Differences in Bone Mineral Density Among Adolescent Female Tennis Players and Non-Tennis Players

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DIFFERENCES IN BONE MINERAL DENSITY AMONG ADOLESCENT FEMALE TENNIS PLAYERS AND NON-TENNIS PLAYERS

A Thesis presented partial fulfillment of requirements for the degree of Masters of Science in the Department of Health, Exercise Science and Recreation Management Degree The University of Mississippi

By
KEVSER ERMIN

November 2010
DEDICATION

I dedicate this thesis to mom (Sevgi Ermin) and dad (Omer Ermin) for their endless love and support.
ACKNOWLEDGMENTS

I would like to express my deepest appreciate to my advisor, Dr. Scott Owens and my committee members, Drs. Allison Ford-Wade and Martha Bass for their support, encouragement, patience, guidance, and friendship. I owe my heartily gratitude to Dr. Jeff Hallam for his continuous support. I also would like to thank Dr. Melinda Valliant for her time and support.

I thank my whole family for their endless love and support. This thesis would not have been possible without my sister, Dr. Nurhayat Tabanca. I would like to thank her for believing in me and never leaving me alone at every step of my life.

I acknowledge the support from my dear friends for making this part of my life enjoyable and enriching. Lastly, I offer my regards and blessings to all of those who supported me in any respect during the completion of this study.
Approximately 10 million Americans have osteoporosis. Physical activity (PA) is an important step in preventing osteoporosis and is one of the major determinants of peak bone mass during adolescence. However, type of PA plays an important role when examining the effects of PA on bone mineral density (BMD). **PURPOSE:** 1) To determine the differences in BMD among adolescent female tennis players (TP) and non-tennis players (NTP); 2) to determine the differences in body composition (BC) between adolescent female TP and NTP; 3) to determine whether BC variables (weight, fat mass, and lean mass) were predictive of differences in BMD; and 4) to assess osteoporosis knowledge among female high school adolescents. **METHODS:** Nineteen female TP and 19 female NTP, aged 14 to 18 years, participated in this study. Lumbar spine, total hip, femoral neck, and left and right forearm BMD, and BC were assessed using dual-energy x-ray absorptiometry. Total osteoporosis knowledge (TOK) was assessed by the Osteoporosis Knowledge Test. One-way ANOVA was used to assess differences between TP and NTP for BMD, BC, and OKT. Multiple regression analysis was used to identify significant predictors of BMD. **RESULTS:** TP had significantly greater femoral neck BMD than NTP ($p = 0.017$). In addition, when data were analyzed with an outlier excluded, TP also had significantly greater total hip BMD than NTP ($p = 0.02$). Although TP had greater BMD for lumbar spine, and dominant arm measurements, these differences were not significantly greater than NTP. There were no significant differences for total body percent fat ($p = 0.72$), total body lean mass ($p = 0.07$) or total body fat mass ($p = 0.59$) between the groups. Collectively, body composition variables (body weight, total body lean mass and total body fat mass) significantly predicted BMD.
at the femoral neck and hip with lean mass being the best predictor among the three independent variables. A moderate level of knowledge related to osteoporosis was found among female adolescents. In addition, there were no significant differences between TP and NTP for TOK. **CONCLUSION:** This study suggests that adolescent female TP have greater femoral neck and total hip BMD than NTP. This difference might play an important role in preventing osteoporosis and decreasing the risk of fractures at the hip later in life.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Preface</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>9</td>
</tr>
<tr>
<td>Implications of the study</td>
<td>9</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>10</td>
</tr>
<tr>
<td>Operational Definitions</td>
<td>11</td>
</tr>
<tr>
<td>Literature Review</td>
<td>12</td>
</tr>
<tr>
<td>Adult Studies</td>
<td>12</td>
</tr>
<tr>
<td>Adolescent Studies</td>
<td>24</td>
</tr>
<tr>
<td>Summary</td>
<td>26</td>
</tr>
<tr>
<td>Methods</td>
<td>28</td>
</tr>
<tr>
<td>Participant Selection</td>
<td>28</td>
</tr>
<tr>
<td>Procedures</td>
<td>29</td>
</tr>
<tr>
<td>Instruments</td>
<td>31</td>
</tr>
<tr>
<td>Delimitations</td>
<td>34</td>
</tr>
<tr>
<td>Limitations</td>
<td>34</td>
</tr>
<tr>
<td>Statistical Analysis</td>
<td>34</td>
</tr>
<tr>
<td>Results</td>
<td>36</td>
</tr>
<tr>
<td>Subject Characteristics</td>
<td>36</td>
</tr>
<tr>
<td>Bone Mineral Density...</td>
<td>37</td>
</tr>
<tr>
<td>Body Composition Measurements</td>
<td>38</td>
</tr>
</tbody>
</table>
Osteoporosis Knowledge ....................................................... 38
Physical Activity ................................................................. 39
Pearson Correlations ............................................................. 41
Summary of results and formal hypotheses ............................. 41
Discussion .................................................................................. 44
Bone Mineral Density Measurements ........................................ 44
Body Composition Measurements ............................................. 48
Osteoporosis Knowledge ....................................................... 49
Pearson Correlations ............................................................. 50
Conclusion ................................................................................ 53
Recommendations for future research ................................. 54
References ............................................................................... 55
LIST OF TABLES

TABLE                          PAGE

Table 1.  Subject Characteristics................................................................. 68
Table 2. Bone Mineral Density Measurements of adolescent tennis players and non-tennis
players ............................................................................................................. 69
Table 3.  Body Composition Measurements of adolescent tennis players and non-tennis
players ............................................................................................................. 70
Table 4.  Results of Regression Analysis ............................................................. 71
Table 5.  Results of Osteoporosis Knowledge Test (OKT) ..................................... 72
Table 6.  Results of 7-Day Physical Activity Questionnaire. ............................... 73
Table 7.  Correlations of variables measured ....................................................... 74
Table 8.  Characteristics of control group participants of previous research ............ 75
LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1. Outlier / Extreme variables for total body, lumbar spine,</td>
<td>77</td>
</tr>
<tr>
<td>total hip and femoral neck BMD z-scores. O indicates an outlier.</td>
<td></td>
</tr>
<tr>
<td>Figure 2. Outlier / Extreme variables for dominant arm and non-</td>
<td>78</td>
</tr>
<tr>
<td>dominant arm BMD raw scores.</td>
<td></td>
</tr>
<tr>
<td>Figure 3. Outlier / Extreme variables for total body fat mass and</td>
<td>79</td>
</tr>
<tr>
<td>total body lean mass.</td>
<td></td>
</tr>
<tr>
<td>Figure 4. Outlier / Extreme variables for upper body extremities</td>
<td>80</td>
</tr>
<tr>
<td>lean mass and fat mass.</td>
<td></td>
</tr>
<tr>
<td>Figure 5. Outlier / Extreme variables for lower body extremities</td>
<td>81</td>
</tr>
<tr>
<td>lean mass and fat mass.</td>
<td></td>
</tr>
<tr>
<td>Figure 6. Outlier / Extreme variables for weekly physical activity.</td>
<td>82</td>
</tr>
<tr>
<td>Figure 8. Dominant arm and non-dominant arm BMD raw scores.</td>
<td>84</td>
</tr>
<tr>
<td>Figure 9. Body composition results.</td>
<td>85</td>
</tr>
</tbody>
</table>
# LIST OF APPENDICES

<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Flyer</td>
<td>84</td>
</tr>
<tr>
<td>B Recruitment</td>
<td>86</td>
</tr>
<tr>
<td>C Initial Phone Contact Script</td>
<td>87</td>
</tr>
<tr>
<td>D Initial Phone Contact with Potential Subjects</td>
<td>92</td>
</tr>
<tr>
<td>E Child Assent Form</td>
<td>93</td>
</tr>
<tr>
<td>F Parental Consent Form</td>
<td>96</td>
</tr>
<tr>
<td>G Consent Form</td>
<td>99</td>
</tr>
<tr>
<td>H Pregnancy Script</td>
<td>102</td>
</tr>
<tr>
<td>I Osteoporosis Risk Factor Assessment</td>
<td>103</td>
</tr>
<tr>
<td>J Osteoporosis Knowledge Test</td>
<td>110</td>
</tr>
<tr>
<td>K DXA Test Results Report Form</td>
<td>114</td>
</tr>
<tr>
<td>L Tanner Stage Questionnaire</td>
<td>115</td>
</tr>
<tr>
<td>M Seven-Day Physical Activity Recall Questionnaire</td>
<td>116</td>
</tr>
<tr>
<td>N BMI Script</td>
<td>117</td>
</tr>
</tbody>
</table>
Chapter I

Introduction

Preface.

The bony skeleton is a remarkable organ with two major functions. The first major function is providing mechanical support, mobility, and protection for the soft tissues and levers for muscle actions. The second major function is the reservoir function; the skeleton is the storehouse for essential minerals such as calcium and phosphate (Rodan, 2003). Turner (1998, p.1) stated that “bone architectures are elegant and structurally efficient as if they were designed based on an engineering blueprint”.

Bone must have massive strength and flexibility while at the same time being lightweight and adaptable so that transportation is not a metabolic burden (Khan et al., 2001, p.3). Throughout life, old bone breaks down while new bone is formed on a continuous basis. Every ten years most of the adult skeleton is replaced by modeling and remodeling processes (Manolagas & Weinstein, 1999). However, bone formation decreases with aging in both men and women. Moreover, an imbalance occurs between bone resorption and bone formation causing loss of bone mass and structural abnormalities that make the skeleton more fragile (Manolagas & Jilka, 1995).

Osteoporosis is as a skeletal condition that is characterized by decreased density of mineralized bone (Glaser & Kaplan, 1997). According to the NOF (2008a), approximately 10 million Americans have osteoporosis. Furthermore, approximately 1.5 million people suffer an osteoporotic related fracture each year and, 20% of senior citizens who suffer a hip fracture die within a year in the US (United States Department of Health and Human Services [USDHHS], 2004). It is estimated that the number of
Osteoporotic fractures will increase more than 3-fold over the next 50 years in both men and women (World Health Organization [WHO], 2004).

The economic cost of osteoporosis has been found to be comparable to other major chronic diseases such as cardiovascular disease and asthma (Chan et al., 2003). The cost of osteoporosis-related fractures was approximately $19 billion in 2005 and is expected to increase to $25.3 billion by 2025 (National Osteoporosis Foundation [NOF], 2008a). Moreover, osteoporosis causes more hospital bed days than stroke, myocardial infarction or breast cancer (Lippuner, Overbeck, Perrelet, Bosshard, & Jaeger, 1997). The estimated lifetime risk for osteoporotic related wrist, hip or vertebral fractures has been found to be very close to that for coronary heart disease in developed countries (WHO, 2004).

Osteoporosis has been classified as primary and secondary osteoporosis. Primary osteoporosis is the most common form of osteoporosis and occurs when individuals experience the cumulative impact of bone loss and deterioration of bone structure that is caused by aging (USDHHS, 2004). Primary osteoporosis is divided into three categories: (1) post-menopausal osteoporosis – Type I, (2) age-related osteoporosis – Type 2, and (3) idiopathic osteoporosis in which the exact causes of bone loss is not known (Glaser & Kaplan, 1997). Secondary osteoporosis occurs as a result of a variety of diseases and certain medications that cause or contribute to the development of bone loss (USDHHS, 2004).

Osteoporosis is more common in women than men since men have greater bone mass than women at all ages and experience no physiologic equivalent of menopause. However, severe Type II - age related osteoporosis is seen among men (Glaser & Kaplan,
The probability of women experiencing an osteoporotic fracture at the age of 50 is more than 40% in developed countries (WHO, 2004).

Individuals with a previous fracture, who are on corticosteroid treatment for a long time, women who experience premature menopause, individuals with risk factors such as liver or thyroid disease or whose body mass index is lower than 19 kg/m², smokers, and individuals with a falling history have been found to be at higher risk for fragility fractures (Chan et al., 2003).

Osteoporosis is identified on the basis of bone mineral density (BMD). According to the WHO (2004), an individual who has a BMD value between 1 and 2.5 standard deviations below the average value in a young reference population is classified as having low bone mass, in other words having osteopenia (a T-score that is <-1 or >-2.5). If the BMD value is 2.5 standard deviations or more below the average value of young healthy population, the individual is considered as having osteoporosis (a T-score of ≤-2.5 SD). T-score is a calculated value based on the comparison of the raw BMD score of an individual with the mean peak bone density of a 25 – 30 year old healthy, race- and sex-matched individual (Khan et al., 2001, p.42).

Many different techniques have been used to measure bone density at different sites such as the hip, spine and forearm. Dual X-Ray absorptiometry (DXA) measurement of hip and spine is the gold standard for BMD measurement and is used to verify a diagnosis of osteoporosis and predict future fracture risk (Watts, Lewiecki, Miller, & Baim, 2008; Chan et al., 2003).

Peak bone mass (PBM) is one of the major determinants of bone mass later in life (Haapasalo et al., 1998; Kannus et al., 1995). PBM primarily depends on heredity, race,
gender, hormonal status, nutrition, and physical activity (Compston, 1995; Kannus et al., 1995; Kröger, Kotaniemi, Kröger, & Alhava, 1993). Heredity has the biggest effect (60 – 80%) on peak bone mass compared to other factors (Haapasalo et al., 1998; Johnston & Slemenda, 1993). In post-menopausal twins, a strong genetic contribution to bone mass at all sites was measured (Arden, Baker, Hogg, Baan, & Spector, 1996). African-American individuals have higher bone density and lower risk of osteoporosis than Caucasians or Asians (Ott, 1991). It is estimated that 25% of non-Hispanic Caucasian and Asian women aged 50 and older have osteoporosis and 52% have low bone mass whereas only 5% of non-Hispanic black women over age 50 have osteoporosis and 35% have low bone mass (NOF, 2008a). In addition, 80%) of the Americans who have osteoporosis are women whereas 20% are men. Hormones play an important role in resolving how much bone is formed at different phases of skeletal growth and determine the bone mass and strength that is maintained throughout life (USDHHS, 2004). For example, sex hormones such as estrogen and testosterone are enormously important in regulating the growth of the skeleton and maintaining the mass and strength of bone (USDHHS, 2004). Researchers have confirmed that estrogen and testosterone play major roles in maintaining bone formation in elderly men (Falahati-Nini et al., 2000). Johnston and Slemenda (1994) stated that hormone replacement therapy may cause small increments approximately 2% in bone mass even though it is a short-term increase. Nutrition is an important factor in bone health. According to the NOF (2008b), individuals aged 9 to 18 years should consume 1300 mg daily of calcium per day. People who consume sufficient amounts of calcium and vitamin D throughout life have better bone health. The US Surgeon General stated that obtaining a negative balance of only 50
- 100 mg of calcium per day, which is much less than the 300 mg of calcium in a single glass of milk, over a long period of time is sufficient to develop osteoporosis (USDHHS, 2004). In addition, adolescent girls who have anorexia nervosa have lower bone density values perhaps combined with decreased bone accretion (Bachrach, Katzman, Litt, Guido, & Marcus, 1991).

Physical activity makes a significant contribution to bone mass and structure. Physical activity is one of the most important steps in preventing osteoporosis (Chan et al., 2003). However, type of exercise is also important when examining the effects of physical activity on BMD. Weight bearing activities that require ground reaction forces greater than or equal to three times the body weight are likely to be more beneficial than non-gravitational sports (Düppe, Gärdsell, Johnell, & Ornstein, 1996). For instance, weight lifters have significantly higher BMD than their control pairs (Karlsson, Johnell, & Obrant, 1993). Volleyball players and gymnasts have greater bone mineral density at a majority of skeletal sites than swimmers (Fehling, Alekel, Clasey, Rector, & Stillman, 1995). In addition, badminton players also have significantly higher bone mineral density than hockey players (Nordström, Petterson, & Lorentzon, 1998).

Childhood is an appropriate time period to increase peak bone mass. However, the prevention of osteoporosis is seen more often in postmenopausal women who already show the signs of depleted bone mass (Gunter et al., 2007; Poslušná, Matějova, & Březková, 2008). Primary prevention during childhood and adolescence is the most important prevention and actually much more efficient (Poslušná et al., 2008). In the United Kingdom, the incidence of fractures of the ulna and radius was similar between males 16 – 24 years old and men 85 years and older in 1991 – 1992: 23/10,000 vs
24/10,000, respectively (McCormick, Fleming, & Charlton, 1995). Moreover, data have shown that lower bone mass is associated with fracture risk in children (Clark, Tobias, & Ness, 2006). Therefore, the purpose of the primary prevention should be to maximize bone mass and to minimize the risk of fractures during childhood and adolescence.

