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An Evaluation of Select Physical Activity Exercise Classes (PEX) on Bone Mineral Density

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AN EVALUATION OF SELECT PHYSICAL ACTIVITY EXERCISE CLASSES (PEX)
ON BONE MINERAL DENSITY

By

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Bachelor of Science
Indiana State University
2013

A thesis submitted in partial fulfillment
of the requirements for the

Masters of Science--Exercise Physiology

Department of Kinesiology and Nutrition Sciences
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We recommend the thesis prepared under our supervision by

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Master of Science - Kinesiology

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ABSTRACT

An Evaluation of Select Physical Activity Exercise Classes (PEX) on Bone Mineral Density

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INTRODUCTION: According to the National Institute of Health consensus, Osteoporosis causes premature disability in approximately 44 million people (National Institute of Health [NIH], 2001), 80% of this population being women (Ulrich, Georgiou, Gillis, & Snow, 1999). This chronic disease causes 1.5 million fractures annually, 700,000 occurring at the spine (NIH, 2001). One prevention technique developed in recent years is to build a high peak bone mass during growth and in young adult life (Almstedt, Canepa, Ramirez, & Shoepe, 2011). Several publications positively correlate an increase in BMD with increased amounts of exercise. Bone mineral density can be observed through DEXA scans, as well as, by monitoring specific biochemical markers in the blood such as osteocalcin, known to be sensitive to bone formation. **PURPOSE:** The purpose of this research is to assess the efficacy of select structured physical activity classes. Specifically, we intend to determine the effect of these exercise classes on bone mineral density (BMD) as measured through Dual Energy X-Ray Absorptiometry (DEXA) scans,

and analysis of the biochemical marker osteocalcin. **METHODS:** As part of a prospective cohort study design participants included females, ages 18-35 years, who were enrolled in either a yoga (N=14) or a cardio-kickboxing (N=13) physical activity class both provided by the University of Nevada, Las Vegas (UNLV). Twelve individuals not enrolled in either class served as controls. Participants provided baseline hip, spine, and total body DEXA scans as well as a blood sample to obtain osteocalcin concentrations. Participants were also asked to complete food/medication/supplementation questionnaires concerned with intake prior to and during the study. Previous and current physical activity was also accounted for via questionnaire. Participants were then asked to return for testing after completion of the semester physical activity course to provide post DEXA scans and blood samples. **RESULTS:** Results suggest no significance observed for BMD by DEXA scans for TB ($p = .383$), HP ($p = .305$), or SP ($p = .009$) sites after completion of a yoga PEX class. In fact, measurements at the SP revealed a significant reduction in BMD ($p = .009$). Similarly, no significance was observed for BMD by DEXA scans for TB ($p = .524$), SP ($p = .062$), or HP ($p = .433$) after completion of a CKB class. Bone mineral density also failed to be significant across all three groups at each site TB ($p = .845$), SP ($p = .789$), and HP ($p = .519$). However, osteocalcin concentration displayed significance in both yoga ($p = .000$) and CKB ($p = .001$) classes but failed to be significant across all three groups including controls ($p = .071$). **DISCUSSION:** We can conclude 12 weeks of yoga and CKB classes evoke a significant increase in osteocalcin's biochemical response. This conclusion could actuate the assumption that biochemical activity is far more sensitive to physical activity than actual bone growth. It is likely that 12 weeks is an

insufficient amount of time to induce bone growth, regarding the standard life cycle of bone. Cardio kickboxing is an active physical activity incorporating quick repetitive movements into its curriculum that require the individual to exert force onto an object. This group did not increase BMD, but they did maintain levels at all tested sites. Yoga is a passive physical activity requiring the individual to shift their own body weight through sustained static poses. Force or stress is necessary to induce bone growth. Without an outside stimulus to react against it is reasonable to assume the bone growth response is not initiated. Cardio kickboxing seems to elicit enough force acting against bone to promote maintenance of BMD whereas yoga does not.

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CHAPTER 1

INTRODUCTION

Osteoporosis causes premature disability among approximately 44 million¹ people in the United States, 80% being women.² This chronic disease causes 1.5 million fractures annually, 700,000 of which occur at the spine.¹ These fractures can cost up to \$3.8 billion in medical treatment annually.^{3 4} One prevention technique developed in recent years is to build a high peak bone mass during growth and in young adult life.⁵ Peak bone mass is the highest bone mineral density (BMD) achieved and is an important determinant of future fracture risk.⁵ Those who do not optimize peak bone mass development in youth and young adult years are at an increased risk of developing osteoporosis, even without experiencing accelerated bone loss.¹ Physical activity (PA) helps to maintain BMD, as well as, build up to this peak bone mass.

There are numerous works published that explore BMD and how it can be effected by physical activity. Changes in BMD can be observed through Dual Energy X-ray Absorptiometry (DEXA) scans, as well as monitoring specific biochemical markers within the blood associated with bone formation. Osteocalcin and bone alkaline phosphatase are two biomarkers known to be the most sensitive to bone development. Osteocalcin is a protein that is secreted by osteoblasts, cells that build up the bone matrix. Bone alkaline phosphatase is a glycoprotein found on the surface of these osteoblasts, and reflects their biosynthetic activity. In regards to PA, certain types seem to be responsible for evoking a greater or lesser response of bone growth. Physical

activity that elicits high impact forces upon the body is more capable to promote greater increases in BMD, while PA known to elicit a lower impact force upon the body will promote an increase to a lesser degree, if an increase is achieved at all. Within the present literature, high impact physical activities are those that contribute to the concept of bone loading. This concept can be further reinforced by understanding Wolf's Law, stating: if bone loading increases, that bone will then remold itself to resist that outside stimulus, therefore becoming thicker and stronger. Wolf's Law also demonstrates an inverse relationship that is an important contribution to understanding the nature of bone growth. More commonly referred to as turnover, bone has a tendency to become thinner and weaker if the applied loading forces against it cease to continue. High impact physical activities can include, but are not limited to: walking, jogging, running, weight lifting, and gymnastics, while low impact physical activities can include those such as swimming and cycling. Cardio kickboxing and yoga are two types of PA that are relatively new and becoming increasingly more popular. Both can be done at home, in a gym, with a personal trainer, or with a group class. Cardio kickboxing may be considered more of a high impact activity while yoga may be a low impact activity.

Purpose of Study

The purpose of this research is to assess the efficacy of select structured physical activity classes in individuals aged 18-34 years. Specifically, we intend to determine the

effect of these exercise classes on bone mineral density as measured through DEXA scans. Additionally, attempted to determine the effect of select physical activity classes on osteocalcin and bone alkaline phosphatase, considered to be two of the most sensitive and specific biochemical markers of bone formation.

