. At first glance our findings along with previous studies, indicates that extra weight during childhood appears to strengthen bone. However, as noted before, bone fracture risk was found to be associated with higher BMI and adiposity (Goulding A, et al, 2001). Unfortunately fracture data was not available for the present study. Thus researchers have concluded that, although these obese children may demonstrate greater BMD and BMC, it may not be sufficient to overcome excessive forces put on the bone with a fall (Leonard MB, et al, 2004).

In addition to LST being identified as a predictor of bone health, race was also identified as a strong predictor of BMD and BMC. This was evident in our regression models and can also be observed in the descriptive characteristics of the different races within sex. Both Black boys and girls had significantly greater BMD and BMC of the whole body, hip and spine than White males and females (Table 2). It is well established that Black adults have greater BMD than White adults (Khan K, et al., 2001). Recent work in the United States also supports that Black children have superior BMD and BMC at the whole body, hip, lumbar spine and forearm than non-Black children (Kalkwarf HJ, et al, 2007).

While our data indicate these two factors independently contribute to bone status in children, race and lean mass may have an additive effect. In 2004, Leonard and colleagues found the Black children in their study to have significantly more LST than the other participants (Leonard MB, et al., 2004). Both the Black girls and boys were found to have greater LST than the White girls and boys in the present study. They were also found to have superior BMD and BMC at all sites, suggesting that the body

composition in Black children may be influencing the higher bone status. The potential interactive effects of race and body composition on bone status remain an understudied area with high potential importance to health disparity in the United States.

This study is not without limitations. First, it is recognized that there is no cause and effect relationship established due to the cross-sectional nature of the study. Second, this study was a part of a larger federally funded clinical trial therefore; any health or medication factors potentially affecting bone were not identified. However, as all children had to be eligible for participation in an exercise intervention they were free of cardiovascular and metabolic diseases. Thirdly, dietary intake, specifically calcium, phosphorus and magnesium, was not analyzed as a contributing factor to BMD. Finally, forearm scans were not collected and fracture history was no obtained due to the design of the parent study. Future studies should include the forearm scans along with fracture incidence to better relate body composition to fracture risk in children.

In conclusion, results from this study indicate that LST is the strongest determinant of BMD and BMC of the whole body, hip and lumbar spine in preadolescent children. Race also contributes to bone status in children with Black children having higher bone measures compared to their age matched counterparts, with this effect likely being influenced by LST.

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APPENDIX A:

Forms and Data Sheets

UNIVERSITY OF ILLINOIS

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Child Assent Script

Directions: Once parental written consent has been attained, written consent will be attained from the child participant. Hand the child a copy of this script so he/she can read along with you.

Please read the following script to the child prior to proceeding with the testing.

Script:

Hello, my name is _____ and I am a scientist at the University of Illinois. I am asking for your help with this study. This study asks that you talk with us on the two days at the beginning of the school year and two days at the end of the school year that you will be visiting the laboratory. I would like to explain what you are going to be doing and make sure that it's okay with you.

Today we will have you and your parent/guardian fill out three forms that tell us what types of foods you eat that contain calcium, beverages you drink and what types of physical activity you like to do for fun.

Then you will meet us on your second visit to the laboratory to measure how tall you are, how much you weigh and the size of your belly. After that, you will lie down on a table and lie still with eyes closed for about 10 minutes while a picture is taken of your body.

At the end of the school year, you will come back to the lab two more times and fill out the same forms and have your picture taken again along with the other testing.

Even though your parent/guardian has given their permission for you to complete these added tests, you can decide whether or not you want to be in the project. If you want to stop at any time, you can.

The results from this study will be given to scientists and doctors around the world to help them understand how important exercise and diet is for your body as you grow. The scientists involved in this study will deliver this information at meetings and through written reports. You will not be identified in any of these meetings or reports.

To thank you for helping us out we will pay you a bonus $10 in addition to the other rewards you may receive from completing the other measurements.

You will be given a copy of this form that I am reading to you. If you have a question, please ask. If you have a question after you leave, you can contact Dr. Charles Hillman at 217-244-2663 or Dr. Ellen Evans at 217-333-6678. If you wish to speak with someone about your *rights as a participant* in this study, you may contact the University of Illinois Institutional Review Board (217) 333-2670 (email: irb@uiuc.edu). You may call either of these numbers collect if you live outside the calling area. Do you have any questions about what we are asking you to do?

Would you like to participate in these activities (questionnaire and having your picture taken)?

YES NO

[Circle the verbal response from the participant]

Participant's signature: _____Date: _____

Researcher who read script: _____

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Informed Consent Form

"ERPs to Academics: Exercise Effects on Cognition in School-Aged Children"

Investigator Directing Research: Charles Hillman, Ph.D., University of Illinois at Urbana-Champaign, (217) 244-2663, chhillma@uiuc.edu.