PBM is attained during the first two decades of life (Haapasalo et al., 1998; Kannus et al., 1995; Kröger et al., 1993; Lu et al., 1994). Therefore maximizing the amount of bone gained during childhood and adolescence is essential to prevent osteoporosis and decrease the risk of fractures later in life (Bailey, McKay, Mirwald, Crocker, & Faulkner, 1999; Bass et al., 1998; Bonjour, Theintz, Buchs, Slosman, & Rizzoli, 1991; Bradney et al., 1998; MacKelvie, McKay, Khan, & Crocker, 2001).

Several cross-sectional studies have shown that exercise during growth increases BMD. Active pre-pubertal gymnasts had higher BMD values than controls at the legs, spine, and arms (Bass et al., 1998). Female football (soccer) players aged 15-30 years old had significantly greater BMD values, higher lean body mass and lower fat content than controls at all measured sites except the lumbar spine (Düppe, et al., 1996). Bradney et al. (1998) showed that boys aged 8.4 to 11.8 years old who performed 30-minutes sessions of weight bearing physical education lessons three times per week during eight months increased their BMD twice much as controls. It was concluded that the growing skeleton is responsive to moderate exercise.

Tennis is a recreational and professional sport performed in more than 200 countries (Pluim, Staal, Windler, & Jayanthi, 2006). It is the most popular sport among all of the racquet sports and approximately 2 million people play tennis recreationally each year in the US (Bylak & Hutchinson, 1998). Tennis requires intermittent exercise
with vigorous involvement of both lower and upper body musculature during short periods of activity, plus includes fast reactions, quick acceleration, fast arm, leg and whole body movements and an ability to change direction quickly (Reilly, Secher, Snell, & Williams, 1990, p.299). Tennis players usually start playing during childhood and many continue playing into late adulthood (Bylak & Hutchinson, 1998).

Researchers have been interested in the relationship between tennis and BMD. Many studies have focused on a side-to-side measurement that compares the playing extremity to the non-playing side. It has been reported that most of the tennis players have significantly greater bone mass and bone area on their dominant arm than their non-dominant arm (Bass et al., 2002; Calbet, Moysi, Dorado & Rodriguez, 1998; Haapasalo et al., 1994; Haapasalo et al., 1996; Haapasalo et al., 2000; Juzwiak, Amancio, Vitalle, Szejnfeld, Pinheiro, 2008; Kannus, Haapasalo, Sievänen, Oja, & Vuori, 1994; Kannus et al., 1995; Kontulainen et al., 2001; Krahl, Michaelis, Pieper, Quack, & Montag, 1994; Montoye, Smith, Fardon, & Howley, 1980; Tsuji et al., 1995). Some of the researchers examined the state of maturity (Tanner stage) at which BMD varies between the dominant and non-dominant arm of junior tennis players (Haapasalo et al., 1998). Others examined the effects of starting age and whether the players started to play before or after menarche (Kannus et al., 1995; Kontulainen et al., 2001). However, there is still need for further research examining the effects of tennis on BMD of adolescent players. There are only a few studies that investigated the total body, lumbar spine and femoral neck BMD of adult tennis players (Calbet et al., 1998; Jacobson, Beaver, Grubb, Taft, & Talmage, 1984; Nichols, Sanborn, Bonnick, Gench, & DiMarco, 1995). In these studies, the age range of the participants was 18 – 75 years old. In adolescents, the results are in
disagreement for BMD measurements. Haapasalo et al. (1998) reported significant upper extremities and spine BMD differences between female tennis players and controls whereas Juzwiak et al. (2008) assessed no significant differences in forearms BMD and spine BMD between male tennis players and controls. Significant differences were found for dominant arm bone mineral content (BMC) and trochanter BMD. Hip BMD have not been assessed in female tennis players. Therefore more studies are necessary to examine the effects of tennis on regional BMD in adolescents.

There is a strong relationship between body weight (lean mass and fat mass) and BMD. Some researchers have concluded that fat mass is a better determinant of whole body bone mineral density than lean mass in females (Bedogni et al., 2002; Seeman et al., 1996; Wang et al., 2005) whereas others have stated that fat mass had a negative impact on BMD in 10 – 19 year old females (Hage, Courteix, Benhamou, Jacob, Jaffré, 2009). In tennis players, data have shown that regional lean mass is better correlated with BMD than weight, lean mass, and fat mass in college aged female tennis players (Nichols et al., 1995). In adolescent male tennis players, only Juzwiak and colleagues (2008) reported that lean body mass was the best predictor of BMD and BMC. However, there is no study that has examined the relationship between body composition (fat mass and fat free mass) and BMD among female adolescent tennis players. Hence there is a need for conclusive research examining the relationship between BMD, fat mass, and fat free mass among female adolescent tennis players.

In order to achieve the goal of primary prevention for osteoporosis, children and adolescents should consume adequate amounts of calcium and protein, perform reasonable physical activity (Poslušná et al., 2008). Despite these facts, research showed
that 58% of adolescent girls consumed less than the adequate intake for calcium, and 52% performed only low to moderate physical activity (Anderson, Chad, & Spink, 2005). Therefore, it is necessary to assess knowledge and beliefs about osteoporosis risk factors among adolescents.

Statement of the Problem.

The primary purpose of this study was to determine the differences in bone mineral density among adolescent female high school tennis players and non-tennis players. The secondary purpose was to determine the differences in body composition (fat mass-fat free mass) between adolescent female tennis players and non-tennis players and whether body composition variables are predictive of differences in BMD. Another secondary purpose was to assess the osteoporosis knowledge and health beliefs among female high school adolescents and to examine whether tennis players have better osteoporosis knowledge than non-tennis players.

Implications of the study.

Primary prevention during childhood and adolescence is essential to prevent osteoporosis and to decrease risk of fractures later in life. Tennis as a weight bearing physical activity has been shown to increase BMD of female adolescent tennis players in the dominant arm, and lumbar spine (Haapasalo et al., 1998). However, these results are not in agreement with those of Juzwiak et al. (2008) who found no significant differences in spine and forearms BMD between male adolescent tennis players and controls. The present study examined the differences in forearms, spine and hip BMD in female adolescent tennis players and non-tennis players. Since female adolescents who were able to be involved in sports other than tennis participated in this study as controls,
this study showed whether tennis is a unique sport which develops bone health. The current research also examined the association between tennis playing and body composition (fat mass and fat free mass) and whether body composition variables were predictive of differences in BMD. Last, osteoporosis knowledge among female adolescents was assessed to determine whether tennis players have better osteoporosis knowledge than non-tennis players.

**Hypotheses.**

HO₁: There is no significant difference in mean lumbar spine bone mineral density between adolescent tennis players and non-tennis players.

HO₂: There is no significant difference in total hip bone mineral density between adolescent tennis players and non-tennis players.

HO₃: There is no significant difference in femoral neck bone mineral density between adolescent tennis players and non-tennis players.

HO₄: There is no significant difference in mean bone mineral density in dominant forearm between adolescent tennis players and non-tennis players.

HO₅: There is no significant difference in mean bone mineral density in non-dominant forearm between adolescent tennis players and non-tennis players.

HO₆: There is no significant difference in mean fat mass between adolescent tennis players and non-tennis players.

HO₇: There is no significant difference in mean fat-free mass between adolescent tennis players and non-tennis players.
HO8: There is no significant relationship between BMD at the various sites in the body and a group of predictor variables, including weight, fat mass, and fat free mass in adolescent tennis players and non-tennis players.

HO9: There is no significant relationship between tennis playing and osteoporosis knowledge among adolescent tennis players and non-tennis players.

**Operational Definitions.**

**Anorexia nervosa:** Eating disorder that causes individuals to have an intense fear of gaining weight (Smith, 1998, p.11).

**Bone mineral content:** Total grams of mineral density within a measured bone area (Khan et al., 2001, p.37).

**Bone mineral density:** Grams of bone mineral per unit of bone area scanned (Khan et al., 2001, p.37).

**Menarche:** First menstrual period (Khan et al., 2001, p.114).

**Modeling:** Process that occurs when bone is formed at one side, and broken down at a different site where its shape and position is changed (USDHHS, 2004).

**Remodeling:** Process of removal and replacement of bone at the same site (USDHHS, 2004).

**Peak bone mass:** Highest bone mineral content during adulthood (Nilsson, Ohlsson, Mellström, & Lorentzon, 2009).
Chapter II

Literature Review

This literature review includes previous research that have examined the relationship between tennis playing and bone mineral density (BMD). The previous studies were obtained from online databases including: Medline, PubMed, and Google Scholar. The key words used to identify research for this literature review were: “tennis playing”, “bone mineral density”, “bone mass”, “bone mineral content”, “bone health”, “adolescent tennis players”, “health benefits of tennis”. Articles published during 1956 – 2009 were included in this literature review. Studies articles were divided into two sections depending on whether participants were adults or adolescents.

Adult Studies.

Researchers became interested in the relationship between BMD and tennis playing as early as 1956. Although the measuring equipment was different than today’s, researchers found similar side-to-side differences compared to current results. Buskirk, Andersen, and Brozek (1956) compared the BMD of the forearms of 7 nationally ranked tennis players to 11 soldiers. It was concluded that tennis playing caused muscular hypertrophy and an increase in length of the radius and ulna in the forearm used to swing the tennis racquet.

Later, Montoye et al. (1980) measured BMD of the dominant and non-dominant arms of 61 male senior tennis players aged 55 and older. The average time of tennis playing of the participants was 40 years. In order to measure the BMD of radius, ulna and humerus, a photon absorptiometry was used as a radioactive source. In addition to the BMD measurements, skin-fold thickness of the posterior side of the right and left
forearms at the maximum circumference, the mid-part of the biceps and triceps of the upper arms, and grip strength were measured. The results of this study indicated that the width and the mineral content of the radius and humerus were significantly greater on the dominant arm (7.9% & 13%, respectively). Grip strength was 12% greater in the dominant hand than non-dominant hand. However, skin-fold thickness did not change between the dominant and non-dominant arms.

Huddleston, Rockwell, Kulund, & Harrison (1980) examined BMD of 35 active male tennis players. Twenty-one subjects were between the ages of 70 to 74 years, 9 subjects were aged 75 to 79 years and 5 subjects were aged 80 to 84 years old. Tennis playing experience of the participants ranged between 25 to 72 years. Bone mineral content and bone width of the mid-shaft of the radius were measured using a commercially available bone mineral analyzer. Results showed bone mineral content of the playing arm was greater (4% to 33%) than the non-playing arm in all but one subject who was an ambidextrous.

Jacobson and colleagues (1984) examined BMD of 11 intercollegiate female tennis players, 23 female swimmers (age range was 18 to 22 years), and 86 older athletic women (22 to 70 years old). Single-photon densitometry was used to measure BMD at the distal radial site, mid-radius, and the first metatarsus. In addition, dual-photon densitometry was used to measure bone mineral density of lumbar spine. For the tennis players, bone mineral content of the dominant arm was 16% greater than the non-dominant arm. Only the tennis players had significantly higher lumbar spine bone density. The participants of both sports (tennis and swimming) had increased metatarsal density but with a much greater degree in the tennis players. For the adult athletic
women, bone density values for all parameters were higher in the athletic group than for their age-matched controls. It was concluded that the effect of gravitational stress on weight-bearing bone was more apparent in tennis players.

More recently, researchers have compared BMD values between the dominant and non-dominant arms in adult tennis players using DXA. Not only cross-sectional studies, but also longitudinal research have been completed to determine the effects of time of tennis playing on BMC and BMD values. Furthermore, some investigators have examined the effects of starting age of tennis playing on BMC and BMD in adult tennis players.

Kannus et al. (1994) sought to answer the following questions: (1) “Does active tennis playing affect the bone mineral content (BMC) and the BMD of the playing upper extremity?” (2) “How extensive is the effect and which are the affected bone?” (3) “Are there differences between the side-to-side differences in BMC and BMD? (4) “Do these differences exist in controls and, if so, to what extent?” and (5) “Are there any correlations between the side-to-side differences in BMC and BMD and the players’ training history or muscle strength?” Twenty top-level male tennis players with a mean age of 25 years and 20 right-handed male controls with a mean age of 26 years participated in this study. BMD and BMC were measured from 7 different sites which were proximal humerus, humerus shaft, radial shaft, ulnar shaft, distal radius, distal ulna, and hand of the upper extremities by a DXA scanner. Furthermore, elbow extension and flexion forces were determined with an isometric dynamometer. The results of this study showed that the measured bone parameters were significantly greater in the playing arm. In the tennis players, the largest side-to-side differences were seen in the humeral shaft.
(BMD 25.4%, BMC 28.7%) and proximal humerus (BMD 14.4%, BMC 20.5%) whereas the smallest differences were observed in the ulnar shaft (BMD 3.1%, BMC 7.5%) and distal ulna (BMD 6.3%, BMC 7.8%). The side-to-side differences were small ranging from 0.0% to +6.4% (mean ($M$) = 3%) in the control group. Plus, all the strength measurements were significantly greater in the players.

Little is known regarding the maintenance of bone mass gained by physical activity into adulthood despite decreased activity (Kontulainen et al., 1999). As a follow-up study of Kannus et al. (1994), Kontulainen and colleagues (1999) measured BMC of upper extremities of 26 participants (13 tennis players and 13 controls) who participated in the previous study 4 years earlier. The tennis players had retired from competing at the national level before BMC measurements. For each subject, BMC of the proximal humerus, humeral shaft, radial shaft, and distal radius in upper extremities were measured using a DXA scanner. In addition, elbow extension and flexion forces, and grip strength were also measured using an isometric dynamometer. The results of this study showed that the tennis players still had greater BMC than controls at each site measured. When compared to the previous study, the tennis players’ side-to-side differences were similar (25% in 1992 and 26% in 1996 at the humeral shaft). This difference in the control group was only 5%. Therefore, it was concluded that the side-to-side BMC difference was well maintained during the 4-yr follow up period although the mean training frequency and the mean hours of training were decreased.

The aim of Kannus et al. (1995) was to determine the effect of biological age when unilateral loading was started, on the difference in bone mass of the dominant and non-dominant arms of female racket players (tennis and squash). One-hundred and five
ranked, national-level, female tennis and squash players (mean age ($M_{age} = 27.7$ years) and 50 healthy women ($M = 27.2$), as a control group, participated in this study. In order to examine the hypothesis that the biological age at which the playing career was started was important for the development of side-to-side difference in bone mass, the players were divided into six groups according to the starting age of playing relative to age at menarche: (1) more than 5 years before menarche - childhood, (2) 3 to 5 years before menarche - pre-puberty, (3) 2 to 0 years before menarche - puberty, (4) 1 to 5 years after menarche - post-puberty, (5) 6 to 15 years after menarche - early adulthood, and (6) more than 15 years after menarche - adulthood. Bone mineral content at the proximal humerus, humeral shaft, radial shaft, and distal radius were measured using a DXA scanner. In addition, the maximal isometric strength of upper extremities, using an arm flexion-extension dynamometer, and grip strength, using a standard grip strength meter, were also measured. The results showed that the dominant to non-dominant side difference in BMC was significantly greater in players in all of the measured sites (players 8.5% to 16.2%; controls 3.2% to 4.6%). When only the dominant arm BMC of the players and controls was measured, the players had significantly greater values than the controls in every measured site except the radial shaft. For the non-dominant arm, there were no significant differences between the players and controls. The researchers also stated that the benefit was about two times greater if women started their playing career at or before menarche (humeral side-to-side difference 17% to 24%) than after menarche (8% to 14%).

Five years later, Kontulainen et al. (2001) compared the changes in the playing and non-playing arm difference in BMC of 64 tennis and squash players and 27 controls
who participated in the previous study of Kannus et al. (1995). Thirty-six of the total players had started playing tennis before or at menarche (young starters), and 28 of the players had begun playing tennis a minimum 1 year after menarche (old starters). During the follow-up, the young starters had decreased the average playing time frequency from 4.7 times a week to 1.4 times a week and the old starters from 4.0 times a week to 2.0 times a week. BMC was measured at the proximal humerus, humeral shaft, and distal radius using a DXA scanner. The results of this study have shown a good protection of the side-to-side BMC difference (22% in the humeral shaft of the young starters and 10% in the old starters) between the dominant arm and the non-dominant arm during the follow up, even though the mean training frequency and the mean hours of training were decreased.