Research Hypotheses

Hypothesis 1

H₀₁: There will be no change in BMD when measured by DEXA scan after completion of a yoga PEX class

H_{A1}: There will be significant increase in BMD measure by DEXA scan after completion of a yoga PEX class

Hypothesis 2

H₀₂: There will be no change in biochemical marker osteocalcin after completion of a yoga PEX class

H_{A2}: There will be a significant increase in biochemical marker osteocalcin after completion of a yoga PEX class

Hypothesis 3

H₀₃: There will be no change in BMD measured by DEXA scan after completion of a cardio kickboxing PEX class

H_{A3}: There will be a significant increase in BMD measured by DEXA scan after completion of a cardio kickboxing class

Hypothesis 4

H₀₄: There will be no change in biochemical marker osteocalcin after completion of a cardio kickboxing PEX class

H_{A4}: There will be a significant increase in biochemical marker osteocalcin after completion of a cardio kickboxing PEX class

Hypothesis 5

H₀₅: There will be no difference in BMD and osteocalcin in students enrolled in cardio kickboxing compared with students enrolled in yoga

H_{A5}: There will be a significant increase in BMD and osteocalcin in students enrolled in cardio kickboxing compared with students enrolled in yoga

Hypothesis 6

H₀₆: More frequent class attendance will not correlate with increased measure of bone formation

H_{A6}: More frequent class attendance will correlate with increased measures of bone formation

Significance of the Study

The significance of this study lies in the possibility of finding results suggesting yoga and cardio kickboxing have the potential to positively affect bone mineral content. Research is focused on high impact activities such as running or resistance training as

being the sole activities that can increase BMD. These two active (cardio kickboxing) and passive (yoga) PEX classes will provide variety to types of PA that may increase BMD, therefore cardio kickboxing and yoga can provide a greater range of PA that may increase bone mineral density and contribute to filling the present gap within the literature. The clinical application also provides significance to this study. Osteoporosis effects many Americans each year. More often than not, the population most affected by this disease are the elderly. Yoga could provide a low intensity activity that is safe and effective in increasing BMD. Osteoporosis also tends to affect women earlier than men as well as to a greater degree. One of the most common fracture sites for women is the hip. Cardio kickboxing may increase BMD in the hip because this type of exercise focuses on repetitive loading movements of the lower body. It also requires a certain stance that provides pelvic girdle stabilization to assist the torso and upper body in remaining upright and able to receive impact by an outside force.

CHAPTER 2

REVIEW OF RELATED LITERATURE

As previously stated, BMD and peak bone mass can be built or maintained through PA. Certain types of physical activities may promote a greater effect on BMD depending on what type of activity. Yoga and CKB are two that possibly can effect BMD, but not defined within the literature. Biochemical markers osteocalcin and bone alkaline phosphatase can assist in monitoring minuscule changes within bone formation and help to determine bone health. This particular review will focus on BMD by these specific structured PA regimens. Furthermore, it will address possible reactions on distinct biochemical markers, Osteocalcin and bone alkaline phosphatase that are related to increases in bone thickness.

Physical Activity and Bone Mineral Density

PA is a modifiable factor that plays a significant role in maximizing BMD.⁶ Current research has indicated moderate levels of PA, two or more times per week is a modest prescription for bone health and can exert a protective effect against various types of fractures.^{6 7 8} It is not uncommon for athletes to accumulate 20+ hours a week dedicated to training for their sport. This excessive time commitment could serve as rationale to why athletes tend to have a higher bone mineral density than a non-athletic

population. Torstveit and Sundgot-Borgen took random samples of athletes and non-athletes aged 13-34yrs and invited them to participate in a three part study. Part I: screening, included a questionnaire consisting of assessment questions. Part II: assessment of BMD by DEXA scan to obtain accurate measurements of BMD. Part III: clinical interview, was included to determine whether subjects met the criteria for subclinical or clinical eating disorders.⁹ Among the subject pool, the sample of athletes represented 66 different sports/events. Results affirmed BMD was higher at all measurement sites in athletes compared to controls with athletes having 3-20% higher BMD. Twenty-eight percent of the controls were diagnosed with low BMD in at least one of the five measurement sites, while only 11% of the athletes were diagnosed. A higher percentage of controls than athletes were diagnosed with lower total body BMD (15% v 4.9%, respectively) and low total femur BMD (15% v 2.9%, respectively).⁹ It was also concluded that low BMD is two to three times more common in non-athletic women than in elite athletes.⁹ Torstveit and Sundgot-Borgen did not show partiality to one sport compared with controls, and rather included 46 sports/events. Because of this we can assume the amount of time dedicated to any type of physical activity or event results in greater effects on BMD than when less time is spent being physically active. Greene et al. proved the assumption of amount of time in relation to BMD to be true by comparing bone strength index in female middle distance runners and age matched controls to investigate factors predictive of bone strength index. The runners participated in 8.9 hours of PA a week while controls participated in approximately 2 hours of PA a week, approximately.¹⁰ Greene et al. found the stronger predictor of bone

strength index was hours of physical activity a week ($R^2 = 0.46$).¹⁰ They concluded athletes habitually exposed to high training loads displayed greater bone strength index than controls at tests sites.¹⁰ These two studies indicated an individual's BMD and PA regimen correlate strongly depending on their present amount of activity. But past activity is a determinant of bone health as well. To examine the relationship between BMD and past and recent PA, Ford and colleagues took a sample of 157 college-aged (18-39yrs) women and presented them with a questionnaire. The questionnaire presented the subjects with questions designed to obtain information about their past PA and their present PA. BMD measurements were obtained by DEXA scan. Subjects who reported having exercised at least 12 times per month were categorized into "high" exercise group (3 days per week x 4 weeks per month), and the subjects who reported having exercised less than 12 times per month were categorized into the "low" exercise group.¹¹ To determine past physical activity, the following question was asked: "Did you participate in sports in high school?" Eighteen percent (n=29) of the women reported they participated in some form of PA 12 days or less per month, whereas 82% (n=128) reported they participated in PA more than 12 days per month. Sixty-six percent (n=104) reported they participated in sports in high school, whereas 34% (n= 53) reported they did not participate in high school sports.¹¹ Fort and colleagues were able to conclude individuals who participate in PA during school-age years are more likely to continue this practice later in life.¹¹ The study also revealed participation in high school sports programs (past physical activity) affected BMD in women when they were in college.¹¹ Ulrich et al. conducted an in depth study similar to Ford and colleagues with a group of