Co-Investigator: Ellen Evans, Ph.D., University of Illinois at Urbana-Champaign, (217)333-6678, elevans@uiuc.edu.

You and your child are being invited to participate in optional research measurements that coincide with the primary research project. These measurements will evaluate the effects of physical activity and diet on your child's body composition and bone health. If you and your child agree to participate, you will complete three questionnaires and your child will have his/her body composition and bone health measured. The testing will *not* require an additional visit to the laboratory. These procedures will be incorporated into your two visits with the primary project. Your child will be given a bonus $10 for his/her participation at the conclusion of this study along with a written report on his/her body composition and bone health.

This form is designed to provide you with information about the measurements. Before you agree, you must provide informed consent indicating that you are:

1. Informed about the procedure.
2. Give your consent voluntarily (i.e., participate because you want to).
3. Know that you can withdraw your consent at any time.

Nature of the procedure

During the two visits to the laboratory (one at the beginning of the intervention and one at the end) you will be asked to complete three questionnaires and your child will have his/her bone health and body composition measured which will provide an indication of risk for osteoporosis and obesity. The questionnaires will measure your child's calcium intake, soft drink consumption and physical activity. They will be administered by an experimenter and will require you to recall your child's intake of high calcium foods/beverages, soft drink intake and quantify your child's physical activity.

Your child will come to the Bone and Body Composition Laboratory and we will measure his or her body composition and bone health. For this part of the study, your child will change into shorts and a T-shirt and his/her height, weight, waist (belly) and hip circumference will be measured. Then your child will lie down on their back on the DXA table for about 10 minutes, lying motionless with his/her eyes closed, the DXA machine will scan his/her body and measure the amount of bones, muscles, and fat.

<u>Potential Risks and Benefits</u>

The benefits of this line of research are to gain further insight into the influence of physical activity and dietary intake on your child's body composition and bone health. As such, this research will provide a basic understanding of whether an exercise program and dietary intake has a role in bone development and body composition changes in youth. As a participant, your child will receive a written report on his/her body composition and bone health. That report will be analyzed and mailed to you following completion of all study procedures. Note, however, that the tests conducted as a part of this study are not diagnostic procedures.

All procedures, techniques, equipment, and measures to be used in the study are routinely used in educational and research settings involving human subjects. No individual methodological element is new, untested, or of questionable safety for the health and general well being of human subjects.

During the DXA scan your child will be exposed to a very small amount of radiation from the DXA scan. As a part of everyday living, everyone is exposed to naturally occurring background radiation and receives a dose of about 200 to 300 millirem (mrem) each year. The effective dose from the set of the DXA x-ray procedure is about one (1) mrem. At this dose level, no harmful effects of radiation have been documented and the risk is negligible.

Results of this study will be disseminated by the investigators through conference presentations and scientific papers. The identity of all participants will be protected, and data will be presented from groups of participants rather than from individual participants.

When you sign this document, you are stating that the experiment has been fully explained to you, and that you understand that the data obtained from this study are to be used for research purposes only, not for the evaluation or diagnosis of any disorder, and that such data will remain confidential, except as required by law. You are also stating that you have had the opportunity to ask questions concerning any and all aspects of the procedures involved, that you are aware that participation is voluntary, and that you may withdraw your consent at any time.

In the event of physical injury resulting from this research study, immediate medical treatment is available from a number of health care providers in the area. However, the University of Illinois does not provide medical or hospitalization insurance coverage for participants in this research study, nor will the University of Illinois provide compensation for any injury sustained as a result of participation in this research study, except as required by law. If at any time, day or night, your child experiences adverse physical symptoms, you should immediately contact your personal physician or emergency personnel (i.e., dial 911).

You will be given a copy of this consent form for your records. If at any time, either now or later, you have a question, you are free to ask it, and you may contact the researcher, Dr. Charles Hillman (217-244-2663, chhillma@uiuc.edu) or Dr. Ellen Evans (217-333-6678, elevans@uiuc.edu). If you wish to speak with someone specifically about complaints or concerns regarding *rights as a participant* in this study, you may contact the University of Illinois Institutional Review Board (217) 333-2670 (E-mail: irb@uiuc.edu).

I the undersigned, hereby consent for my child to be a participant in the project described above conducted in the Department of Kinesiology and Community Health at the University of Illinois.

Signature of guardian: _____ Date: _____

Signature of experimenter: _____ Date: _____

Signature of witness:_____ Date _____

FIT KIDS ID #: _____

Date: _____

Time point (circle) 1 2

Date of Birth: _____

ANTHROPOMETRIC MEASURES

Measures	Trial 1	Trial 2	Trial 3	Comments
Body Mass (kg)				
Height				
BMI (kg/m^2)				
Circumferences (cm):				
Waist - natural				
Waist – umbilicus				
Hip				