Haapasalo et al. (1996) evaluated the effects of long-term unilateral tennis playing on the playing arm humerus. Seventeen young males ($M_{age} = 25$ years), and 30 young female athletes ($M_{age} = 19$ years) who had started playing tennis competitively early in childhood (mean starting age ($M_{starting\ age} = 10$ years for males and $M_{starting\ age} = 9$ years for females), 20 older female athletes ($M_{age} = 43$ years) who had started playing tennis competitively in adulthood ($M_{starting\ age} = 29$ years) and 16 young men ($M_{age} = 25$ years), and 25 young women ($M_{age} = 21$ years) as the control group participated in this study. BMD of the three sites of the humerus (distal, middle, and proximal) were measured using a DXA scanner. In the young male tennis players, the side-to-side differences in BMC and BMD were significant (ranged from 12.8% to 45.2%) in every measured site. Young male controls also had significant side-to-side differences (range 0.4% to 8.2%) in BMC and BMD at the middle and distal sites. In young female players,
BMC and BMD values were significant (range 0.5% to 30.9%) in all of the measured sites, whereas the female controls had significant side-to-side differences at the humerus (the difference was always less than 6.5%). However, when female players were compared to controls, tennis players had significantly greater values for BMD and BMC values. The older participants had smaller side-to-side differences (range 0.1% to 12.4%) than young participants. Compared with the controls, the older players had significantly greater BMD and BMC values. It was concluded that the bone mineral acquisition and geometric adaptation of the humerus were dependent on the starting age of tennis playing, even though mechanical loading of a mature bone could also increase bone mass and cortical wall thickness of the target bone to some degree. The effects of mechanical loading were more than 2-fold better if the playing was started in childhood or adolescence.

Ducher, Prouteau, Courteix, and Benhamou (2004) examined the effects of tennis induced mechanical strains at the dominant and non-dominant distal radius and ulna. Thirty three men and 24 women ($M_{age} = 24.5$ years) tennis players who had been practicing for at least 5 years participated in this study. Bone area, BMC, and BMD were assessed using DXA. The side-to-side BMD difference at the ultra-distal radius was larger than the bone area (8.4 ± 5.2% vs 4.9 ± 4.0%, respectively). In the cortical sides, the asymmetry was lower in BMD than in the bone area (mid-distal radius: 4.0 ± 4.3% vs 11.7 ± 6.8%; third-distal radius: 5.0 ± 4.8% vs 8.4 ± 6.2%). The conclusion was that cortical and trabecular bone responds differently to mechanical loading.

Researchers also examined whether long-term recreational tennis participation is associated with increased bone mass and density in postmenopausal tennis players.
Ten healthy post-menopausal tennis players and 12 post-menopausal non-active women participated in this research. Whole body, femoral, and lumbar BMD and BMC were assessed using DXA. There were no significant differences between the groups for lumbar spine and femoral BMD and BMC. BMC was increased in the dominant arm of tennis players compared to the non-dominant arm.

Tsuji et al. (1995) examined the relationship between grip strength and radial bone mineral density in 10 male college amateur wrestlers (age range 19 to 21 years), 16 female college basketball players whose age ranged between 18 and 24 years (mean menarche \(M_{\text{menarche}} = 12.3\) years), and 12 female college tennis players whose age ranged between 19 and 23 years \(M_{\text{menarche}} = 12.1\) years. BMD at the distal radius and mid-radius were measured using a DXA scanner. Only for the tennis players, the radial BMD of both of the dominant and non-dominant forearms was evaluated. Isometric grip strength was measured using a hand-held dynamometer. As expected, the grip strength of the dominant forearm was significantly greater than in the non-dominant forearm in tennis players. The mid-radial BMD of the dominant arm was also significantly greater than the non-dominant arm in tennis players. It was also concluded that grip strength was a better determinant of radial BMD than body weight in the dominant arm.

In addition to bone mineral measurements, some of the researchers also measured both total and regional body composition and determined the relationship between fat and fat-free mass and BMD of the adult tennis players. Calbet et al. (1998) measured body composition and BMD of the dominant and non-dominant arms, lumbar spine and femoral neck of nine male tennis players and 14 non-active men aged 20 to 32 years old using a DXA scanner. Tennis players showed a 20% more BMC and greater muscle
mass in the dominant arm than the non-dominant arm. Moreover, tennis players also had approximately 11% greater BMD at the femoral neck and 15% more BMD at the lumbar spine than their sedentary pairs. Even though the difference was greater in the tennis players, both the players and the controls had greater muscle mass in the dominant arm than the non-dominant arm (20% vs 5%). In tennis players, BMC of the dominant arm was correlated with their respective muscle mass and total mass \( r = 0.76; r = 0.83 \), respectively. In the sedentary subjects, these correlations were \( r = 0.86 \) and \( r = 0.86 \), respectively. It was suggested that tennis playing is as efficient as other weight bearing sports in increasing BMD at clinically relevant sites such as the femoral neck and the lumbar spine.

The purpose of Nichols and associates (1995) was to determine whether regional values of tissue mass, both lean and fat, were related to the corresponding values for BMD in a group of college females. Fourteen basketball, 13 gymnastics, 6 tennis, 13 volleyball athletes, and 12 non-athletic females participated in this study. BMD of the lumbar spine, right femoral neck, and the total body was measured using a DXA scanner. Mean age for all of the participants was 19.9 years and mean years of training of the athletes was 9.7. Mean lumbar, femoral neck, and total body BMD of the athletes were significantly greater than non-athletes (stats). However, no differences were found in BMD among any of the athletic groups and between the leg lean tissue mass and femur BMD. However, significant relationships \( (r = 0.58, p < 0.001) \) were found between leg BMD and leg lean tissue mass. Significant relationships were also seen between arm lean tissue mass and arm BMD and arm lean tissue mass and lumbar BMD \( (r = 0.47, p < 0.001, \text{ and } r = 0.56, p < 0.001 \text{ respectively}) \). On the other hand, leg fat mass was
significantly correlated to leg BMD ($r = .40, p = 0.001$). Therefore, body weight, total lean tissue mass and total fat were significantly related to total BMD. In addition, total lean tissue mass was significantly correlated with leg and lumbar BMD as well ($r = 0.54$ and $0.42$, respectively, $p < 0.001$). Overall, this study has shown that there are moderate but significant relationships between regional lean tissue mass and the corresponding regional BMD. The regional lean mass was better correlated with BMD than weight, lean mass, or fat mass.

Squash players also showed the same side-to-side differences in BMD and BMC of the upper extremities. Haapasalo and colleagues (1994) examined BMD of 19 female national level squash players and 19 female controls (age range 18 to 32 years) using DXA. The measured sites of the upper extremities were proximal humerus, humeral shaft, ulnar shaft, distal radius, and distal ulna. The players had significantly higher BMC and BMD on the dominant arm with the greatest side-to-side difference in the proximal humerus (BMC 17.8% and BMD 15.6%) and with the smallest difference in the ulnar shaft (BMC 7.3% and BMD 5.6%). These differences for the controls were very small ranging from 1.6% to 4.1%. Significantly greater side-to-side differences were seen in the players who had started their training before or during menarche (22%) than the players who had started their career 1 year or more after the menarche (9%).

Besides DXA measurements, some researchers used a peripheral quantitative computed tomography (CT) scanner that measures the bone mass as three dimensions, volumetric density and geometric properties. Ashizawa et al. (1999) evaluated the effect of long-term unilateral physical activity on volumetric density and geometric properties of playing arm radius of tennis players compared with non-playing radius using a
Peripheral CT scanner. Ten young adult female and 6 young adult male tennis players, and 7 female and 5 male non-tennis players (age ranged from 18 to 24 years old) participated in the study. For the mid-radius measurements, players’ dominant arm showed an increase in total BMC (13.3%), cross-sectional bone area (15.2%), cortical BMC (12.6%), and cortical bone area (13.5%) when compared to the non-dominant arm. Volumetric density of the total bone and the cortical bone were lower in the playing arm than in the non-playing arm. Significant side-to-side differences were also found for the controls in total BMC (3.1%), cortical BMC (3.6%), and cortical area (4.0%). However, these differences were significantly less than those found in the players. For the distal radius, the total BMC was greater for the dominant arm than the non-dominant arm (13.8%) in all cases for the total bone and in all but one case for the trabecular bone in tennis players. The control group did not show any significant side-to-side difference in any measured parameter. The researchers suggested that physical activity induces cortical drift toward periosteal direction, resulting in a significant increase in mechanical strength despite a lower volumetric density at mid-radius of the playing arm. An increase in the trabecular BMD of the distal radius was inversely related to side-to-side differences in total bone area.

Peripheral CT was used to assess side-to-side differences in female tennis players who initiated playing tennis after bone had matured (Nara-Ashizawa et al., 2002). Ninety-two adult tennis players (age range was 35 to 55 years old) participated in this study. Results showed that there was no significant side-to-side difference in cortical thickness, cortical BMD, and BMD of whole bone at the midradius. BMC of the dominant distal radius was greater than non-dominant radius; however, the difference was not statically
significant. It was stated that unlike young subjects, tennis playing after bone had matured did not stimulate cortical drift toward the periosteal direction in middle aged female subjects.

Haapasalo et al. (2000) also evaluated the characteristics of the upper extremity bones in male tennis players and their sedentary controls using a peripheral CT scanner. Twelve national top-level tennis players ($M_{age} = 29.8 \pm 4.8$ years) and 12 corresponding controls ($M_{age} = 29.8 \pm 5.2$ years) participated in this study. The bone characteristics of the proximal humerus, humeral shaft, distal humerus as well as radial shaft and distal radius were measured for each subject. The tennis players showed significant side-to-side differences, in favor of the dominant arm, in BMC (14.2 to 27.3%) at all measured sites. It was concluded that the additional bone mineral in the dominant arm was mainly used for increasing the bone size, not the volumetric density of the cortical or trabecular bone. Besides, when the absolute values of the cortical and trabecular densities were compared, there were no differences between the tennis players and controls.

Ducher et al., (2005) examined the bone response to loading in terms of bone geometry and volumetric bone mineral density in young adults who started playing tennis prior to puberty. Ten male and 10 female tennis players with mean age of $23.1 \pm 4.7$ years old participated in this research. The total bone volume, cortical volume, subcortical volume, and muscle volume were measured at both radii by magnetic resonance imaging (MRI) and BMC was measured using DXA. Plus, grip strength was assessed by a dynamometer. There were significant side-to-side differences in muscle volume (9.7%), grip strength (13.3%), BMC (13.5%), total bone volume (10.3%) and sub-cortical volume (20.6), but not in cortical volume (2.6%).
Adolescent Studies.

Researchers have also examined BMD among adolescent tennis players. Haapasalo et al. (1998) examined at which stage of maturity (Tanner stage), the side-to-side BMD alters between the playing and non-playing arms of tennis players and to determine (within each Tanner stage) which training or background variables could explain the individual differences in bones’ response to mechanical loading. This study included 91, 7-to-17 year old female tennis players and 58 non-tennis players. Areal BMD was measured at the proximal humerus, humeral shaft, and distal radius of both upper extremities and lumbar spine using a DXA scanner. In addition to the BMD measurements, the maximal isometric strength of the forearm extensors and flexors and the grip strength were measured using a hand dynamometer. The results of this study showed that the tennis players’ side-to-side differences were clear and significant (the mean difference ranged from 1.6 to 15.7%) at all measured sites and Tanner stages, except at the distal radius in Tanner stage II. The controls also showed significant side-to-side differences at the humeral shaft in Tanner I (2.4%), at the proximal humerus in Tanner II (4.6%), and at the humeral shaft in Tanner IV (2.9%) and Tanner V (2.9%). Furthermore, significant differences between the players and controls were found in Tanner IV and V for the lumbar spine. It was concluded that the effect of unilateral activity on bone is greatest during a relatively short period in puberty, a period when rapid natural bone mineral accumulation and rapid longitudinal growth occur.

Bass et al. (2002) examined whether the effects of physical loading were site specific and depended on the maturation stage of the region. The participants of this study were 47 pre-, peri-, and post-pubertal competitive female tennis players aged 8-17
years. Longitudinal data were collected after 1 year and only 37 subjects were able to participate in the study. Six of the subjects remained pre-pubertal (Tanner stage 1), 6 of the subjects became peri-pubertal (Tanner stage 2 – 4), 9 subjects remained peri-pubertal, and 16 subjects remained post-pubertal (postmenarche) during this observation stage. Bone dimensions of mid- and distal humerus were determined using a MRI and BMC of the dominant and non-dominant arms was measured using a DXA scanner. The results of this research showed a 14% increase in cortical area of the mid- and distal humerus from the pre- to peri-pubertal years in the non-loaded arm due to the greater periosteal (outer surface) expansion. Plus, cortical area of the mid- and distal humerus was approximately 20% greater in the post-pubertal players than in the peri-puberty players. Furthermore, BMC of the dominant arm of the players was 11 – 14% greater than the non-dominant arm in the pre-pubertal years; however, it did not increase further in peri- or post-pubertal years. The conclusion of this study was that loading before puberty increases bone size and its resistance to bending. After puberty, loading increases the acquisition of bone on the endocortical surface with little benefit in the bone’s resistance to bending.

Juzwiak et al. (2008) assessed the effect of tennis playing, body composition and, calcium intake on BMD of Brazilian male adolescents. Forty four male adolescent tennis players aged 10 to 19 years old and 32 age matched male adolescents who were classified as insufficiently active participated in this study. BMD and body composition measurements were assessed with DXA and calcium intake was obtained by asking the participants to record their food intake for 4 days. Tennis players had significantly lower mean fat mass and higher fat-free mass. Tennis players had significantly greater dominant arm BMC and trochanter BMD than controls whereas controls had significantly
greater non-dominant radius (33%) than tennis players. Spine BMD did not change significantly between the groups. Lean body mass was the best predictor of BMD as calcium intake had no effect on BMD.

Ducher, Tounaire, Meddahi-Pellé, Benhamou, and Courteix (2006) investigated whether tennis playing, when started during growth, would have positive effects on bone tissue at the distal radius. Twenty two boys and 6 girls with mean age of 11.6 ± 1.4 years old and 47 adult tennis players with mean age of 22.3 ± 2.7 years participated in this study. Ten boys and 2 girls who were swimmers and 58 sedentary adults were recruited as a control group. Bone area, BMC, and BMD were measured using DXA. The results of this study indicated young tennis players who started playing during pre- or early puberty had greater side-to-side differences between dominant and non-dominant radii at the ultradistal region where longitudinal bone growth occurs. These side-to-side differences observed in children were similar to that found in adults who had much longer tennis practice experience. On the other hand, bone asymmetry at the mid-and third-distal radius was greater in adults than in children, showing that further increase in bone mass at diaphyseal sites occurred when tennis playing was maintained into young adulthood. It was concluded that practicing impact loading sports during growth and maintaining physical activity into adulthood enhanced bone mass.

Summary.

Overall, research have shown that tennis and squash playing increases BMD and BMC of the dominant arm. The smallest side-to-side difference in adolescents has been reported as 1.6 % (Haapasalo et al., 1998) and the largest side-to-side difference has been reported as 15.7% (Haapasalo et al., 1998). Most of the studies were completed on adult
population with small sample sizes. In female adolescents, significant BMD differences between the tennis players and controls were found in spine and upper extremities at the Tanner stages IV and V (Haapasalo et al., 1998). On the other hand, Juzwiak and colleagues (2008) assessed no significant differences on spine and forearms BMD in male adolescent tennis players. Significant differences were found in the dominant arm BMC and trochanter BMD. More adolescent studies are necessary to determine the differences in BMD measurements between tennis players and non-tennis players.
Chapter III

Methods

This study was performed with the approval of the Institutional Review Board of the University of Mississippi. This chapter discusses the experimental design of the study, including information about the participants, the instruments used, data collection procedures, as well as the statistical tests used to analyze the data.

Participant Selection.

Tennis players (TP) were recruited through high schools in Oxford, Mississippi, through flyers (Appendix A) at tennis courts and by word of mouth. The primary investigator (PI) contacted tennis coaches of the Lafayette and Oxford High Schools and provided information about the study. Next, the PI attended an exercise session of both Oxford and Lafayette High School tennis teams and explained the research to the female tennis players and provided contact information for those who wanted to participate. In addition, female tennis players were recruited through tennis camps at the University of Mississippi. The non-tennis players (NTP) were recruited by an email which was sent to University of Mississippi employees (Appendix B) and by word of mouth. The email intended to gain the attention of parents of 14 to 18 year old female teenagers. Parents contacted the PI by email or phone and were asked about their child’s physical activity levels, body composition, and health status. Once the prospective participant was determined eligible to participate, a meeting time was determined. It was estimated that at least 17 TP would be recruited from the high schools in Oxford, MS and Lafayette County and 17 non-tennis players would be recruited by the email to the University of Mississippi employees. G Power analysis (Faul, Erdfelder, Land & Buchner, 2007).
indicated that a total of 34 subjects were needed in order to obtain a power of 0.80 with an effect size of 0.50 at an α-level of 0.05 utilizing a one-way ANOVA.