25 women aged 28-50yrs. Lifetime history of physical activity was obtained by a structured interview, and estimates of lifetime weight-bearing exercise, total exercise, total weight-bearing PA (including occupational and household activities), and perceived PA were computed.² The interview consisted of questions about regular exercise during five age period: childhood (age 6-12), teens (age 13-19), early adulthood (age 20-39), mid-adulthood (over age 40), and the past 2 years specifically.² The averages of the scores were then put into a formula. Ulrich et al. found that measures of lifetime PA were highly correlated. All correlation coefficients between lifetime weight-bearing exercise, total exercise, and total weight-bearing PA were greater than $r = 0.80$. Weaker correlations were observed between perceived PA and other lifetime activity variables.² Results also indicated the level of lifetime weight-bearing exercise may be a stronger predictor of total and peripheral BMD than levels of total exercise, a measure that includes nonweight-bearing exercise.² How often PA is or has been performed, as well as, the amount of time the activity is performed has an apparent effect on BMD. It is also apparent that any amount of PA is superior over a sedentary lifestyle. Other than frequency and time, the type of exercise also contributes to how, or what degree, BMD is affected. As previously mentioned, Torstveit and Sundgot-Borgen compared the BMD of an athletic population and a non-athletic population. They found low BMD is two to three times more common in non-athletic women than elite athletes.⁹ Their study design was rather unique, though, and by including 46 different sports/events they were able to distinguish which activities were found to have the greatest influence on BMD and therefore draw further conclusions from those results. After the 46 represented

activities were determined, researchers divided the athletes into three groups based on the degree of mechanical loading in their sport: low impact (LI), medium impact (MI), and high impact (HI) sports.⁹ After various statistical analysis were run (two sample t test and χ^2 test) comparisons between athletes and controls, between HI, MI, and LI sports could be achieved.⁹ Results showed athletes who competed in HI sports have higher BMD in all measurement sites, and similarly athletes competing in MI sports generally had greater BMD than athletes competing in LI sports.⁹ Furthermore, athletes competing in MI and HI sports had higher BMD than controls in all measurement areas except the lumbar spine and the MI sport group, and LI sport athletes had higher femur trochanter and Ward's triangle BMD than controls.⁹ The HI category, sports included tennis, and soccer, while sports like swimming were categorized as LI. Silva and colleagues (2011) conducted a study and utilized these exact sports and observed BMD among a group of athletes who were active competitors. Their objective was to investigate the impact of different sports on totally and regional BMD in male Brazilian adolescent athletes.¹² Forty-six adolescents aged 10-18yrs participated in the study: 12 swimmers, 10 tennis players, 10 soccer players, and 14 sedentary individuals.¹² Athletes were asked to complete a series of questions specifically designed for the study. These athletes engaged in physical activity for more than 10 hours per week in the previous 6 months.¹² BMD was determined using a DEXA scan. The difference in skeletal loading among the three chosen sports served as the primary factor regarding selection of the sports for the study.¹² Swimming represented a non-weight-bearing sport without a direct loading impact to skeletal structures, while tennis and soccer expose the skeleton

to intermittent loads, repetitive and prolonged impact, and ground reaction force.¹² As expected, results suggested total and regional BMD were higher in athlete groups than the control groups, which reinforce reported results within previous literature, although significant differences were only observed for BMD from the proximal femur region with higher mean values in the soccer and tennis groups than in the swimmers and control groups.¹² Lumbar spinal BMD values in groups were lower than proximal femur and total body values, with significant differences in proximal femur region bone mineral densities favoring tennis and soccer players over swimmers and controls.¹² Silva and colleagues were able to conclude adolescent athletes involved in sports that support body weight, such as tennis and soccer demonstrate a local osteogenic effect in the proximal femur region compared with swimmers and sedentary adolescents.¹² Torstveit and Sundgot-Borgen were able to classify a multitude of sports and physical activities into three groups based on the degree of mechanical loading the sport demonstrated. These groups included high impact sports, medium impact sports, and low impact sports. High impact sports include those that apply a direct loading impact to skeletal structures and are repetitive and prolonged with ground reactive forces.¹² These activities are often referred to as weight-bearing activities.

High Impact Physical Activity and Bone Mineral Density

Athletes, especially those undertaking strength training and/or high impact activities, have approximately 10% greater BMD than non-athletes⁹. High impact activities, defined as application of forces, at 4-8 times the body weight have been

shown to be effective in increasing bone mass.¹³ Types of activities that are considered high impact have the potential to reach 3-22% higher BMD measurements when compared with medium impact and low impact activities.⁹ The American College of Sports Medicine recommends weight-bearing endurance activities 3-5 times per week and resistance exercise 2-3 times per week to preserve bone health during adulthood.¹⁴ According to Torstveit and Sundgot-Borgen's classification of sports, walking is considered a medium impact sport, most likely due to the repetitive loading and ground reactive force the motion of walking promotes. Kato et al. examined the difference in metacarpal BMD associated with the duration of walking and participation in habitual exercise in order to assess the benefits of walking for the prevention of bone loss in Japanese women.¹⁵ Subjects included 1873 healthy women, aged 18-72 years and classified them into pre, early post, and late post-menopausal phases. DEXA scans were used to assess BMD. The questionnaire on lifestyle factors included habitual exercise and daily walking time.¹⁵ The profile of habitual physical exercise included the type, frequency per week, and length of time per day spent in sports or fitness activities exclusive of household chores.¹⁵ The questionnaire probed for the duration of daily walking time outside the home (average time per day), which included such activities as shopping, dining out, and walking around the neighborhood.¹⁵ To consider the factors of aging and physical characteristics, the BMD of all subjects was adjusted for age and height using a multiple non-linear model based on the data for premenopausal women.¹⁵ For all three classes of subjects, results for anthropometric characteristics, walking time, BMD and adjusted BMD (BMD_{adj}) were assessed. BMD_{adj} of premenopausal women

was significantly higher than that of early and late-postmenopausal women, with no significant difference in BMD_{adj} between the early and late-postmenopausal women.¹⁵ In premenopausal women, they found a significant effect on BMD_{adj} due to walking duration, but not to habitual exercise. There was no interaction between walking duration and habitual exercise, but when a post hoc test was run there was an indication that BMD_{adj} in long- and medium-duration walking groups was significantly greater than that in the short-duration walking group, whereas results in late-postmenopausal women suggested that BMD_{adj} in the long-duration walking group was significantly higher than for those in the short-duration walking group.¹⁵ Kato and his colleagues main finding was that significant differences in adjusted BMD in all menopausal phases were due to the duration of walking time irrespective of habitual exercise.¹⁵ This result suggests long daily walks have the potential to minimize the amount of BMD loss in Japanese women.¹⁵ A widely accepted rationale for the positive effects of exercise on bone is the attendant mechanical strain is a crucial signal for the maintenance of bone formation.^{16 17} Walking seems to support this rationale. Resistance training is classified as a high impact activity by Torstveit and Sundgot-Borgen and is one of the most commonly prescribed forms of exercise.⁵ Studies previously conducted have shown loads at the hip and spine of the squat and deadlift exercises to reach 5-8 times body weight^{18 19}, thus supporting a critical level of force exposure that would support the efficacy of resistance training in optimizing bone health.⁵ Almstedt et al. gathered 12 recreationally active men and 12 recreationally active women all between the ages of 18 and 23 to perform 24 weeks of resistance