Tennis players were included in the study only if they had been playing tennis for a minimum of two years and were playing at least 3 hours per week (Bass et al., 2002). The control group included female adolescents who did not play tennis; however they were able to be involved in any other sports competitively or recreationally.

Since body mass index (BMI) may play an important role while assessing BMD in female adolescents, BMI of TP and NTP were matched in the same range. In order to determine the BMI range for control group participants, TP were tested first. When testing the tennis players was completed, participants for the control group were recruited according to BMI range of TP.

Race plays an important role on bone mineral density (Ott, 1991). All of the tennis players in this study were Caucasians. Therefore, only Caucasian non-tennis players were included in the control group.

All of the subjects were healthy with no known diseases and were not receiving medications known to effect bone metabolism such as corticosteroid use as determined by the initial phone or email contact. Permission to participate was obtained from the adolescents (child assent) and their parents (parental consent for child’s participation (Appendix E and F, respectively). Participants who were 18 years old were asked to sign a consent form without obtaining consent from their parent(s) (Appendix G).

**Procedures.**

Once a subject was determined eligible to participate (after the initial phone or email contact), the PI met the subject and her parent in the lobby of the Turner Center on
the University of Mississippi campus and proceeded to the Body Composition and Bone Mineral Density Laboratory. Participants aged 14 to 17 years old were asked to read and sign the assent form and their parent was asked to read and sign the parental permission form. Participants aged 18 years old were asked to read and sign the consent form. Next, all of the participants were asked to take a urine pregnancy test. The PI gave a sterile urine specimen container to the participant with directions, and then accompanied the participant to the restroom in the Turner Center in order to obtain the urine sample. After returning to the Laboratory, the urine sample was analyzed by the PI. In this study, all of the participants had negative results from the pregnancy tests and were then asked to complete questionnaires related to their eating habits, physical activity levels, osteoporosis knowledge, and puberty status. Next, participants were asked to remove all metal objects from their body. Weight and height were measured by using a standard doctor’s scale. Participants were asked to take their shoes off and were wearing a t-shirt, shorts and socks. Total body, forearms, femoral and anterior posterior (AP) lumbar spine and non-dominant hip BMD measurements were completed by the PI using dual X-ray absorptiometry (DXA) following procedures outlined in the DXA manufacturer’s user’s manual.

For the total body scan, the anatomical areas analyzed were the head, the left arm, the right arm, the left rib, the right rib, the T-spine, the L-spine, the pelvis, the left leg, and the right leg. The forearm scans included the area of the radius and ulna, and the wrist bones (carpals). The AP lumbar spine scans included the vertebrae L1 through L4. The non-dominant hip of participants was scanned and determined by asking each subject the following question: if you were to kick a ball, which leg/foot would you likely kick.
with (Sone, Imai, Joo, Onodera, and Fukunaga, 2006)? A copy of the results was given to each participant after interpretation by the PI.

**Instruments.**

A Hologic Delphi-W (Hologic, Bedford, MA) DXA machine was used to measure BMD and body composition. The DXA machine included pediatric-specific software and gave bone mineral content (BMC, g) and areal bone mineral density (BMD, g/cm²) values as well as a T and a Z score for every skeletal site measured. In this study, Z scores were used to determine differences in BMD measurements between the groups. The Z (standard) score is based on a comparison of subjects on the same age and sex. The mathematical formula for a Z score is: Z score = [BMD x age specific mean BMD] / [SD of BMD of age-matched controls] (Khan et al., 2001, p.41).

The DXA machine exposes subjects to a very low level of radiation. The reported natural radiation dose in western populations such as the US is about 3000 µSv (1 µSv = 0.1 mrem) per year and a single DXA exam is equal to about 0.03% of their natural annual dose of radiation; whereas, a chest X-ray is equal to about 4% and a mammogram is equal to about 25% (Khan et al., 2001, p.38).

A demographic/health history questionnaire (Appendix I), that took approximately 10 minutes, was completed by each participant. The questionnaire included data on age, gender, ethnicity, family history related to osteoporosis, participants’ eating habits, smoking status, and menstruation status. In addition, tennis players answered questions on years of active playing, age when started to play, number of training sessions per week, average duration of each session, age at onset of menses,
injury history, medications, known diseases, possible vitamin and mineral
supplementations, and physical activities other than tennis.

Daily calcium intake was calculated from dairy product intake that was assessed
by asking the participants to report how many times per week they drank milk, and ate
cheese, yogurt, ice cream…etc. Daily value for calcium intake was determined as weekly
dairy intake divided by 7. Next, participants were separated into two categories
depending on whether they consumed the recommended three or more servings daily of

Osteoporosis knowledge was determined using the Osteoporosis Knowledge Test
included 22 items and had 2 subscales: (1) osteoporosis knowledge related to calcium
(OKC) and (2) osteoporosis knowledge related to exercise (OKE). Participants were
instructed that all of the questions in the OKT had the “don’t know” choice so that they
could choose it if they did not know the answer to the question. The reliability
coefficients of internal consistency of the OKC and OKE is 0.72 and 0.69, respectively.
Participants were given one point for each correct answer. Questions 1 to 16 were
calculated as osteoporosis knowledge related to exercise and questions 1 to 9 and 17 to
24 were calculated as osteoporosis knowledge related to calcium.

Tanner stages were assessed by a questionnaire (Morris & Udry, 1980) that is
related to the child’s pubertal status. The questionnaire (Appendix L) asked the
participants to examine a series of five drawings showing pubic hair development in
females. Participants then selected the drawing that was most closely matched with their
own pubic hair. The first drawing indicated Tanner stage one which is considered as pre-
Pubertal when ovaries start to enlarge to prepare for hormone production. The second drawing indicated stage two. During this stage a rapid growth is observed that leads to an increase in height, weight, and breast buds. Traces of fine straight pubic hair also start to grow. The third drawing indicated stage three. During this stage girls’ breast development continues and pubic hair keeps growing and becomes darker. Underarm hair also begins to grow. The fourth drawing indicated stage four when girls start experiencing their menstrual cycle. The last drawing indicated stage five. During this stage, breasts are fully developed and menstrual cycles are regular.

Physical activity was assessed using the 7-day Physical Activity Recall Questionnaire (Dishman & Steinhardt, 1988). Participants were asked to write the physical activities that they performed during the last 7 days (Appendix M). Moderate physical activity was assessed by asking the participants how many times and how many minutes of not exhaustive physical activity they performed during the last 7 days. Vigorous physical activity was assessed by asking the subjects how many times and how many minutes of heart beat rapidly physical activity they performed during the last 7 days. Participants received 1 point for 30 minutes of exercise for each day. Therefore, physical activity ranged from 0 to 7. Total minutes of physical activity, total minutes of moderate and vigorous physical activity per week and number of physical activity per week were also calculated.

All of the questionnaires were contained inside a manila folder. The participants removed the questionnaires from the file, completed the questionnaires and placed the questionnaires back in the manila folder. The parent of the participant was asked to leave the testing area while the participant completed the questionnaires in order to give the
participant privacy. The questionnaires did not have the participant’s name on them, only an ID number appeared.

**Delimitations.**

All of the participants had to be between the ages of 14 and 18. Because females are at a higher risk for osteoporosis than males, only females were included in this study. In order to establish the range of BMI values for the recruitment of non-tennis players, tennis players were tested first and tested for all of the measurements. All the tennis players were Caucasians. Therefore, the non-tennis players group also included all Caucasian participants. Tennis players who had been playing tennis at least 3 hours per week for the last two years were included in the experimental group. Control group subjects were able to participate in sports other than tennis recreationally or competitively.

**Limitations.**

One of the limitations of this study was that physical activity, osteoporosis knowledge, calcium intake, and Tanner stages were assessed via self-reported questionnaires. Although the PI explained the participants that their answers were secure, participants’ answers for questionnaires might be biased.

**Statistical Analysis.**

Power analysis indicated that a total of 34 subjects were needed in order to attain a power of 0.80 to detect an effect size of 0.50 at an α-level of 0.05 for one-way ANOVA. Statistical convention indicated that 10 subjects were needed per independent variable utilized in the multiple regression analysis (Darlington, 1990). In this study, independent variables were total weight, fat mass, and fat-free mass. Therefore, 30
subjects were needed. This study included 38 female adolescents aged 14 to 18 years old.

Data were also examined for outliers and extreme scores using boxplots (Figures 1, 2, 3, 4, 5). Extreme scores would be eliminated from the analyses. If outliers were found data were analyzed with and without the outliers included.

Descriptive statistics were used in all variables to check for the assumptions of normality and homoscedasticity. One way ANOVA was used to assess differences between the groups for all of the BMD and body composition measurements as well as osteoporosis knowledge. Multiple regression analysis was used to determine the best predictor of BMD among 3 independent body composition variables (total weight, total fat mass, and total fat-free mass). Pearson correlations were used to observe any potential relationships among BMD variables, weight, BMI, body composition variables, daily calcium intake, Tanner stages, osteoporosis knowledge, and PA levels. Significance level was set at p < 0.05 and data were analyzed using SPSS version 18.0. All of the variables for this study are reported as means ± standard deviations.
Chapter IV

Results

The primary purpose of this study was to determine the differences in bone mineral density among adolescent high school female tennis players and their controls. The secondary purpose was to determine the differences in body composition (fat mass-fat free mass) between adolescent female tennis players and non-tennis players and whether body composition variables were predictive of differences in BMD. Another secondary purpose was to assess osteoporosis knowledge among high school female adolescents and to examine whether tennis players had better osteoporosis knowledge than non-tennis players. This chapter describes the results of the statistical analysis used for this study. No extreme scores were observed. Four outliers associated with BMD measurements were observed and are discussed below.

Subject Characteristics.

Nineteen female TP between 14 and 18 years of age completed all sections of the data collection. After testing of the TP was completed, 27 NTP were recruited. Eight of those NTP were excluded and their results were not included in the data analysis since three of them had lower BMI values than the BMI range of TP, 2 of them had higher BMI values, 1 had different ethnicity and 1 was younger than 14 years old. Therefore, data of 19 NTP between 14 and 18 years of age were included in this study.

Participant characteristics are reported in Table 1. There were no significant differences between the characteristics of the TP and NTP. The mean age of TP was 16.2 ± 1.08 years. The mean BMI of TP was 21.79 ± 2.69 kg/m² ranging from 17.1 to 26.6 kg/m². Ten (52.63%) of the TP were at the Tanner Stage 4 and 9 (47.37%) of them were
at the Tanner Stage 5. The TP’s active playing history averaged $5.32 \pm 3.38$ years ranging from 2 to 13 years. None of the TP was smokers. All of the TP had started their menstrual periods and the mean starting age for menstrual cycle was $13.22 \pm 1.47$ years. Four of them were using birth control pills for an average of 12.5 months.

The mean age of NTP was $16.3 \pm 1.5$ years. The mean BMI of NTP was $20.5 \pm 1.82$ kg/m$^2$ ranging from 17.6 to 23.7 kg/m$^2$. Six (31.58%) of the NTP were at the Tanner Stage 4 and 13 (68.42%) of them were at the Tanner Stage 5. The mean starting age for menstrual cycle was $12 \pm 1.3$ years. Two of the NTP were smokers and 7 of them were using birth control pills for an average of 6.64 ± 4.52 months.

Mean daily calcium intake was not significantly different between the groups ($p = 0.95$) and was below the recommendation of 3 or more servings per day in both groups. The mean daily dairy intake was $2.70 \pm 0.90$ servings for the TP and was $2.67 \pm 1.55$ servings for the NTP. Forty two percent ($n = 8$) of the TP were consuming at least 3 servings of dairy daily whereas 32% ($n = 6$) of the NTP were consuming at least 3 servings of dairy daily.

**Bone Mineral Density Measurements.**

Results of BMD measurements for both groups are summarized in Table 2. For BMD measurements, there were a total of three outliers (one for total hip BMD, and two for femoral neck BMD). Therefore, BMD data were analyzed and reported with the outliers and without the outliers included. With outliers included, TP had somewhat greater BMD for lumbar spine, and total hip measurements, although these differences were not significantly greater than NTP. On the other hand, TP had significantly higher femoral neck BMD than the NTP ($p = 0.017$). However, when data were analyzed
without the outliers included, TP also had significantly greater total hip BMD than NTP ($p = 0.02$).

When the difference between the dominant arm and non-dominant arm BMD was compared for both of the groups, only TP had statistically significant differences which means that the dominant arm BMD of the TP was significantly greater than the non-dominant arm BMD ($p < 0.001$). This difference was not observed for the NTP.

**Body Composition Measurements.**

Table 3 displays the mean results of body composition variables for both groups. There were no significant differences for total body percent fat ($p = 0.72$), total body lean mass ($p = 0.07$) and total body fat mass ($p = 0.59$) between the groups. Fat and lean mass of the dominant and non-dominant arms of the TP and NTP were not also statistically significant. However, right leg lean mass was significantly higher in TP than NTP ($p = 0.03$) whereas left leg lean mass values were not different between the groups. Right and left leg fat mass were not significantly different between the groups.

The results of the regression analysis are shown in Table 4. The combination of the three independent variables significantly predicted BMD at the femoral neck and total hip ($p < 0.001; p = 0.03$, respectively) with the lean mass being the best predictor for both variables. However, none of the independent variables were significant predictors of BMD at any of the measurement sites independently.

**Osteoporosis Knowledge.**

Total osteoporosis knowledge (TOK) did not differ significantly between the groups. Total osteoporosis knowledge was also divided into two subscales as osteoporosis knowledge related to calcium (OKC) and osteoporosis knowledge related to
exercise (OKE). There were no significant differences between the TP and NTP for either of the osteoporosis knowledge subscales. Table 5 displays the mean values for TOK, OKC, and OKE for both groups. The highest possible score was 22 for TOK, 16 for OKC, and 17 for OKE. Approximately 90% of the participants knew that eating a diet low in milk products would affect their bones negatively and 36% knew that osteoporosis is highly related to genetics. Ninety percent were aware that exercising on a regular basis would reduce the risk for osteoporosis; however, for the type of exercise (walking vs swimming) only four% knew that weight bearing activity is the best way to reduce a person’s chance of getting osteoporosis. Ninety percent of the adolescents also knew that in order to strengthen their bones, they needed to exercise three or more days a week. Ninety seven percent of the adolescents knew that cheese is a good source of calcium and all of the participants (100%) knew that yogurt is a good source for calcium. On the other hand, only 45% thought that broccoli is a good source of calcium. Lastly, only 11% were aware of the recommended amount of daily calcium intake for adolescents.

**Physical Activity.**

Results of physical activity measurements for both groups are summarized in Table 6. The mean starting age of playing tennis was $10.84 \pm 3.39$ years ranging from 5 to 16 years. TP played tennis 4.83 times per week on average and the average duration of each session was $83.5 \pm 25.5$ minutes ranging from 10 to 120 minutes. Seventeen (89.47%) of the TP were right handed and used their right arm when performing a forehand stroke and two (10.53%) were left handed, one used her left arm when performing a forehand stroke and one used both of the arms. Additionally, 14 (73.68%)
of the TP used both arms when performing a backhand stroke, 3 (15.79%) used their dominant arm, and 1 (5.26%) used her non-dominant arm when performing a backhand stroke. Eleven (57.89%) of the TP were also playing different sports other than tennis for their high school teams.

One of the inclusion criteria for NTP was that they could be involved in sports other than tennis. In this study, 57.89% (n = 11) of the NTP were involved in a sport competitively. Seventeen (89.47%) of the NTP were right handed and 2 (10.53%) were left handed.

Figure 6 shows the extreme/outlier scores for the PA data. There were a total of seven outliers (five for total minutes of weekly PA (three TP and 2 NTP), and two NTP for vigorous PA). Therefore, PA data were analyzed and reported with the outliers and without the outliers included. With outliers included, the 7-day recall physical activity data were statistically significant between the two groups (p = 0.005). The mean 7-day physical activity (days per week of at least 30 minutes) for the TP was 4.27 ± 5.83 ranging from 2 to 7 and was 2.39 ± 4.24 ranging from 0 to 6 for the NTP. On the other hand, total minutes of PA per week did not differ significantly between the groups (p = 0.21). The amount of weekly moderate PA was significantly greater for the NTP than the TP (p = 0.005). Although the TP performed more vigorous PA than the NTP, it was not statistically significant between the 2 groups (p = 0.06). Seventy nine percent (n = 15) of the TP were exercising at least 5 times per week whereas only 47% (n = 9) of the NTP were physically active at least 5 times per week (p = 0.04). In addition, 95% (n = 18) of the TP were physically active at least 150 minutes per week while 74% (n = 14) of the
NTP performed at least 150 minutes of PA per week (p = 0.08). When data were analyzed without the outliers, the results did not change between the groups.

**Pearson Correlations.**

Pearson Correlations were calculated in order to observe any potential relationship among BMD variables, weight, BMI, body composition variables, daily calcium intake, tanner stages, osteoporosis knowledge, and PA levels. Table 7 displays correlation data for all variables. Weight and BMI were correlated positively and significantly with all of the BMD measurements. There were also positive and significant correlations between total body lean mass and all of the BMD measurements. All BMD variables were significantly correlated to each other. Tanner stages were only correlated with age, dominant and non-dominant BMD variables significantly and positively. The only significant correlation for TOK was that TOK was significantly and negatively correlated with spine BMD. For the PA measurements, the only significant correlation was found between vigorous PA and spine BMD. Age was positively and significantly correlated with Tanner stages and TOK. Daily calcium intake, total body fat mass, total minutes of weekly PA, the number of PA per week, moderate PA and starting age of physical activity for TP were not correlated significantly to any of the BMD measurements.

**Summary of results and formal hypotheses.**

The formal null hypotheses and the statistical statements as determined by the data analysis are as follows.
Hypotheses:

HO1: There is no significant difference in mean lumbar spine bone mineral density between adolescent tennis players and non-tennis players. Fail to reject.

HO2: There is no significant difference in total hip bone mineral density between adolescent tennis players and non-tennis players. Reject

HO3: There is no significant difference in femoral neck bone mineral density between adolescent tennis players and non-tennis players. Reject

HO4: There is no significant difference in mean bone mineral density in dominant forearm between adolescent tennis players and non-tennis players. Fail to reject.

HO5: There is no significant difference in mean bone mineral density in non-dominant forearm between adolescent tennis players and non-tennis players. Fail to reject.

HO6: There is no significant difference in mean fat mass between adolescent tennis players and non-tennis players. Fail to reject.

HO7: There is no significant difference in mean fat-free mass between adolescent tennis players and non-tennis players. Fail to reject.

HO8: There is no significant relationship between BMD at the various sites in the body and a group of predictor variables, including weight, fat mass, and fat free mass in adolescent tennis players and non-tennis players. Reject.
HO$_9$: There is no significant relationship between tennis playing and osteoporosis knowledge among adolescent tennis players and non-tennis players. Fail to reject.
Chapter V

Discussion

This study assessed the differences in bone mineral density (BMD) between adolescent female tennis players (TP) and non-tennis players (NTP). Nineteen female high school tennis players aged 14 to 18 years and 19 female non-tennis players aged 14 to 18 years participated in this study. Lumbar spine, total hip, femoral neck, and left and right forearms BMD and body composition were assessed using dual X-ray absorptiometry.

**Bone Mineral Density Measurements.**

The main finding of this research was that TP had significantly greater femoral neck BMD than NTP. Moreover, when the data were analyzed without an outlier, TP also had significantly greater total hip BMD than NTP. On the other hand, there were no significant differences between TP and NTP in spine, and forearms BMD. Recently, Juzwiak et al. (2008) found no significant differences in lumbar spine, total hip, and dominant arm BMD between male tennis players aged 10 to 19 years and male adolescents who were classified as insufficiently active. The only significant difference was in trochanter BMD and dominant arm BMC. On the other hand, others have demonstrated significant differences in lumbar spine, femoral neck, and forearms BMD between tennis players and controls (Calbet et al., 1998; Haapasalo et al., 1998; Jacobson et al., 1984). However, from those previous studies, only Haapasalo et al. (1998) examined adolescent tennis players. Participants of the other research were adults.

One of the differences between this study and the previous studies in the literature was the characteristics of the control group. In this research, the control group included
11 (58%) participants who were involved in other competitive sports. In contrast, mostly sedentary individuals were included in the control group of the previous research. In this aspect, this study addresses the question whether tennis is a unique sport to increase BMD in different regions of the body. Table 8 shows the characteristics of the control group participants in the previous research.

In this study, there were no significant differences in forearm BMD between TP and NTP. The reason for this outcome may be because, as stated previously, participants of the NTP group were not sedentary and were involved in sports that might affect their forearm BMD. Another possible explanation may be that a very tight grip seen in top-class players increases the power of the stroke as well as the magnitude of the vibrations transmitted to the hand; hence, in unskilled tennis players, a fairly loose grip reduces both the vibrational shocks at the hand and the power of the stroke (Hatze, 1976). In this study, tennis players were included only if they had been playing tennis for at least 2 years. Therefore, it is possible that TP might not have adequate experience to obtain the correct technique to perform very tight grip strength. On the other hand, the difference between the dominant arm BMD and the non-dominant arm BMD was significant only in TP. This result supports most of the previous data which showed that side-to-side differences were significantly greater in TP (Ducher et al., 2005; Haapasalo et al., 1996; Haapasalo et al., 1998; Kannus et al., 1994; Tsuji et al., 1995). When playing tennis, the dominant arm might be generally under greater mechanical stress than the dominant arm. This might not be true for other sports such as volleyball and basketball. In this study, 95% of the TP used their dominant arm when performing a forehand stroke and 75% of them used both arms when performing a backhand stroke. This shows that the dominant
arm was under greater mechanical stress than the non-dominant arm. Interestingly, the mean non-dominant arm BMD of the NTP was slightly higher than the mean non-dominant arm BMD of the TP. Juzwiak and colleagues (2008) also observed that tennis players presented lower mean BMD for the non-dominant arm than controls. It was suggested that intense training might affect only sites of greater impact thus the non-dominant arm, which also might function as an immobilized or resting arm, acquires lower bone mass or presents greater bone loss.

In this study, there was no significant difference in lumbar spine BMD between TP and NTP. Juzwiak et al. (2008) also observed no significant differences in lumbar spine BMD between adolescent male TP and controls. However, other previous research have shown that tennis players have better lumbar spine BMD than controls (Calbet et al., 1998; Nichols et al., 1995; Haapasalo et al., 1998; Jacobson et al., 1984). In these studies, only Haapasalo and colleagues (1998) have examined adolescent tennis players and controls whereas other studies had adult participants who had been playing tennis at least 17 years. Haapasalo et al. (1998) reported that lumbar spine BMD was significantly greater only in tennis players who were at Tanner stages 4 and 5 compared to control group participants who did not participate in casual sports. In the current study, all of the TP and NTP were at the Tanner stages 4 and 5. When the mean BMD values for the lumbar spine in both studies are compared, TP in the current study have greater values than the tennis players of Haapasalo et al. (1998) (0.980 g/cm² vs 0.971 g/cm² for Tanner Stage 4 and 1.045 g/cm² vs 0.963 g/cm² for Tanner Stage 5, respectively). Therefore, in the current study, TP had higher BMD values for lumbar spine when they were compared to the BMD values of another control group from the
previous research. The NTP in this study were as active as TP and also had higher mean BMD of the lumbar spine when they were compared to the tennis players in the research of Haapasalo et al. (1998).

This study supports previous research findings suggesting that tennis players have significantly greater femoral neck BMD than controls (Calbet et al., 1998; Nichols et al., 1995). However, tennis players in the previous research were adult male and female tennis players. This study shows that adolescent female tennis players have greater femoral neck BMD than adolescent female non-tennis players. Furthermore, TP in this study also had significantly greater total hip BMD than NTP when data were analyzed without the outliers included. Previous data have shown that high impact exercise such as jumping increases BMD in the femoral neck (Heinonen et al., 1996). Tennis requires mostly anaerobic rapid accelerations and decelerations with twisting components and can produce ground reaction forces 5 to 10 times a person’s body weight (Alexander, 1985). Nordström and colleagues (1998) also observed that badminton players have significantly greater femoral neck BMD than ice hockey players and controls. The researchers stated that this difference may be due to the movements executed in the sport. Badminton players are generally subjected to short high-impact bursts when jumping and high strains in unusual directions during leg lunges forward and fast direction changes from side to side. Furthermore, the ground reaction forces created by a jump may be absorbed first in the feet and joints of the lower extremities in which the created high strains may be a powerful stimuli to increase BMD. The same statement may be true for tennis players as well. Therefore, it can be suggested that tennis is a unique sport for its executed movements which produce great ground reaction forces to increase BMD in the femoral
neck. According to NOF (2008a) 297,000 hip fractures as a result of osteoporosis occurred in the United States in 2005. Furthermore, approximately 293,000 Americans aged 45 years and older were admitted to hospitals with a fracture of the femoral neck in 2005. Peak bone mass is one of the major determinants of bone mass later in life (Haapasalo et al., 1998; Kannus et al., 1995). Developing a high BMD in the femoral neck and total hip by playing tennis during teenage years might play a very important role to prevent osteoporosis and decrease the risk of fractures at the hip later in life.

**Body Composition Measurements.**

Juzwiak et al. (2008) observed that adolescent male tennis players have significantly higher lean body mass content and lower fat mass than controls. In contrast, Calbet et al. (1998) found no significant differences in body mass, total lean body mass, total body fat, and the percentage of body fat between tennis players and sedentary controls. In the present study, there were no significant differences in fat mass and fat-free mass variables between the TP and NTP except lean mass of the right leg that was significantly greater in TP than NTP. The disagreement in the previous studies might be explained by gender. Data have shown that fat-free mass is greater in boys than girls whereas fat mass is greater in girls than boys in healthy children and adolescents (Arabi et al., 2004). Furthermore, in the present study, there were no significant differences between the groups for the total minutes of weekly PA. NTP had performed significantly greater amounts of moderate PA than TP. Although TP had performed more vigorous PA, it was not statistically significant. This may explain why there were not significant differences between the groups in body composition measurements. On the other hand, researchers have suggested that in children, lean mass in relation to body height (lean
mass / height) should be assessed since sole usage of age and sex specific charts for BMC and BMD limits the clinical interpretation of DXA output and the relation of lean mass to height provides and enhances understanding of the origin of low BMD / age or BMC / age (Högler, Briody, Woodhead, Chan, & Cowell, 2003). When lean mass is calculated as related to body height (lean mass / height) for this study, TP had significantly greater total body lean mass than NTP \((p = 0.02)\). Furthermore, a twin study has suggested that approximately 80% of the variance in lean mass might be explained by genetic factors (Seeman et al., 1996).

The results of the regression analysis are in agreement with the results of the previous data. In the present study, all of the independent variables were significant predictors of BMD and the lean mass was the best predictor among the three independent variables. Previous studies have also shown that lean mass is a significant predictor of BMD in young females (Bedogni et al., 2002; Seeman et al., 1996; Wang et al., 2005). On the other hand, data also have shown that fat mass is a better predictor of BMD in females (Hage et al., 2009). Furthermore, others have stated that both fat mass and fat-free mass were independent predictors of BMD in females (Arabi et al., 2004; Pietrobelli et al., 2002). In tennis players, Juzwiak et al. (2008) have stated that lean mass was the main bone mass predictor in male tennis players and controls. Nichols and colleagues (1995) stated that regional lean mass was the main significant predictor of BMD in college aged females.

**Osteoporosis Knowledge.**

In the present study, a moderate level of knowledge related to osteoporosis was found. In addition, there were no significant differences between TP and NTP for TOK,
OKC, and OKE. Most of the participants knew that osteoporosis is related to genetics and exercise is good for their bones. However, less than 40% of them knew what type of exercise would be beneficial for their bone (weight bearing vs not weight bearing activities). Interestingly, although 90% knew that eating a diet low in milk products would affect their bones in a negative way and approximately all of them knew that cheese and yogurt are good sources for calcium, only 38% of the participants consumed the recommended amounts of daily calcium. Approximately 90% were not aware of the recommended daily calcium intake for their age group. Previous data have also found moderate knowledge level in college aged females and males for osteoporosis knowledge (Ford, Bass, & Keathley, 2007; Turner & Bass, 2001). In adolescent females, data have shown that the knowledge of physical activity related to osteoporosis was quite good whereas the knowledge of nutrition was inadequate (Posluná et al., 2008). Similar to the current study, another study reported that although participants demonstrated general knowledge pertaining to osteoporosis risk factors, 25% of the participants were current smokers, 58% consumed less than adequate intake for calcium, and 52% performed low to moderate levels of physical activity (Anderson et al., 2005). Researchers have suggested females would consume adequate calcium, perform regular physical activity, and refrain from cigarette smoking if they believe that they are at risk for osteoporosis. Hence, it might be difficult for adolescents to relate their current lifestyle practices to their future adult health status (Anderson et al., 2005).

**Pearson Correlations.**

Even though there was no significant BMD predictor for the current study, there were significant correlations between fat-free mass and BMD in all of the measured sites.
On the other hand, fat mass did not associate with BMD. These findings are in agreement with the results of previous research (Ellis, 1997; Travison, Araujo, Esche, Beck, & McKinlay, 2008; Vicente-Rodriguez, Dorado, Perez-Gomez, Gonzalez-Henriquez & Calbet, 2004). The significant associations between lean mass and BMD have been shown to be the results of direct action of the mechanical loads on bone performed by strength and muscle mass (Juzwiak et al., 2008). Data have suggested that according to the mechanostat theory, the increase in muscle mass (muscle force) creates the stimulus for the increase in bone mass and bone strength; thus, muscle development precedes bone development during pubertal growth spurt (Rauch, Bailey, Baxter-Jones, Mirwald, & Faulkner, 2004). On the other hand, Seeman and colleagues (1996) have suggested that the significant positive correlations between lean mass and BMD could be explained by genetic determinants rather than non-genetic factors. In tennis players, Nichols et al. (1995) stated that in college aged females regional lean mass was more greatly correlated with BMD than weight or fat mass. Similar results were also assessed for male adolescent tennis players (Juzwiak et al., 2008).

Not surprisingly weight and BMI were associated significantly with BMD. Previous data have shown that bone mass is greater in obese children and adolescents than normal weight children and adolescents (Manzoni et al., 1996). This might be explained by the mechanical loading or stress on bone created by body weight.

Tanner stages were positively correlated with dominant and non-dominant arms BMD. Haapasalo et al. (1998) have reported that adolescent female tennis players’ BMD differences began to differ significantly from the corresponding values of the controls after Tanner stage 3 and have stated that the adolescent growth spurt is the only
time in life when substantial amounts of bone is added to the inner and outer sides of the bone cortex. In the present study, all of the subjects were at the Tanner stages 4 and 5 which could mean that they might be at their bone mass peak. Kannus and colleagues (1995) have demonstrated that adult female tennis players who started playing at or before menarche had significantly greater bone mass than tennis players who started playing after menarche. In this study, starting age of playing tennis was not associated with any of the BMD measurements. Plus, BMD did not differ between players who started playing before or after menarche. This might be because all of the tennis players in this study were still in their pubertal stages whereas in the previous research some of the tennis players had started playing tennis 15 years after their menarche.

Previous research are in disagreement whether daily calcium intake is significantly associated with BMD. A Medline research has shown that 27 studies found no relationship between dietary calcium intake and bone health whereas 9 studies reported that the effects of calcium intake on bone health are small (Lanou, Berkow, & Barnard, 2005). In the current study, there were no significant correlations between calcium intake and BMD. In adolescent male tennis players Juzwiak and colleagues (2008) also stated that calcium did not correlate with bone mass. In the present study, only 38% of the participants consumed the recommended 3 or more servings of calcium. This might be one of the reasons why calcium intake did not correlate with any of the BMD measurements. Besides, daily calcium intake was assessed with a questionnaire asking the participants how many times they consumed dairy products per week. Wilson and Horwath (1996) have stated that food frequency questionnaires might be limited
when assessing calcium intake for individual women, whereas the seven-day diet record is more accurate for estimating calcium intake for women.

Solely vigorous exercise was significantly correlated with spine BMD. This might be because vigorous exercises are more intense exercises, thus apply higher mechanical stress on bone.

**Conclusion.**

The primary purpose of this study was to assess differences in forearms, lumbar spine, total hip, and femoral neck BMD between female adolescent tennis players and non-tennis players. The finding of this study indicated that there were no significant differences in lumbar spine, total hip, and forearms BMD between tennis players and non-tennis players. Statistically significant differences were found for only femoral neck BMD with tennis players having greater femoral neck BMD than non-tennis players. However, when an outlier was removed, TP also had significantly greater total hip BMD than NTP. Non-tennis players of this study were female adolescents who participated in sport recreationally and competitively. Therefore, unlike the previous research, this study showed that tennis may be a unique sport that develops BMD in femoral neck and total hip.