training three days a week at periodized intensities varying between 67 and 95% of 1 repetition maximal effort (1RM) on the multijoint exercises of bench press, squats, and deadlifts and 67-80% of 1RM for 7 additional upper and lower body assistance exercises.⁵ DEXA scans were used to assess BMD of the spine and hip and changes from baseline were evaluated for possible influence on the dependent variables (change in BMD) at the various bone sites.⁵ Results suggested men had a more favorable bone response than women. Male subjects had an increase in BMD between 2.7 and 7.7% whereas percent change in women subjects ranged from -0.8 to 1.5%, depending on the bone site.⁵ Possible explanations for the lack of improvement in BMD observed in the female exercisers included hormonal differences, baseline strength, and dietary intake.⁵ Hormonal differences may be responsible for the differential sex responses.⁵ Another explanation given as to why improvements were seen in the male subject group rather than the female group is perhaps the male study recruits had greater relative strength at baseline and therefore were able to create greater strain on the bone inducing a more substantial increase in BMD in the 24 week intervention period.⁵ Rector and associates also examined resistance training, but included running and cycling as well. The purpose of their study was to determine the effects of long-term running, cycling, and resistance training on whole-body and regional BMD.¹⁴ Only men were included and were between the ages of 19-45yrs. DEXA scans were used to assess BMD for whole-body and regional areas, as well as body composition. Subjects included 19 cyclists, 10 runners, and 13 resistance trained men. Bone turnover was monitored by obtaining blood in the early morning (6-9am) after an overnight fast via an antecubital

vein by a trained phlebotomist.¹⁴ Markers of bone formation measured included bone alkaline phosphatase and osteocalcin, which are secreted by osteoblasts during bone formation by Enzyme Linked Immunoabsorbent Assay (ELISA) kits.¹⁴ Bone loading history was achieved by subjects completing a medical history questionnaire developed to measure historical leisure-time physical activity across the lifespan and to relate prior activity to bone density.¹⁴ Results suggested the resistance trained athletes had significantly greater body weight, lean body mass and fat mass than cyclists and runners. Unadjusted BMD at all sites was significantly greater in the resistance trained athletes compared with the cyclists and runners. After adjusting for lean body mass, runners had significantly greater spine BMD than cyclists. Researchers were able to conclude the subjects' lean body mass was a significant predictor of BMD in resistance trained athletes and cyclists but not in runners, further suggesting high-impact activity may override the benefits of lean body mass on BMD.¹⁴ Subjects current bone loading was positively associated with serum osteocalcin concentrations. Results demonstrated long-term running and resistance training increase BMD compared with cycling, however, high-impact activities such as running have a greater positive effect on BMD than resistance training according to Rector et al and this particular work.¹⁴ Rector and colleagues work can benefit those who compete or take part in a variety of sports and physical activities. McClanahan et al. (2002) conducted similar work targeting a special group of triathletes. They are known to have rigorous training regimens accompanied by a high volume and high intensity work load. Although there is cogent evidence that moderate exercise can increase bone mineral, there is also evidence that high volumes

of exercise can have deleterious effects on bone.²⁰ A study of elite collegiate basketball players found a 3.3% decrease in BMD over 4 months relating to high activity possibly inducing negative bone turnover which effected BMD changes.²¹ Due to triathlete's intense and demanding training schedule, they are at risk for developing detriments to bone associated with high levels of physical activity. McClanahan and colleagues wished to determine if triathletes who engage in relatively high volumes of all three activities were at risk for bone mineral density loss during training.²⁰ They tested 21 competitive triathletes (9 men, 12 women) at the beginning of the training season and then again 24 weeks later. BMD was assessed for the total body, arms and legs using DEXA scans. Participants were also asked to complete diet records for 7 days during the week before the second and third laboratory visits, which occurred at weeks 12 and 24 of the study.

²⁰ Researchers were able to conclude men had greater BMD at all sites than women and there were no significant changes over the 24 weeks for either total body or leg BMD.²⁰ BMD in both arms increased by approximated 2% in men, but no change was observed for women.²⁰ Change in BMD at all sites were unrelated to age, body mass index, calcium intake and training volume. The results suggested adverse changes in bone mineral density do not occur over the course of 6 months of training in competitive triathletes.²⁰ McClanahan and colleagues results could be interpreted in a number of ways. They did not see any changes in BMD over 6 months, and rather saw maintenance of current BMD. This could be due to the fact athletes were continuing their normal regimens. These athletes were active for several years, and because of this their skeletal systems may have become acclimated to exercise training such that skeletal changes

would only be manifested if significant training alterations were imposed.²⁰ They did see a slight increase in BMD of the arms. Typically, the greatest bone mineral changes occur in the regions affected by the particular type of exercise,²² but without having knowledge of their specific training protocols it would have been impossible to understand the reasoning behind the observed increase in BMD of the arms in these athletes. So, given previous evidence that highly competitive athletes may be at risk for training-related BMD loss, McClanahan and colleagues found encouraging results suggesting no negative bone effects.²⁰ Cardio kickboxing is a cardiovascular workout through the use of aerobics, Tae Kwon Do, and boxing usually put to music. Thus far, research has failed to include this specific type of exercise within any research relating to BMD. Although, it has explored some exercises that are very closely related to actions and movements seen within cardio kickboxing. Zribi and associates used plyometric training to attempt to observe changes in BMD over 9 weeks. Plyometric training can be closely related to cardio kickboxing because of its cardiovascular nature by utilizing various movement seen within aerobics, and Tae Kwon Do. The aim of their study was to examine the effects of plyometric training in early pubertal male basketball players on both aBMD, bone metabolic makers, and physical fitness.²³ Subjects included 51 participants in two; a control group (n= 26) and a plyometric group (n=25). All participants belonged to the same basketball team and practiced twice weekly, and played a match weekly for at least two years.²³ Before the plyometric training program, all participants were engaged in a 4-week training program designed to prevent injuries. The testing procedure was performed in two testing periods, including two

familiarization sessions before the experiment.²³ They were also asked to complete a questionnaire including parental information, child's use of mineral supplement, and background information including history of bone disease, medication use, and bone fractures.²³ The plyometric training was designed to load the lower-body musculoskeletal system.²³ The control group completed regular practice while the plyometric group was instructed to jump from boxes and over hurdles. The two major findings within this study were early pubertal basketball players who participated in additional biweekly lower-body plyometric training program for 9 weeks increased their whole body bone mineral content and biomarker osteocalcin.²³ Percentage increases of physical fitness were positively correlated with those of osteocalcin.²³ Cardio kickboxing includes various movements associated with plyometrics used by Zribi et al. (2014). If significant results were seen regarding BMD and plyometric training, similar results may be seen in a cardio kickboxing class.²³ Although multitudes of studies have found significant data relating high impact PA to BMD, others have found significance in low impact PA as well. Swimming is a low impact PA, a non-weight bearing activity may also improve BMD according to Swissa-Svan et al. (1990)²⁴ Orwoll and Huntington²⁵ reported an increase in BMD at the lumbar spine and radial sites for male swimmers but not for female swimmers.²⁴ However, Rourke et al. indicated female swimmers have higher BMD than those who do not participate in any exercise.²⁴ Low impact physical activity can provide benefits of bone health, perhaps just at a lower caliber than high impact physical activity.