Secondary purpose of this study was to assess differences in body composition variables between tennis players and non-tennis players and to determine whether body composition variables are predictive of differences in BMD. The results showed that there were no significant differences in fat mass and fat-free mass measurements between the groups. Furthermore, none of the independent variables predicted any of the BMD measurements.
Another purpose of this study was to assess osteoporosis knowledge among female adolescents and to determine whether tennis players have better osteoporosis knowledge than non-tennis players. There were no significant differences in osteoporosis knowledge between the groups. Overall, female adolescents showed moderate level of osteoporosis knowledge.

**Recommendations for future research**

This study assessed the differences in BMD, body composition, and osteoporosis knowledge between female adolescent tennis players and non-tennis players. Future research should evaluate these differences in male adolescent tennis players and non-tennis players. In addition, in this study, physical activity levels and dietary intake were measured with self-reported questionnaires. In order to determine the differences in BMD between physically active and non-active participants, physical activity should be measured using more reliable techniques such as accelerometers. Furthermore, previous data have suggested that direct observation such as oxygen consumption is the most appropriate standard criteria to measure physical activity in children and adolescents (Sirard & Pate, 2001). Future research should also assess the relationships between maximal oxygen consumption ($\text{VO}_{2\text{max}}$) and bone mineral density in adolescents and adults. Moreover, future study may assess dietary intake using prospective methods such as diet record.
References


Table 1. Subject Characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Tennis Players (n = 19)</th>
<th>Non-Tennis Players (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>16.2 ± 1.1</td>
<td>16.3 ± 1.5</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.6 ± 6.7</td>
<td>165.0 ± 6.7</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.0 ± 7.3</td>
<td>55.9 ± 6.5</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>21.8 ± 2.7</td>
<td>20.5 ± 1.8</td>
</tr>
<tr>
<td>Tanner Stages</td>
<td>4.5 ± 0.5</td>
<td>4.7 ± 0.5</td>
</tr>
<tr>
<td>Calcium Intake (servings)</td>
<td>2.7 ± 0.9</td>
<td>2.7 ± 1.5</td>
</tr>
<tr>
<td>Adequate Calcium Intake</td>
<td>42%</td>
<td>32%</td>
</tr>
</tbody>
</table>

All values are means and standard deviations.
Table 2. Bone Mineral Density Measurements of adolescent tennis players and non-tennis players

<table>
<thead>
<tr>
<th></th>
<th>Tennis Players (n = 19)</th>
<th>Non-Tennis Players (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Body</td>
<td>1.0 ± 0.8</td>
<td>0.8 ± 1.3</td>
</tr>
<tr>
<td>Lumbar Spine</td>
<td>0.3 ± 0.8</td>
<td>-0.2 ± 1.1</td>
</tr>
<tr>
<td>Total Hip</td>
<td>0.7 ± 0.6</td>
<td>0.3 ± 1.0</td>
</tr>
<tr>
<td>Femoral Neck</td>
<td>0.5 ± 0.7*</td>
<td>-0.3 ± 1.0</td>
</tr>
<tr>
<td>Dominant Arm (g/cm²)</td>
<td>0.6 ± 0.04</td>
<td>0.6 ± 0.05</td>
</tr>
<tr>
<td>Non-Dominant Arm (g/cm²)</td>
<td>0.6 ± 0.04</td>
<td>0.6 ± 0.05</td>
</tr>
</tbody>
</table>

All values are means and standard deviations. Z scores are reported for total body, lumbar spine, total hip, and femoral neck. BMD raw scores are reported for dominant and non-dominant arms. *Tennis players significantly higher than controls.
Table 3. Body Composition Measurements of adolescent tennis players and non-tennis players.

<table>
<thead>
<tr>
<th></th>
<th>Tennis Players (n = 19)</th>
<th>Non-Tennis Players (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total body % fat</td>
<td>26.5 ± 5</td>
<td>27.1 ± 4.3</td>
</tr>
<tr>
<td>Left arm % fat</td>
<td>29.7 ± 8.6</td>
<td>29.3 ± 6.8</td>
</tr>
<tr>
<td>Right arm % fat</td>
<td>28.0 ± 7.9</td>
<td>27.8 ± 6.9</td>
</tr>
<tr>
<td>Left leg % fat</td>
<td>32.1 ± 7.1</td>
<td>33.1 ± 4.4</td>
</tr>
<tr>
<td>Right leg % fat</td>
<td>31.6 ± 6.7</td>
<td>33.8 ± 4.2</td>
</tr>
<tr>
<td>Total body fat mass (kg)</td>
<td>15.5 ± 4.8</td>
<td>14.8 ± 3.2</td>
</tr>
<tr>
<td>Left arm fat mass (kg)</td>
<td>0.9 ± 0.3</td>
<td>0.9 ± 0.3</td>
</tr>
<tr>
<td>Right arm fat mass (kg)</td>
<td>0.9 ± 0.3</td>
<td>0.9 ± 0.3</td>
</tr>
<tr>
<td>Left leg fat mass (kg)</td>
<td>3.4 ± 1.0</td>
<td>3.3 ± 0.6</td>
</tr>
<tr>
<td>Right leg fat mass (kg)</td>
<td>3.5 ± 1.1</td>
<td>3.4 ± 0.7</td>
</tr>
<tr>
<td>Total body lean mass (kg)</td>
<td>40.0 ± 4.4</td>
<td>37.4 ± 4.3</td>
</tr>
<tr>
<td>Left arm lean mass (kg)</td>
<td>1.9 ± 0.2</td>
<td>1.9 ± 0.2</td>
</tr>
<tr>
<td>Right arm lean mass (kg)</td>
<td>2.1 ± 0.3</td>
<td>2.0 ± 0.3</td>
</tr>
<tr>
<td>Left leg lean mass (kg)</td>
<td>6.7 ± 1.2</td>
<td>6.2 ± 0.9</td>
</tr>
<tr>
<td>Right leg lean mass (kg)</td>
<td>7.0 ± 1.1*</td>
<td>6.3 ± 0.8</td>
</tr>
</tbody>
</table>

All values are means and standard deviations.
*Tennis players significantly higher than controls.
Table 4. Results of Regression Analysis

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>R²</th>
<th>ADJ R²</th>
<th>Sig</th>
<th>Predictor Variable</th>
<th>Beta</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar Spine</td>
<td>.03</td>
<td>-.06</td>
<td>.82</td>
<td>Body Weight</td>
<td>-.29</td>
<td>-.19</td>
<td>.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fat Mass</td>
<td>.26</td>
<td>.29</td>
<td>.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lean Mass</td>
<td>.05</td>
<td>.05</td>
<td>.97</td>
</tr>
<tr>
<td>Total Hip</td>
<td>.23</td>
<td>.16</td>
<td>.03</td>
<td>Body Weight</td>
<td>-1.25</td>
<td>-.94</td>
<td>.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fat Mass</td>
<td>.88</td>
<td>1.11</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lean Mass</td>
<td>1.27</td>
<td>1.37</td>
<td>.18</td>
</tr>
<tr>
<td>Femoral Neck</td>
<td>.38</td>
<td>.33</td>
<td>.001</td>
<td>Body Weight</td>
<td>-1.24</td>
<td>-1.05</td>
<td>.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fat Mass</td>
<td>.87</td>
<td>1.23</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lean Mass</td>
<td>1.42</td>
<td>1.71</td>
<td>.1</td>
</tr>
<tr>
<td>Dominant Arm</td>
<td>.17</td>
<td>.1</td>
<td>.08</td>
<td>Body Weight</td>
<td>-.8</td>
<td>-.6</td>
<td>.95</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fat Mass</td>
<td>.14</td>
<td>.17</td>
<td>.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lean Mass</td>
<td>.45</td>
<td>.46</td>
<td>.65</td>
</tr>
<tr>
<td>Non-Dominant Arm</td>
<td>.13</td>
<td>.05</td>
<td>.2</td>
<td>Body Weight</td>
<td>.4</td>
<td>.28</td>
<td>.78</td>
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<td>Fat Mass</td>
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<td>-.12</td>
<td>.9</td>
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<td></td>
<td></td>
<td>Lean Mass</td>
<td>.02</td>
<td>.03</td>
<td>.98</td>
</tr>
</tbody>
</table>
Table 5. Results of Osteoporosis Knowledge Test (OKT)

<table>
<thead>
<tr>
<th></th>
<th>Tennis Players (n = 19)</th>
<th>Non-Tennis Players (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total OK</td>
<td>14.4 ± 3.6</td>
<td>13.7 ± 2.6</td>
</tr>
<tr>
<td>OK for Calcium</td>
<td>10.0 ± 2.5</td>
<td>9.9 ± 1.9</td>
</tr>
<tr>
<td>OK for Exercise</td>
<td>9.4 ± 2.6</td>
<td>9.0 ± 2.2</td>
</tr>
</tbody>
</table>

All values are number correct with means and standard deviations.
Table 6. Results of 7-Day Physical Activity Questionnaire.

<table>
<thead>
<tr>
<th></th>
<th>Tennis Players (n = 19)</th>
<th>Non-Tennis Players (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-day PA recall (days/wk&gt;30 min)</td>
<td>5.0 ± 1.6</td>
<td>3.3 ± 1.9</td>
</tr>
<tr>
<td>Total PA (min/wk)</td>
<td>631.2 ± 732.0</td>
<td>391.7 ± 377.7</td>
</tr>
<tr>
<td>Number of PA (days/wk)</td>
<td>5.7 ± 1.5</td>
<td>4.6 ± 3.1</td>
</tr>
<tr>
<td>Moderate PA (min/wk)</td>
<td>65.0 ± 82.4</td>
<td>183.0 ± 150.1*</td>
</tr>
<tr>
<td>Vigorous PA (min/wk)</td>
<td>566.2 ± 745.2</td>
<td>208.7 ± 326.1</td>
</tr>
<tr>
<td>Starting age for playing tennis (yr)</td>
<td>10.8 ± 3.4</td>
<td>-</td>
</tr>
<tr>
<td>Number of playing tennis (days/wk)</td>
<td>4.8 ± 1.2</td>
<td>-</td>
</tr>
<tr>
<td>Duration of each tennis exercise (min)</td>
<td>83.6 ± 25.6</td>
<td>-</td>
</tr>
</tbody>
</table>

All values are means and standard deviations.
*Non-tennis players significantly higher than tennis players.
Table 7. Correlations of variables measured.

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>BMI</th>
<th>W</th>
<th>TBz</th>
<th>SPz</th>
<th>THz</th>
<th>FNz</th>
<th>DAz</th>
<th>NDAz</th>
<th>TBIm</th>
<th>TOK</th>
<th>HBPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-</td>
<td>.06</td>
<td>.18</td>
<td>-.12</td>
<td>-.05</td>
<td>-.05</td>
<td>.09</td>
<td>.19</td>
<td>.09</td>
<td>.18</td>
<td>.35*</td>
<td>-.10</td>
</tr>
<tr>
<td>BMI</td>
<td>-</td>
<td>.77**</td>
<td>.46**</td>
<td>.26</td>
<td>.46**</td>
<td>.47**</td>
<td>.37*</td>
<td>.32</td>
<td>.42**</td>
<td>.15</td>
<td>.11</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>-</td>
<td></td>
<td>.52**</td>
<td>.39*</td>
<td>.41**</td>
<td>.54**</td>
<td>.38*</td>
<td>.35*</td>
<td>.81**</td>
<td>.10</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>TBz</td>
<td>-</td>
<td>.74**</td>
<td>.76**</td>
<td>.72**</td>
<td>.73**</td>
<td>.73**</td>
<td>.54**</td>
<td>-.14</td>
<td>.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPz</td>
<td>-</td>
<td></td>
<td>.57**</td>
<td>.57**</td>
<td>.60**</td>
<td>.56**</td>
<td>.44**</td>
<td>-.38*</td>
<td>.34*</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>THz</td>
<td>-</td>
<td>.91**</td>
<td>.65**</td>
<td>.58**</td>
<td>.44**</td>
<td>.06</td>
<td>.21</td>
<td></td>
<td></td>
<td></td>
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<td>.58**</td>
<td>.50**</td>
<td>.59**</td>
<td>.12</td>
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<td></td>
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</tr>
<tr>
<td>DA</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>.92**</td>
<td>.41*</td>
<td>-.13</td>
<td>.27</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>NDA</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.33*</td>
<td>-.15</td>
<td>.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBIm</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.08</td>
<td>.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOK</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>VPA</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Abbreviations for this table are as follows: BMI-Body Mass Index, W-Weight, TBz-Total Body z score, SPz-Total Body z score, THz-Total Hip z score, FNz-Femoral Neck z score, DA-Dominant Arm BMD, NDA-NonDominant Arm BMD, TBIm-Total Body lean mass, TS-Tanner Stages, TOK-Total Osteoporosis Knowledge, VPA-Vigorous Physical Activity.

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

*Correlation is significant at the 0.05 level (2-tailed).
Table 8. Characteristics of control group participants of previous research.

<table>
<thead>
<tr>
<th>Research</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kannus et al., 1994</td>
<td>Subjects were not involved in physical activity or work affecting the dominant extremity only.</td>
</tr>
<tr>
<td>Fehling et al., 1995</td>
<td>Subjects did not perform more than 1 hour regular PA training for the last 12 months.</td>
</tr>
<tr>
<td>Calbet et al., 1998</td>
<td>Subjects did not participate in either a sport during at least the last 5 years or any physically demanding work activity.</td>
</tr>
<tr>
<td>Haapasalo et al., 1998</td>
<td>Subjects did not participate in causal sports or were not involved in PA affecting the upper extremities.</td>
</tr>
<tr>
<td>Nordstrom et al., 1998</td>
<td>Subjects performed PA 3 hour per week or less.</td>
</tr>
<tr>
<td>Bass et al., 1998</td>
<td>Subjects did not engage in weight bearing activity not more than 6 hours per week.</td>
</tr>
<tr>
<td>Rodriguez et al., 2003</td>
<td>Subjects performed PA twice weekly for 45 min.</td>
</tr>
<tr>
<td>Courteix et al., 2007</td>
<td>Subjects performed no more than 3.5 hour of PA 3 times per week.</td>
</tr>
<tr>
<td>Juzwiak et al., 2008</td>
<td>Subjects were insufficiently active.</td>
</tr>
</tbody>
</table>
Figures
Figure 1. Outlier / Extreme variables for total body, lumbar spine, total hip and femoral neck BMD z-scores. O indicates an outlier.
Figure 2. Outlier / Extreme variables for dominant arm and non-dominant arm BMD raw scores.
Figure 3. Outlier / Extreme variables for total body fat mass and total body lean mass.
Figure 4. Outlier / Extreme variables for upper body extremities lean mass and fat mass.
Figure 5. Outlier / Extreme variables for lower body extremities lean mass and fat mass.
Figure 6. Outlier / Extreme variables for weekly physical activity.
Figure 7. Z-scores for total body, spine, total hip, and femoral neck BMD.

All values are means and standard deviations.
*Tennis players significantly higher than controls.
Figure 8. Dominant arm and non-dominant arm BMD raw scores.

All values are means and standard deviations.
All values are means and standard deviations.
*Tennis players significantly higher than controls.

Abbreviations for this table are as follows: LAFM – Left arm fat mass, RAFM – Right arm fat mass, LLFM – Left leg fat mass, RLFM – Right leg fat mass, LALM – Left arm lean mass, RALM – Right arm lean mass, LLLM – Left leg lean mass, RLLM – Right leg lean mass, TBFM – Total body fat mass, TBLM – Total body lean mass.
Appendices
Female Tennis Players
14 TO 18 YEARS OLD
LEARN YOUR BONE DENSITY and BODY COMPOSITION FREE and GET A CHANCE TO WIN ONE OF TWO $50 GIFT CERTIFICATE FROM HIBBETT SPORTS!

The Body Composition and Bone Mineral Density Laboratory at the University of Mississippi is conducting a research study to examine the effects of tennis playing on bone mineral density and body composition. We are looking for tennis players between the ages of 14 and 18.

Participants will be asked to complete surveys related to osteoporosis knowledge, eating, and physical activity habits, bone density test and come in for one visit which will last approximately 1 hour.

If interested, email kermin@olemiss.edu or call (662) 915-1527 / (662) 380-3187 ask for Ms. Kevser Ermin
<table>
<thead>
<tr>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
<td>(662) 380-3187</td>
</tr>
<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
<td>(662) 380-3187</td>
</tr>
<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
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</tr>
<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
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</tr>
<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
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<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
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<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
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<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
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<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
<td>(662) 380-3187</td>
</tr>
<tr>
<td><a href="mailto:kermin@olemiss.edu">kermin@olemiss.edu</a></td>
<td>(662) 380-3187</td>
</tr>
</tbody>
</table>

215 Turner Center, University of Mississippi
Recruitment Email

Research Study for Female Adolescents on Bone Mineral Density and Body Composition.

Learn your teenage daughter’s bone mineral density and body composition for free!

If you have a daughter between the ages of 14 and 18 and would like learn about your child’s bone mass and body composition by a FREE DXA scan, please contact us at kermin@olemiss.edu. The study will take about one hour to complete (30 minutes for the scan and 30 minutes to take surveys related to osteoporosis knowledge, eating, and physical activity habits). For questions please call 915-1527 or 380-3187.

All participants will be eligible to win one of two $50 gift certificates from Hibbett Sports.

This study has been approved by UM’s Institutional Review Board (IRB).
APPENDIX C
Initial Phone Contact Script

Initial phone contact with Potential Subjects parent

STUDY: The relationship between physical activity and bone mineral density among high school adolescents girls.
INVESTIGATORS: Kevser Ermin, Scott Owens, Martha Bass, Alison Ford-Wade

Part 1: Subject Information (Part of PI’s confidential records – do not make hard copies of part 1)

Name of investigator or study personnel:
_________________________________________________

Date of phone call: _____/_____/______ Time of phone call: ______:______

How did the subject hear about the study (circle)?

Flyer
Email
Newspaper
Other – Please specify ________________________________

Verbal Informed Consent Process

Verbal informed consent process completed (i.e. phone script on p. 2) (circle): YES - NO

Verbal consent obtained (circle): YES - NO Time: _____:______

If answer to question 2 is NO, discontinue phone conversation with subject; otherwise proceed with question no. 4

If answer to question 2 is YES, then record following information from the subject:

Parent’s Name: ________________________________

Child’s First Name ________________________________

Age: ________
Weight: __________
Height: __________
BMI: __________
Assign subject ID __________________________

Part 2: Phone Script

Thank you for calling to find out more about our research study. My name is {staff name}, and I am a researcher at the University of Mississippi. The purpose of this research study is to examine the relationship between physical activity, bone mineral density and body composition in adolescent girls aged 14 to 18 years old. The following information will be destroyed if you choose not to participate. At any point during this conversation if you answer “NO” to a question and would like to discontinue, no more questions will be asked and you will be deemed ineligible to participate.

If you and your child decide to participate in the study, we will ask you to come in for one visit (~60 minutes). First, we will determine whether your child is eligible to participate in the study by asking you and your child to consent to a urine pregnancy test. Please note that all volunteers must take a pregnancy test whether or not they are sexually active. Upon a negative result of the urine pregnancy test, you and your child will be asked to consent to a DXA scan (for the child) which measures bone mineral density and body composition. Do you think you might be interested in participating in that study?

{If answer is “NO”, discontinue conversation}: Thank you very much for calling.

{If answer is “yes”, proceed}:

O.K.

Before enrolling people in this study, we need to determine if your child is eligible. And so what I would like to do now is ask you a few questions about your child’s physical activity, current and past health condition. Also, I would like to let you know that the information that I receive from you by phone and reveals your name or identity will be strictly confidential and will be kept securely. The purpose of these questions is only to determine whether your child is eligible for our study. Remember that your participation is voluntary.

Do I have your permission to ask you these questions and record your answers?

{If answer is “NO”, discontinue conversation}:

Thank you very much for calling.

{Record answer and time in part 1 / no.2}:

{If answer is “YES”, proceed}:

O.K.

{Record answer and time in part 1 / no.2 and proceed with part 1 / no. 4 and part 3}:

91
Part 3: Eligibility Criteria / Phone screening conducted if answer to question no. 2 in part 1 is YES

Date of phone screening: _____/_____/_____

Ask the parent whether his/her child is involved in any physical activity

{Record answer}

{If the child is playing tennis, ask the parent how long her/his child has been playing tennis. If the answer is less than 2 years and less than 3 hour per week, discontinue conversation}: Thank you very much for calling.

{If the child has not been playing tennis or has been playing tennis for at least 2 years and is currently playing at least 3 hours per week, proceed}: O.K.

Ask the parent the following questions:

Is your child’s weight less than 300 lbs? YES - NO

Ask potential participant the following question regarding current medication:

Does your child take any medications currently? YES - NO

If YES, what are they and what for?

Medication | Condition
---|---
| |
| |
| |
| |
| |
| |

Does your child have any outstanding medical problems? YES - NO
(NOTE: Answer to previous question has to be NO for subject to be eligible)

If a parent answers YES to any of the following questions, this will be noted as this may influence their children’s BMD score.

Has your child ever taken synthetic glucocorticoids—also called steroids including cortisone, prednisone? 

YES - NO

If yes, have you taken these for longer than 6 weeks

YES - NO

Has your child ever taken any of the following medications?

- Anti-convulsants
  
  YES - NO

- Thyroid hormone
  
  YES - NO

- Cyclosporine A—used in organ transplantation and for the treatment of some diseases of the immune system
  
  YES - NO

- Heparin—used to prevent blood clotting
  
  YES - NO

Do you have any questions for me? 

If yes, summarize subject’s concerns/questions:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Subject’s questions and concerns were answered (circle): 

YES - NO

Based on phone screening, is subject eligible to participate in the study? 

YES - NO
If YES, proceed with part 4. If NO, please destroy all subject information.

As determined through this phone screening, your child is eligible to participate, would you and your child be interested in participating:       YES -       NO

Next, tell parent that:
"I also would like to talk to your daughter about the procedures of our study. Can she please call me when she has a little free time before our meeting?"
If NO, please destroy all subject information

Now that we have determined your child is eligible to participate, I would like to record your contact information to contact you for testing purposes and scheduling:

Parent’s Phone Number: __________________________________________
Alternate Phone Number: _________________________________________
Parent’s Email Address: __________________________________________

Other Information provided to subject:
- For testing, your child should wear
  - Pants
- Comfortable clothing that does not contain metal objects such as buttons and zippers or under wire bras.
- Your daughter must consent to a urine pregnancy test
- Directions to Turner if needed
- Schedule time or will be contacted to schedule a time

Additional notes:
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
APPENDIX D

INITIAL PHONE CONTACT WITH POTENTIAL SUBJECTS

Date of phone screening: ______/_____/_____

First of all, I would like to thank you for calling. My name is \{staff name\}, and I am a researcher at the University of Mississippi. I already talked to your parent about your participation in our study. I also would like to explain you the procedures of this study. The purpose of this research study is to examine the relationship between physical activity, bone mineral density and body composition in adolescent girls aged 14 to 18 years old.

If you decide to participate in the study, we will ask you to come in for one visit (~ 60 minutes). First, we will determine whether you are eligible to participate in the study by asking you to consent to a urine pregnancy test. Please note that all volunteers must take a pregnancy test whether or not they are sexually active. I want you to know that the result of your pregnancy test will be read when your parent is also with you. Upon a negative result of the urine pregnancy test, we will ask you to complete questionnaires related to osteoporosis knowledge, eating, and physical activity habits (takes about 30 min) then we will measure your BMD and body composition (takes about 30 min). Do you think you might be interested in participating in that study?

{If answer is “NO”, discontinue conversation}: Thank you very much for calling.

{If answer is “yes”, proceed}: O.K.

Thank you. We already determined a meeting time with your parent.

- Do you have any questions for me? YES - NO

If yes, summarize subject’s concerns/questions:

_____________________________________________________________________

_____________________________________________________________________

Subject’s questions and concerns were answered (circle): YES - NO
CHILD (age 14-17) ASSENT FORM

Assent to Participate in an Experimental Study

Title: The relationship between physical activity and bone mineral density among high school adolescents.

Investigator
Kevser Ermin
Department of Health, Exercise Science, and Recreation Management
220 Turner Center
The University of Mississippi
(662) 915-1527

Co-Investigator
Scott Owens, Ph.D.
Department of Health, Exercise Science, and Recreation Management
220 Turner Center
The University of Mississippi
(662) 915-5527

Dear (Participant):

We are investigating the effects of physical activity, osteoporosis knowledge, and health beliefs on bone mineral density in high school adolescents aged 14 to 18 years old. In order to test our hypotheses, we are asking you to complete surveys related to osteoporosis knowledge, eating, and physical activity habits in the Bone Mineral Density and Body Composition Lab in Turner Center. It will take about 30 minutes to finish the surveys. Next you must consent to take a pregnancy test. Please note that all volunteers must take a pregnancy test whether or not they are sexually active. We will then measure your height and weight. Next you will receive a DXA scan (which uses low-dose radiation) to measure bone mineral density. This will take about 30 minutes. We will explain the experiment to you and you can ask any questions you have about the experiment.

DXA Scan:
1) Your height and weight, with your shoes removed, will be obtained using a standard doctor’s scale.
2) You will be asked to lie on a padded table during the total body, hip, and spine DXA scans.
3) A member of the research staff will position your body properly prior to the initiation of the scan.
4) You will be asked to lie still for approximately 6 minutes for body composition and 30 seconds during four scans (hip, spine, and forearms). During these scans you will be exposed to a small dose of radiation.

Risks and Benefits
The risks associated with participation in this study include exposure of the participant (and possibly an unborn fetus) to radiation. The amount of radiation you will receive is about 1/10 of a chest x-ray’s radiation dose. To eliminate the risk of radiating a fetus, all volunteers must take a urine pregnancy test that we provide. You will not be able to participate in this study unless the result is negative. Please note that all volunteers must take a pregnancy test whether or not they are sexually active.

Direct benefits include learning your bone mineral density and body composition results. Should the testing procedure indicate that your bone mineral density is low, you will be advised to make an appointment with your physician. We will provide the results of your scan to your physician at no cost.

Cost and Payments
The surveys will take about 30 minutes to complete. The DXA scan will also take approximately 30 minutes. There is no cost for participating in this study. You will not be paid for your participation in this project.

Confidentiality
All contact information (i.e. names and email addresses) will be kept under lock and key in Mrs. Ermin’s office and the DXA laboratory (Turner 248A). Once all data have been collected, all names and identifying information will be destroyed.

Right to Withdraw
You do not have to take part in this study. If you start the study and decide that you do not want to finish, all you have to do is tell Mrs. Ermin.

The researchers may terminate your participation in the study without regard to your consent and for any reason, such as protecting your safety and protecting the integrity of the research data.

IRB Approval
This study has been reviewed by The University of Mississippi’s Institutional Review Board (IRB). The IRB has determined that this study fulfills the human research subject protections obligations required by state and federal law and University policies. If you have any questions, concerns, or reports regarding your rights as a participant of research, please contact the IRB at (662) 915-7482.

Statement of Consent
I have read the above information. I have been given a copy of this form. I have had an opportunity to ask questions, and I have received answers. I consent to participate in the study.
Statement of Consent to be Contacted for Future Studies

The staff of the DXA Laboratory may be interested in contacting you to participate in future studies. Signing below allows us to contact you with information on future studies.

__________________________ Date
Signature of Participant

__________________________ Date
Signature of Investigator

NOTE TO PARTICIPANTS: DO NOT SIGN THIS FORM
IF THE IRB APPROVAL STAMP ON THE FIRST PAGE HAS EXPIRED.
APPENDIX F
Parental Consent Form

PARENTAL CONSENT FOR CHILD’S PARTICIPATION

Parental Consent for Child to Participate in an Experimental Study

Title: The relationship between physical activity and bone mineral density among high school adolescents.

Investigator
Kevser Ermin
Department of Health, Exercise Science, and Recreation Management
Turner Center
The University of Mississippi
(662) 915-1527

Co-Investigator
Scott Owens, Ph.D.
Department of Health, Exercise Science, and Recreation Management
Turner Center
The University of Mississippi
(662) 915-5527

Description
We are investigating the effects of physical activity, osteoporosis knowledge, and health beliefs on bone mineral density in high school adolescents aged 14 to 18 years old. In order to test our hypotheses, we are asking your child to complete surveys related to osteoporosis knowledge, eating, and physical activity habits in the Bone Mineral Density and Body Composition Lab in Turner Center. It will take about 30 minutes to finish the surveys. Next your daughter must consent to take a pregnancy test. Please note that all volunteers must take a pregnancy test whether or not they are sexually active. We will then measure your child’s height and weight. Next your child will receive a DXA scan (which uses low-dose radiation) to measure bone mineral density. This will take about 30 minutes. We will explain the experiment to you and your child and you can ask any questions you have about the experiment.

DXA Scan:
1) Your child’s height and weight, with her shoes removed, will be obtained using a standard doctor’s scale.
2) Your child will be asked to lie on a padded table during the total body, hip, and spine DXA scans.
3) A member of the research staff will position your child’s body properly prior to the initiation of the scan.
4) Your child will be asked to lie still for approximately 6 minutes for body composition and 30 seconds during four scans (hip, spine, and forearms). During these scans your child will be exposed to a small dose of radiation.
Risks and Benefits
The risks associated with participation in this study include exposure of the participant (and possibly an unborn fetus) to radiation. The amount of radiation you will receive is about 1/10 of a chest x-ray’s radiation dose. To eliminate the risk of radiating a fetus, all volunteers must take a urine pregnancy test that we provide. You will not be able to participate in this study unless the result is negative. Please note that all volunteers must take a pregnancy test whether or not they are sexually active.

Direct benefits include learning your child’s bone mineral density and body composition results. Should the testing procedure indicate that your child’s bone mineral density is low, you and your child will be advised to make an appointment with your child’s physician. We will provide the results of your child’s scan to your physician at no cost.

Cost and Payments
The surveys will take about 30 minutes to complete. The DXA scan will also take approximately 30 minutes. There is no cost for participating in this study. You and your child will not be paid for your child’s participation in this project.

Confidentiality
All contact information (i.e. names and email addresses) will be kept under lock and key in Mrs. Ermin’s office and the DXA laboratory (Turner 248A). Once all data have been collected, all names and identifying information will be destroyed.

Right to Withdraw
Your child does not have to take part in this study. If she starts the study and decides that she does not want to finish, all you and your child have to do is tell Mrs. Ermin.

The researchers may terminate your child’s participation in the study without regard to your consent and for any reason, such as protecting your safety and protecting the integrity of the research data.

IRB Approval
This study has been reviewed by The University of Mississippi’s Institutional Review Board (IRB). The IRB has determined that this study fulfills the human research subject protections obligations required by state and federal law and University policies. If you have any questions, concerns, or reports regarding your child’s rights as a participant of research, please contact the IRB at (662) 915-7482.

Statement of Consent
I have read the above information. I have been given a copy of this form. I have had an opportunity to ask questions, and I have received answers. I consent my child to participate in the study.
Statement of Consent to be Contacted for Future Studies

The staff of the DXA Laboratory may be interested in contacting you to participate in future studies. Signing below allows us to contact you with information on future studies.

Signature of Participant                          Date

                                            Signature of Investigator
                                            Date

NOTE TO PARTICIPANTS:  DO NOT SIGN THIS FORM IF THE IRB APPROVAL STAMP ON THE FIRST PAGE HAS EXPIRED.
CONSENT FORM

Consent to Participate in an Experimental Study

Title: The relationship between physical activity and bone mineral density among high school adolescents.

Investigator
Kevser Ermin
Department of Health, Exercise Science, and Recreation Management
220 Turner Center
The University of Mississippi
(662) 915-1527

Co-Investigator
Scott Owens, Ph.D.
Department of Health, Exercise Science, and Recreation Management
220 Turner Center
The University of Mississippi
(662) 915-5527

Dear (Participant):

We are investigating the effects of physical activity, osteoporosis knowledge, and health beliefs on bone mineral density in high school adolescents aged 14 to 18 years old. In order to test our hypotheses, we are asking you to complete surveys related to osteoporosis knowledge, eating, and physical activity habits in the Bone Mineral Density and Body Composition Lab in Turner Center. It will take about 30 minutes to finish the surveys. Next you must consent to take a pregnancy test. Please note that all volunteers must take a pregnancy test whether or not they are sexually active. We will then measure your height and weight. Next you will receive a DXA scan (which uses low-dose radiation) to measure bone mineral density. This will take about 30 minutes. We will explain the experiment to you and you can ask any questions you have about the experiment.