Low Impact Physical Activity and Bone Mineral Density

Yoga should be considered a low impact PA. Yoga is gaining popularity both as a form of exercise, and a therapy for health maintenance²⁶ yet research is still lacking on this exercise. There are many different forms, or styles, of yoga. Some emphasize the static alignment of posture, and the use of yoga props such as belts and blocks, while others concentrate on incorporating repetitive movements in and out of the yoga postures.²⁶ Lesley Ward states these types of props enable the yoga postures to be adapted to non-weight bearing positions.²⁶ She also holds the opinion yoga is a safe practice in many clinical settings and the physical, breathing, and relaxation techniques of yoga offer a range of benefits for numerous special populations and healthy populations as well.²⁶ Currently, research regarding yoga and its effects on physical fitness have been focused on its utilization within special populations, mostly, those suffering from a chronic disease. Ironically, those suffering from Osteoporosis, a bone mineral density defect, have yet to use yoga as a treatment. This is most likely due to the fact yoga is a low impact PA. Yoga has been used to study its effects on conditions varying from Restless Legs Syndrome (RLS), weight control, chronic neck pain and chronic pain in general. It was used as an intervention to increase flexibility and its corresponding effects on heart rate. Yoga was also used to determine quality of life and cognition. RLS is a common and highly burdensome sleep disorder characterized by a compelling urge to move the legs that is usually accompanied by unpleasant, often painful sensation in the legs, begins or worsens during periods of inactivity, is more

pronounced during the evening, and is at least partially relieved by movement.²⁷ Innes et al. took 10 women aged 32-66yrs and invited them to participate in the study. The women attended an average of 13.4 ± 0.5 classes, and completed a mean of 4.1 ± 0.3 (of 5 possible) homework sessions/week.²⁷ At follow-up, participants demonstrated striking reductions in RLS symptoms and symptom severity, with symptoms decreasing to minimal/mild in all but 1 woman and no participant scoring in the severe range by week 8 (commencement of intervention).²⁷ The International RLS Scale (IRLS) scores declined significantly with increasing minutes of homework practice per session ($r = 0.70$, $p = 0.025$) and total homework minutes ($r = 0.64$, $p < 0.05$), suggesting a possible dose-response relation.²⁷ Yoga programs have been found to be effective in promoting weight loss and/or improvements in body composition.²⁸ Rioux and Ritenbaugh reviewed studies to determine their key features, with each worth a specified number of points, with a maximum total of 20 points.²⁸ The features included a study's duration, frequency of yoga practice, intensity of (length of), each practice, number of yogic elements, inclusion of dietary modification, inclusion of a residential component, the number of weight-related outcome measures, and a discussion of the details of yogic elements.²⁸ Overall, Rioux and Ritenbaugh found extensive evidence yoga programs are frequently effective in promoting weight loss and/or improvements in body composition.²⁸ They found the effectiveness of yoga for weight loss was related to key features such as: an increased frequency of practice, a longer intervention duration, a yogic dietary component, a residential component, the comprehensive inclusion of yogic components, and a home-practice component.²⁸ Cramer et al. assessed a 9 week

yoga intervention on 18 subjects with chronic nonspecific neck pain.²⁹ Each yoga session the participants attended was 90 minutes. The objective of the study was to investigate the perceived influence of yoga on body perception and psychosocial aspects of life for patients with chronic neck pain.²⁹ Therefore, interviews were conducted so participants could complete a drawing of their neck and shoulder regions to reflect their subjective body perceptions before and after their yoga programs.²⁹ Semistandardized interviews were used to explore their body perception, emotional status, everyday life and coping skills, as well as any perceived changes in these dimensions post-participation.²⁹ The yoga program consisted of standing, sitting, and supine postures, starting with simple postures and moving to more complex ones.²⁹ The props included belts, blocks, and blankets in order to improve safety and alignment.²⁹ The body drawings were completed pre and post yoga classes. Results showed participants reported change on five dimensions of human experience: physical, cognitive, emotional, behavioral, and social.²⁹ Participants cited renewed body awareness and increased perceived control over their health, as well as being emotionally effected by noting greater acceptance socially, and renewed participation in an active life.²⁹ Yoga has also been used within a pediatric population, but very scarcely. A moving case study was reported by Evans and colleagues in 2013. It told the story of a 14yr old female with chronic pain. She was entered into a pediatric pain program (PPP) with a history of gastroesophageal reflux disease (GERD), which required two surgeries, resulting in chest and abdominal pain.³⁰ She could not eat properly due to this pain resulting in severe weight loss, she was depressed and anxious, and could not walk, so

used a wheelchair as her primary form of mobility.³⁰ She was prescribed a yoga intervention involving 1-hour classes she attended twice per week for the first month, three times per week for the second month, and twice per week for the last two months.³⁰ The type of yoga used targets her individual health concerns and was designed to develop strength, elevate mood, and ease symptoms by extending the abdomen and increasing tolerance for abdominal sensations.³⁰ The type of yoga used was called Iyengar yoga and is very common, and known for its use of props and static alignment of postures.²⁶ By the end of her yoga treatment plan the young girl was able to walk, sleep through the night, had more energy during the day, and returned to her normal weight. She reported her esophageal and abdominal pain had resolved completely and her eating patterns returned to normal, with no vomiting or food aversion.³⁰ Her mood also improved and she reported feeling more content and less anxious.³⁰

Yoga has also been used within a senior population in attempt to achieve similar outcomes as this case study regarding quality of life, as well as, cognition. Oken et al. enlisted 35 generally healthy men and women aged 65-85yrs and randomized them to 6 months of Hatha yoga class, walking exercise class, or wait-list control. While the subjects were assigned to classes, they were still encouraged to practice at home. Hatha yoga is described as assuming a series of stationary positions that use isometric contraction and relaxation of different muscle groups to create specific body alignments, along with a deep relaxation component.³¹ In recent US surveys of adults, 7.5% reported having used yoga at least once in their lifetime and 3.8%-5.1% reported

having used it in the previous 12 months.^{32 33} The interventions for the yoga class were as followed: 90 minutes in duration consisting of 18 poses taught throughout the 6 months averaging 7-8 poses taught each week. Repetition was consistent from week to week and linked pose to pose.³¹ Each pose was held for approximately 20-30 seconds, with rest periods between poses lasting 30 seconds to 1 minute with a mixture of standing and seated poses introduced and practiced.³¹ Each class ended with a 10-minute deep relaxation period with the subject lying supine.³¹ The walking group attended 1 class per week, an hour long, along with home exercise. The class consisted of walking on an outdoor 400-meter track for endurance training beginning with walking 2 laps to warm up and then progressed to mild leg stretches.³¹ Intensity of exercise was determined by heart rate and a scale to assess Rate of Perceived Exertion (RPE). Subjects wore a heart rate monitor, and target heart rate was initially estimated as 70% of maximum based on morning resting heart rate and age.³¹ Subjects were instructed to exercise at a level of 6-7 on the RPE scale. After initial assessments were taken subjects underwent attention and alertness tests, mood, fatigue, and quality of life tests, and physical measures. Attention and alertness were measured using The Stroop Color and Word Test and a quantitative electroencephalogram (EEG).³¹ Cognitive assessment focused on aspects of attention (focusing attention, shifting attention, dividing attention, and sustaining attention) that may be altered with aging and were thought to be most likely to be improved with the intervention.³¹ In case there were effects of the intervention on alertness and attention, other cognitive tasks were performed to determine the specificity of the effect including a 10-word list learning task and the