DXA Scan:
1) Your height and weight, with your shoes removed, will be obtained using a standard doctor’s scale.
2) You will be asked to lie on a padded table during the total body, hip, and spine DXA scans.
3) A member of the research staff will position your body properly prior to the initiation of the scan.
4) You will be asked to lie still for approximately 6 minutes for body composition and 30 seconds during four scans (hip, spine, and forearms). During these scans you will be exposed to a small dose of radiation.

**Risks and Benefits**
The risks associated with participation in this study include exposure of the participant (and possibly an unborn fetus) to radiation. The amount of radiation you will receive is about 1/10 of a chest x-ray’s radiation dose. To eliminate the risk of radiating a fetus, all volunteers must take a urine pregnancy test that we provide. You will not be able to participate in this study unless the result is negative. Please note that all volunteers must take a pregnancy test whether or not they are sexually active.

Direct benefits include learning your bone mineral density and body composition results. Should the testing procedure indicate that your bone mineral density is low, you will be advised to make an appointment with your physician. We will provide the results of your scan to your physician at no cost.

**Cost and Payments**
The surveys will take about 30 minutes to complete. The DXA scan will also take approximately 30 minutes. There is no cost for participating in this study. You will not be paid for your participation in this project.

**Confidentiality**
All contact information (i.e. names and email addresses) will be kept under lock and key in Mrs. Ermin’s office and the DXA laboratory (Turner 248A). Once all data have been collected, all names and identifying information will be destroyed.

**Right to Withdraw**
You do not have to take part in this study. If you start the study and decide that you do not want to finish, all you have to do is tell Mrs. Ermin.

The researchers may terminate your participation in the study without regard to your consent and for any reason, such as protecting your safety and protecting the integrity of the research data.

**IRB Approval**
This study has been reviewed by The University of Mississippi’s Institutional Review Board (IRB). The IRB has determined that this study fulfills the human research subject protections obligations required by state and federal law and University policies. If you have any questions, concerns, or reports regarding your rights as a participant of research, please contact the IRB at (662) 915-7482.

**Statement of Consent**
I have read the above information. I have been given a copy of this form. I have had an opportunity to ask questions, and I have received answers. I consent to participate in the study.
Statement of Consent to be Contacted for Future Studies

The staff of the DXA Laboratory may be interested in contacting you to participate in future studies. Signing below allows us to contact you with information on future studies.

Signature of Participant                          Date

Signature of Investigator                      Date

NOTE TO PARTICIPANTS:  Do not sign this form if the IRB approval stamp on the first page has expired.
APPENDIX H
Pregnancy Script

The pregnancy test appears to be positive, so we can’t do the bone scan on you. Sometimes these tests are wrong, so we recommend that you see your doctor to find out for sure. If it turns out that you aren’t pregnant and you still want to be in the study, just give us a call.
APPENDIX I
Osteoporosis Risk Factor Assessment

ORFA
(Osteoporosis Risk Factor Assessment)

Please answer to the best of your knowledge.

1. Was your biological mother or grandmother ever told by a doctor they had osteoporosis, sometimes called thin or brittle bones?
   a. Yes
   b. No
   c. I don’t know

2. Did your biological mother or grandmother ever fracture her hip?
   a. Yes
   b. No
   c. I don’t know

3. When you were a baby, were you breastfed?
   a. Yes
   b. No
   c. I don’t know

4. Now I am going to ask you how often you usually eat certain foods and drink certain beverages. When answering think about your usual diet over the past month. Tell me how often you usually ate or drank these foods per week. DO NOT include their use in cooking.

5. How often did you have chocolate milk and hot cocoa? _____Time(s) per week

6. How often did you have milk to drink or on cereal? (Do not count small amounts of milk added to coffee or tea.) _____Times per week

7. How often did you have yogurt or frozen yogurt? _____Time(s) per week

8. How often did you have ice cream, ice milk, and milk shakes? _____Time(s) per week
9. How often did you have cheese, all types including American, Swiss, cheddar, and cottage cheese?  

______ Time(s) per week

10. How often did you have pizza, calzone, and lasagna? ______ Time(s) per week

11. How often did you have cheese dishes such as macaroni and cheese, cheese nachos, cheese enchiladas, and quesadillas? ______ Time(s) per week

12. Have you ever been on a high protein diet (Atkins, South Beach, etc)?

   a. Yes
   b. No

13. How long have you been on this diet (or how long were you on this diet)?

   a. more than 1 year
   b. 8-12 months
   c. 6-8 months
   d. 3-6 months
   e. 1-3 months

14. Approximately how many servings of milk do you drink each day?

   a. None (0 servings)
   b. 1 serving each day
   c. 2 servings each day
   d. 3 servings each day
   e. 4 or more servings each day

15. Over the past 12 months, did you drink soft drinks, soda, or pop?

   a. No (go to question 16)
   b. Yes

15a. How often did you drink soft drinks, soda, or pop in the summer?

   a. Never
   b. 1 time per month or less
   c. 2-3 times per month
   d. 1-2 times per week
   e. 3-4 times per week
   f. 5-6 times per week
   g. 1 time per day
   h. 2-3 times per day
   i. 4-5 times per day
   j. 6 or more times per day
15b. How often did you drink soft drinks, soda, or pop during the rest of the year?

- g. Never
- h. 1 time per month or less
- i. 2-3 times per month
- j. 1-2 times per week
- k. 3-4 times per week
- l. 5-6 times per week

- g. 1 time per day
- h. 2-3 times per day
- i. 4-5 times per day
- j. 6 or more times per day

15c. How often were these soft drinks, soda, or pop caffeine-free?

- a. Almost never or never
- b. About ¼ of the time
- c. About ½ of the time
- d. About ¾ of the time
- e. Almost always or always

16. How many cups of caffeinated coffee did you drink?

- a. Never
- b. Less than 1 cup per month
- c. 1-3 cups per month
- d. 1 cup per week
- e. 2-4 cups per week
- f. 5-6 cups per week

- g. 1 cup per day
- h. 2-3 cups per day
- i. 4-5 cups per day
- j. 6 or more cups per day

17. How many glasses of caffeinated iced tea did you drink?

- a. Never
- b. Less than 1 cup per month
- c. 1-3 cups per month
- d. 1 cup per week
- e. 2-4 cups per week
- f. 5-6 cups per week

- g. 1 cup per day
- h. 2-3 cups per day
- i. 4-5 cups per day
- j. 6 or more cups per day

18. How many cups of caffeinated hot tea did you drink?

- a. Never
- b. Less than 1 cup per month
- c. 1-3 cups per month
- d. 1 cup per week
- e. 2-4 cups per week
- f. 5-6 cups per week

- g. 1 cup per day
- h. 2-3 cups per day
- i. 4-5 cups per day
- j. 6 or more cups per day
19. Do you take calcium supplementation?

______How many milligrams each ______Time(s) per week

The next questions ask you about your involvement in exercise.

20. In the past month, how often did you walk a mile or more at a time without stopping?
   Times per month ______

21. In the past month, how often did you jog or run?
   Times per month_________ Time spent per exercise_______

22. In the past month, how often did you ride a bicycle or and exercise bicycle?
   Times per month_________ Time spent per exercise_______

23. In the past month, how often did you swim?
   Times per month_________ Time spent per exercise_______

24. In the past month, how often did you do aerobics or aerobic dancing?
   Times per month_________ Time spent per exercise_______

25. In the past month, how often did you garden or do yard work (pulling up weeds, shoveling, digging, push mowing)?
   Times per month_________ Time spent per exercise_______

26. In the past month, how often did you lift weights?
   Times per month_________ Time spent per exercise_______

27. In the past month, how often did you do any other exercises, sports, or physically active which are running, basketball, volleyball, weight lifting, soccer, dancing, softball, baseball, gymnastic, and bowling?

Which sport ____________
Times per month_________ Time spent per exercise_______
28. Do you participate in any competitive sport during the last 2 years?
   a. Yes
   b. No

29. In general, do you take the stairs or the elevator?
   a. Stairs
   b. Elevator

The next questions ask about your background.

30. What is your birthday? (MM/DD/YY) ________________________

31. Are you right or left handed? _________________

32. Which of the following best describes your ethnic group?
   a. Asian
   b. African American
   c. Caucasian
   d. Hispanic
   e. Native American
   f. Other

33. Total number of persons who smoke cigarettes in the home.
   g. 0
   h. 1
   i. 2
   j. 3
   k. 4+

34. Do you smoke?
   l. Yes
   m. No

35. At what age did you start your menstrual period? ____ years
36. Are your menstrual periods regular (every 28 days)?
   n. Yes
   o. No

37. Have you ever been amenorrheic (lost your menstrual cycle for any reason, other than pregnancy for longer than 3 months)?
   p. Yes
   q. No

38. Have you ever taken birth control pills for any reason (i.e. to regulate your periods)?
   r. Yes
   s. No

39. How long altogether have you or did you take birth control pills?

   ______________

Thank you for taking the time to participate in this survey!
Tennis Players Only:

1. At what age did you start playing tennis? ____ years

2. How many times do you play tennis per week? ____________

3. What is the average duration (in minutes) of each exercise session? ____________

4. Which arm do you use, when you perform a forehand stroke? ____________

5. Which arm do you use, when you perform a backhand stroke? ____________

6. Have you had any fractures?
   a. Yes
   b. No

   If yes, at which extremity? ________________

7. Do you play other sports besides tennis?
   a. Yes
   b. No

   If yes, what type of sport do you play? ______________________

   How many times per week? ______________________

   How long for each exercise session (in minutes)? ______________________
APPENDIX J
Osteoporosis Knowledge Test

Osteoporosis Knowledge Test

The following is a list of things which may or may not affect a person’s chance of getting osteoporosis. For each item circle whether this person is:

MORE LIKELY TO GET OSTEOPOROSIS, or
LESS LIKELY TO GET OSTEOPOROSIS, or
IT HAS NOTHING TO DO WITH GETTING OSTEOPOROSIS.

<table>
<thead>
<tr>
<th>Item</th>
<th>More Likely</th>
<th>Less Likely</th>
<th>Neutral</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eating a diet low in milk products</td>
<td>ML</td>
<td>LL</td>
<td>NT</td>
<td>DK</td>
</tr>
<tr>
<td>2. Having big bones</td>
<td>ML</td>
<td>LL</td>
<td>NT</td>
<td>DK</td>
</tr>
<tr>
<td>3. Eating a diet high in dark green leafy vegetables</td>
<td>ML</td>
<td>LL</td>
<td>NT</td>
<td>DK</td>
</tr>
<tr>
<td>4. Having a mother or grandmother who has osteoporosis</td>
<td>ML</td>
<td>LL</td>
<td>NT</td>
<td>DK</td>
</tr>
<tr>
<td>5. Being a white female with fair skin</td>
<td>ML</td>
<td>LL</td>
<td>NT</td>
<td>DK</td>
</tr>
<tr>
<td>6. Taking cortisone (steroids, e.g., Prednisone) for long time</td>
<td>ML</td>
<td>LL</td>
<td>NT</td>
<td>DK</td>
</tr>
<tr>
<td>7. Exercising on a regular basis</td>
<td>ML</td>
<td>LL</td>
<td>NT</td>
<td>DK</td>
</tr>
</tbody>
</table>

8. Which of the following exercises is the best way to reduce a person’s chance of getting osteoporosis?
   a. swimming
   b. walking briskly
   c. doing kitchen chores, such as washing dishes or cooking
   d. don’t know

9. Which of the following exercises is the best way to reduce a person’s chance of getting osteoporosis?
   a. bicycling
   b. yoga
   c. housecleaning
   d. don’t know
10. How many days a week do you think a person should exercise to strengthen their bones?
   a. 1 day a week
   b. 2 days a week
   c. 3 or more days a week
   d. don’t know

11. What is the least amount of time a person should exercise on each occasion to strengthen their bones?
   a. less than 15 minutes
   b. 20 to 30 minutes
   c. more than 45 minutes
   d. don’t know

12. Exercise makes bones strong, but it must be hard enough to make breathing:
   a. just a little faster
   b. so fast that talking is not possible
   c. much faster, but talking is possible
   d. don’t know

13. Which of the following exercises is the best way to reduce a person’s chance of getting osteoporosis?
   a. jogging or running for exercise
   b. golfing using golf cart
   c. gardening
   d. don’t know

14. Which of the following exercises is the best way to reduce a person’s chance of getting osteoporosis?
   a. bowling
   b. doing laundry
   c. aerobic dancing
   d. don’t know

Calcium is one of the nutrients our body needs to keep bones strong.
15. Which of these is a good source of calcium?
   a. apple  
   b. cheese  
   c. cucumber  
   d. don’t know  

16. Which of these is a good source of calcium?
   a. watermelon  
   b. corn  
   c. canned sardines  
   d. don’t know  

17. Which of these is a good source of calcium?
   a. chicken  
   b. broccoli  
   c. grapes  
   d. don’t know  

18. Which of these is a good source of calcium?
   a. yogurt  
   b. strawberries  
   c. cabbage  
   d. don’t know  

19. Which of these is a good source of calcium?
   a. ice cream  
   b. grapefruit  
   c. radishes  
   d. don’t know  

20. Which of the following is the recommended amount of calcium intake for an adolescent?
   a. 300 mg – 500 mg daily  
   b. 500 mg – 1000 mg daily  
   c. 1300 mg or more daily  
   d. don’t know
21. How much milk must an adolescent drink to meet the recommended amount of calcium?

   a. ½ glass daily
   b. 1 glass daily
   c. 2 or more glasses daily
   d. don’t know

22. Which of the following is the best reason for taking a calcium supplement?

   a. if a person skips breakfast
   b. if a person does not get enough calcium from diet
   c. if a person is over 45 years old
   d. don’t know
APPENDIX K

DXA Test Results Report Form

Name of Subject____________________ Date of DXA scan________

Based on guidelines established by the World Health Organization, the results of your DXA scan indicate that you have a lower than desired bone mineral density. I recommend you make an appointment with your physician at your earliest convenience to discuss the results of this test. If you desire, we will fax a copy of these results to your physician.

Recommendation of:

Eric Dahl, D.O.
Supervising Physician
Applied Physiology Laboratory
The University of Mississippi

By signing my name below I acknowledge that I have been advised that the results of my DXA scan indicate that I have a lower than desired bone mineral density. My signature also acknowledges that I have indicated whether I request a copy of these test results be faxed to my physician.

____Yes, I request a copy of my test results be faxed to my physician.

____No, I do not request a copy of my test results be faxed to my physician.

My physician’s name ____________________________________________

Office location __________________________________________________

fax number ______________ phone number__________________________

________________________Date ______________

Signature of Participant

________________________Date ______________

Signature of Witness
The drawings on this page show different amounts of female pubic hair. A girl passes through each of the five stages shown by these drawings. Please look at each drawing and read the sentences under the drawings. Then choose the drawing closest to your stage of hair development and mark it 1. Then choose the drawing that is next closest and mark it 2.

1. Drawing A
2. Drawing B
3. Drawing C
4. Drawing D
5. Drawing E

There is no pubic hair.
There is a little long, lightly colored hair. This hair may be straight or a little curly.
The hair is darker in this stage. It is coarser and more curved. It has spread out and thinly covers a larger area.
The hair is not as dark, coarser, and coarser as that of an adult female. However, the area that the hair covers is not as large as that of an adult female. The hair has not spread out to the thighs.
The hair now is like that of an adult female. It also covers the same area as that of the adult female. The hair usually forms a triangular (△) pattern as it spreads out to the thighs.

Fig. 2
APPENDIX M
Seven-Day Physical Activity Recall Questionnaire

Please record how much exercise you did in the last **SEVEN** days. Please place your exercise into one of the two categories: exercise that is **NOT EXHAUSTING** or exercise that makes your **HEART BEAT RAPIDLY**.

Please do **not** record any **LIGHT** exercise (such as bowling, golfing with a motorized cart, or walking from your car to your house).

- Record only the time you actually exercised. Do not count breaks and rest periods.
- List the activity that you did when you exercised.
- Please ☐ the BOX if you did **NOT** exercise during the last seven days.

☐ I did **NOT** exercise in the last seven (7) days.

<table>
<thead>
<tr>
<th>Day</th>
<th>Total Minutes</th>
<th>LIST ACTIVITY</th>
</tr>
</thead>
<tbody>
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APPENDIX N
BMI Script

For this study, your BMI must be between the range of - / -. Your BMI appears to be not in this range. We are very sorry to inform you that we cannot have you as one of our participants. If you have any questions, you may contact Dr. Owens at 915-5527 or sgowens@olemiss.edu.