Wechsler Adult Intelligence Scale III (WAIS-III) Letter-Number Sequencing to assess working memory.³¹ Two subject scales were used to measure alertness, the Stanford Sleepiness Scale (SSS) and the Profile of Mood States (POMS).³¹ Mood, fatigue, and quality of life were assessed using the Multidimensional Fatigue Inventory (MFI), POMS, State-Trait Anxiety Inventory (STAI) forms were filled out by the subjects at home and reviewed by the research assistant at the time of the cognitive testing to help minimize duration of the assessment session.³¹ Physical measures consisted of flexibility, static leg stands with eyes open, and stand to sit timed measurements. Results weighed heavily with the yoga intervention group. The yoga group members rated themselves significantly better than the exercise group or the wait-list control group on several measures including: quality-of-life measures demonstrating effects on vitality/energy and fatigue ($P=.006$), role-physical ($P=.001$), bodily pain ($P=.006$), social functioning ($P=.015$), and the physical composite scale ($P=.005$).³¹ The yoga group's physical improvements included timed one-legged standing ($P<.05$) and seated forward bending ($P<.05$).³¹ Regarding physicality, yoga does provide other various improvements including those in flexibility and heart rate.

McCarthy et al. evaluated 32 participants assigned to either a training (N=14) group or a control (N=18) group, where the training group completed four weeks of Wii™ flexibility training, for three sessions per week.³⁴ The Wii™ training was closely related to yoga training and was designed to mimic traditional yoga style PA. Participants would complete yoga PA and with success at easier activities be able to unlock new yoga activities within the Wii™ program. During each training session four

yoga activities were completed, although these activities evolved from session to session.³⁴ A heart rate monitor was worn around the subject's trunk and provided measures at 0, 10, and 20 minutes respectively during each training session.³⁴ For evaluation purposes, subjects were asked to perform two flexibility tests, the sit and reach, and the shoulder or reach behind test.³⁴ Data collection occurred over a period of four weeks, for three twenty minute sessions a week per subject.³⁴ Results suggested the control group's performance remained consistent from pre- to post-test with measures of -1.86 cm (pre) (SD= 9.47) and -2.19 cm (post) (SD=10.59).³⁴ In contrast, the training group improved their pre-training shoulder flexibility (upper body flexibility) scores from -5.82 cm (SD= 13.22) to a post-training mean of -2.74 cm (SD= 12.13). Sit and reach test (lower body flexibility) demonstrated similar results showing yet again the control group's scores being consistent between pre- and post-training times (pre mean= 20.58 cm, SD 9.67; post mean = 21.72 cm. SD= 12.77), while the training group demonstrated improved hamstring flexibility (pre-mean= 24.38 cm, SD= 11.18; post-mean= 31.07 cm, SD= 8.14).³⁴ Heart rate was measured at time 0, the start of each training session, again at the 10-minutes mark, and finally at the end of the 20-minutes training session.³⁴ Based on the three measurement times, there was a statistically significant increase in heart rate as physical activity duration increased, therefore suggesting only slight cardiovascular health benefits, but suggesting a considerable amount of benefits to flexibility.³⁴

Yoga has a positive impact of various health and physical fitness components. BMD, though, has yet to be mentioned. Small amounts of data were produced on yoga

as an exercise and even smaller amounts relating yoga's possible effects on BMD. Yoga possesses a variety of movements, positions, and uses of props. Many exercises are closely related to yoga, without being deemed the practice of yoga. One exercise closely related to yoga that did take BMD measurements into account was Swiss ball stabilization exercises. Yoon, Lee, and Kim looked at this exercise and related it to BMD in patients with chronic low back pain. They carried out a 16-week treatment of lumbar stabilization exercise with a ball targeting patients with chronic low back pain and investigated its effect on low back pain and BMD.³⁵ The 36 patients were divided into three groups consisting of a conservative treatment group (n=12), a floor exercise group (n=12), and a ball exercise group (n=12). Their degrees of pain were assessed using a visual analogue scale (VAS).³⁵ In the conservative group interference current and deep-heat treatment were carried out for 20, 15, and 5 minutes respectively 3 times per week for 16 weeks.³⁵ The floor exercise group performed lumbar stabilization exercise on a fixed floor, maintaining 10 seconds of equilibrium, with 3-second breaks between repetitions for 40 minutes a day, 3 times per week for 16 weeks.³⁵ The ball exercise group received the conservative treatment and performed lumbar stabilization exercise on a ball, maintaining equilibrium for 10 seconds, with a 3-second break between repetitions for 40 minutes a day, 3 times per week for 16 weeks.³⁵ A quantitative evaluation of pain and BMD of lumbar vertebrae 1 to 4 was performed before the experiment, 8 weeks after the experiment, and after completion of the 16 weeks of the experiment, and 30 minutes of rest was given to the patients after exercise to minimize fatigue.³⁵ Results suggested significant findings in VAS scores based on intervention

period as well as the interaction based on the intervention period and intervention method.³⁵ There was a statistically significant difference between before intervention and after 16 weeks and between after 8 weeks and after 16 weeks. ³⁵ Comparison of the effect between each subject in regard to the 3 different groups showed there were statistically significant differences as well.³⁵ There were also statistically significant differences in regard to the BMD based on the intervention period for each lumbar vertebra as well as differences in regard to the interaction based on the intervention period and method.³⁵

There were differences between before and intervention and 16 weeks after the intervention and between 8 weeks and 16 weeks after the intervention in regard to lumbar vertebrae.³⁵ Therefore researches were able to conclude patient's evaluation of pain dropped significantly as well as VAS scores were throughout the intervention period in the floor and ball exercise groups when compared to the conservative group. Although there was no significant difference among groups for the BMD, it was increased in the floor and ball exercise groups, while it was decreased in the conservative group.³⁵ T'ai Chi is also a form of exercise very closely related to Yoga. T'ai Chi too promotes muscle strength, balance, coordination, flexibility, pain relief and possible bone health by shifting ones weight through various stances comprised of static or dynamic movements and controlled breathing. Song and colleagues created a study to determine the effect of a 6 month trial of t'ai chi on bone mineral density, as well as knee muscle strength and fear of falling in older women previously diagnosed with osteoarthritis. Sixty-five women were included, split into two groups consisting of a t'ai

chi group, mean age of 63yrs (n=30) or a control group, mean age of 61yrs (n= 35). The t'ai chi group developed protocol following these principles: 1) bending knees with a higher stance, 2) keeping both arms lower than the shoulder, 3) moving forward and backward with following steps, and 4) turning the body with smaller steps.³⁶ There was 10 minutes of warm-up exercises from the joint of the neck to the ankles, 40-50 minutes of t'ai chi, and 5-10 minutes of cooling-down exercise involving stretching and arm and leg muscles and a breathing exercise.³⁷ BMD of the left proximal femur was measured via DEXA scan for the back, Ward's triangle, and trochanter.³⁷ Results on BMD showed change over the 6-month study period significantly higher in the t'ai chi group than in the control group in the femoral neck, Ward's triangle, and trochanter. Over the 6-month study period, T scores improved by 2% in the Ward's triangle, 6% in the femoral neck, and 8% in the trochanter in the t'ai chi group while the control group showed slightly decreased T scores in all areas.³⁷

Biochemical Marker Associated with Bone Formation: Osteocalcin

Bone formation markers are direct or indirect products of osteoblast activity expressed during different phases of osteoblast differentiation and extracellular matrix deposition and maturation³⁸, and measured in serum or plasma. By consensus, BMD is usually measured to estimate bone health.³⁹ Although BMD measurements provide a static representation of bone mineral status, they cannot be used to evaluate the slight

bone metabolic changes induced by physical exercise.⁴⁰ Biochemical markers, though, can be used to assess dynamic changes in bone turnover and appear to be sensitive enough to determine the bone response to a given exercise.⁴⁰ Osteocalcin (OC) is synthesized from osteoblasts and is a protein. Osteocalcin also reflects bone growth. Although OC is secreted by these osteoblasts, it does not necessarily reflect the bone-forming activity of the cells, but there is good evidence that OC plays an important role in energy metabolism.³⁸ Because of OC having a relationship to energy metabolism, if OC content does change while the body is exposed to certain types of PA, this means the change in OC may be an outcome of the increased energy requirements from the particular activity.

Many studies have included biomarker utilization within their data collection to explore bone mineral density and bone sensitivity to specific types of exercise. It is a common practice when observing bone health and PA, along with DEXA scans. Maïmoun et al. sought to observe BMD by testing for OC by taking 38 male athletes aged 18-39yrs, including cyclists (n=11), swimmers (n=13), and triathletes (n=14). Researchers sought to determine the effect on bone remodeling of physical activities that induce moderate external loading on the skeleton by observing specific effects on bone metabolism.⁴¹ Measurement of bone mineral density was done by DEXA scan and bone turnover assessments from OC were done through the use of immunoradiometry assay kits (ELISA kits). DEXA sites included a total body measurement, the antero-posterior lumbar spine, and the proximal part of the left femur at specific sites of the femoral neck and the trochanteric and intertrochanteric areas.⁴¹ The investigations were performed

during the competitive season, after a training period of at least 5 months, and after 48 hours of rest.⁴¹ Results suggested compared with controls, the triathletes had greater BMD at the total proximal femur (+10.3%), femoral neck (+12.5%), trochanter (+13.1%) and lower limb (+6.6%) with no differences found among the three groups.⁴¹ Biochemical activity was found to be significantly lower in the cyclists than in other groups, but no significant differences in this marker between triathletes, swimmers, and controls.⁴¹ Maïmoun et al. were able to conclude an osteogenic effect was found only in triathletes, mainly at bone sites under high mechanical stress, which is in agreement with previous literature. PA such as swimming and cycling are not known to noticeably influence BMD due to the fact that these activities do not provide significant bone loading mechanisms. Triathletes, however, comprised of swimming, running, and cycling are a combination of these two types of exercises including running, which is characterized as an activity eliciting a greater loading mechanism due to external loading. This may be why the triathlete group saw greater responses of biochemical markers, as well as BMD at tested sites. Triathlete's inclusion of running as a PA regimen would be considered a high impact and weight bearing activity, more prone to contribute to bone health. This may explain why Maïmoun et al. saw elevated regional BMD and biomarker activity in this group. Although this group of researchers saw results within a population exposed to high and low impact activities (triathletes), others saw increases in biochemical markers in strictly low impact physical activities.

Shen and colleagues explored Tai Chi to compare the effects of this type of exercise and resistance training on bone metabolism in the elderly. Biomarkers were

used to partially assess bone metabolism along with various other indicators of bone health including pyridinoline, parathyroid hormone, calcium, and urinary calcium. Shen et al. included 28 adults and randomized them into either a Tai Chi group or a resistance group, which served as the control group. The intervention period was carried out for 24 weeks. Shen et al. did collect samples for bone health assessment at four different periods throughout the 24 weeks, including: baseline, 6, 12, and 24 (post) in order to track the earliest signs of activity. The exercise intervention in both the resistance group and the Tai Chi group required subjects to attend three 40-minute exercise sessions per week for 24 weeks.⁴² Each session consisted of 5 minutes of warm-up exercise, 30 minutes of exercise (resistance or Tai Chi), and 5 minutes of cool-down exercise. Researchers deemed this regimen appropriate to evaluate bone turnover response to low-intensity exercise by addressing previously completed work within the same research area.⁴² Researchers were able to conclude similar changes in osteogenic response in both exercise groups indicating the Tai Chi group induces a response similar to the resistance training even though it is deemed a low intensity low impact activity.⁴² After just 6 weeks of intervention, both exercise groups demonstrated higher bone formation rates indicated by an increase of biomarker activity, while the Tai Chi group exhibited a significantly greater increase than the resistance group.⁴² Bone biomarkers provide useful information concerning bone turnover, particularly in short-term interventions where the time may be too short for BMD to manifest any significant change.⁴²

CHAPTER 3

METHODOLOGY

Participant Characteristics

Zribi et al. (2014) provided data for the pre to post difference in the biomarker osteocalcin upon completion of yoga or cardio kickboxing (CKB) classes. Utilization of this data revealed a calculated effect size of 0.60. Using an alpha level of 0.05, and beta level of 0.80, a power analysis revealed that a total of at least 36 total subjects divided among three groups will be sufficient to detect significance. A conservative approach was taken, and 14 subjects from the yoga PEX class, 14 subjects from the CKB PEX class and 12 control subjects were recruited. All subjects were considered healthy, recreationally trained, and fell within the age range of 18-34 years old. See Table 1. There were no between-group differences for height ($p = .596$), weight ($p = .196$), percent body fat ($p = .224$), or lean body mass ($p = .183$).

Pre			
Characteristic	Cardio Kickboxing (n= 14)	Yoga (n= 14)	Control (n= 12)
Age (y)	21.1 ± 1.8	22.7 ± 3.6	21.8 ± 2.1
Height (cm)	163.3 ± 7.9	161.8 ± 5.6	164.6 ± 7.62
Weight (kg))	71.6 ± 19.4	60.5 ± 13.6	65.9 ± 11.1
Body Fat (%)	40.1 ± 6.0	34.9 ± 9.3	35.1 ± 9.9
Lean Body Mass (kg)	39.9 ± 6.5	36.5 ± 4.9	40.2 ± 4.9

Table 1. Baseline Descriptive Characteristics

Recruitment Process

Subjects were recruited through a presentation process. On the day of recruitment the lead researcher visited the targeted PEX courses with predetermined permission from the course instructors. Information on the study was presented in front of classes in an understandable manner. Information was presented from a dialogue developed prior to presentation and did not vary from class to class. Presentation information included components such as: a greeting, thesis description, measurement procedures, time commitment, risk, benefits, and a brief conclusion with closing remarks. After the presentation was given the subjects were informed that researchers will be available after their class to sign up as subjects, or talk about any questions or concerns they have regarding any study requirements. Class members were also supplied with the researchers contact name and a card defining key points of the

presentation. If subjects were interested they were encouraged to reach the head researcher via email to set up their initial visit to obtain pre-measurements. After their class was over a researcher was waiting outside to answer questions. When subjects emailed the head researcher they provided their first name, last name, and offered up potential dates and times that were cooperative with their schedule and the researcher's schedule. Subjects were excluded if they were out of the age range, male, pregnant, or not enrolled in the yoga or CKB PEX class.

Collection of Data

Prior to the visit, participants were advised to wear appropriate athletic attire containing no metal components, be adequately hydrated, consume no alcohol 24 hours prior to testing, and to refrain from vigorous exercise at least 6 hours prior to testing.

When subjects arrived at the Exercise Physiology Laboratory they were briefed on the purpose, requirements, procedures, risks, and benefits of participating in the study. Participants were then asked to sign an informed consent approved by the UNLV International Review Board (1407-4880), as well as, complete dietary history questionnaires, and bone mineral density questionnaires. The Lunar Prodigy DEXA machine was calibrated each day before use. Advised, not enforced, participant guidelines for the DEXA were: maintaining normal hydration status and normal diet (i.e. no fasting is required), removal of all body jewelry, voiding the bowels, and emptying

the bladder. These actions were recommended in order to achieve the most accurate results. Participants entered the laboratory and height and weight measurements were obtained. Subjects then were position on the DEXA mat with their knees and ankles bound to prevent unnecessary movement. A total body scan, hip scan, and spine scan was performed. Upon completion of the test participants received a copy of the printout from the DEXA software of their scans, a copy of their informed consent, and their DEXA scan prescription signed by a licensed nurse practitioner. Body composition (% body fat) was recorded and used as additional information for analysis as well as useful take-home information for the subject.

Exercise Protocol Cardio Kickboxing

Subjects within the CKB group were asked to attend each class required by their instructors. Attendance was accounted for and used for analysis. Classes were held 2 days per week for 50 minutes. Cardio kickboxing is an active physical activity incorporating quick repetitive movements into its curriculum that require the individual to exert force onto an object. The typical class session varied as the semester progressed by continually adopting new and more complex movements. See Table 2.

Exercise Protocol Yoga

Subjects within the yoga group were asked to attend each class required by their instructors. Attendance was accounted for and used for analysis. Classes were held 2 days per week for 50 minutes. Yoga is a passive physical activity requiring the individual to shift their own body weight through sustained static poses while maintaining controlled breathing. The typical class session varied as the semester progressed by continually adopting new stances, positions, and techniques. See Table 3.

Blood Sample Collection

Prior to the DEXA scan subjects came to the Exercise Physiology laboratory to offer their first blood sample. After an informed consent was completed, a blood sample (600 micro liters) was taken from the subject via finger prick into one anticoagulant tube (Multivette 600 LH, Sarstedt, Fisher Scientific, Pittsburgh, PA). Before every blood draw the site was cleaned by an alcohol swab. The first sample was taken towards the beginning of the semester, and the final sample was taken upon class completion (within 10-12 weeks). Samples were labeled according to each participant's identification number and put in a sealed and labeled biohazard bag (primary container)

inside of a sealed and labeled biohazard cooler (secondary container). Blood samples were either be placed directly into the laboratory freezer and stored at (20-27 degrees C) or placed within an ice bath in accordance with the parameters described in the University of Nevada, Las Vegas Institutional Biosafety Manual (Section VIII, page 19). Blood samples were centrifuged directly after obtainment, split into two separate samples, and labeled. This was necessary because the assay required all samples to be run in duplicate. The personal protective equipment used by the research team was latex gloves, laboratory coats, and safety goggles. Any sharps and other biochemical materials were disposed of in a sealed sharps container and decontamination was conducted in accordance with the University of Nevada, Las Vegas Institutional Biosafety Manual (Section IX, page 23).

Blood Sample Analysis

Osteocalcin concentrations were analyzed using an enzyme-linked immunosorbent assay (ELISA) kit. Plasma samples were taken from the laboratory freezer and allowed to thaw to room temperature. ELISA plates and standard curves or whole kits were stored according to instructions from the distributor at -20°C. Reagents were provided by affymetrix eBioscience company along with: aluminum pouch with a microwell plate coated with monoclonal antibody (murine) to hOST and HRP-Conjuage (anti human osteocalcin monoclonal (murine) antibody) and sample diluent lyophilized,

aluminum pouches with a human osteocalcin standard curve (colored), bottle (25ml)
wash buffer concentrate 20x (phosphate-buffered saline with 1% Tween 20), vial (15ml)
substrate solution (tetramethyl-benzidine), vial (12 ml) sample diluent, vial (15 ml) stop
solution (1M phosphoric acid), and adhesive plate covers. Materials that were required
but not provided included: 5 ml and 10 ml graduated pipettes, 5 μ L to 1000 μ L adjustable
single channel micropipettes with disposable tips, 50 μ L to 300 μ L adjustable
multichannel micropipette with disposable tips, multichannel micropipette reservoir,
beakers, flasks, cylinders necessary for preparation of reagents, device for delivery of
wash solution, microwell strip reader capable of reading at 450 nm, glass-distilled or
deionized water, and statistical calculator with a program to perform linear regression
analysis. The number of microwell strips required to test 40 subjects in duplicate was
determined at two 96 well plates. Each sample, standard, blank were assayed in
duplicate. Distilled water (125 μ L) was added to all standard and blank wells. Samples
wells received 100 μ L of distilled water into the wells. 25 μ L of each sample was added,
in duplicate, to the designated wells and the contents were mixed. The plate was
covered and incubated at room temperature (18°C to 25°C) for 2 hours. After the
incubation period the plate cover was removed and the wells were emptied. The
microwell strips were washed 3 times with approximately 400 μ L of wash buffer per well
thorough aspiration of microwell contents between washes. After the last wash the
microwell strips were tapped on an absorbent pad to remove excess wash buffer. 100
 μ L of TMB substrate solution was added to all wells, including the blank wells and then
incubated for another 10 minutes at room temperature. Direct exposure to intense light

was avoided and color development on the plate was monitored. 100 μ L of stop solution was then added into each well. Absorbance of each microwell was read on a spectro-photometer using 450 nm as the primary wave length.

Statistical Analysis

Paired t-tests were used to analyze the data for any changes in bone mineral density or markers of bone formation that occurred during the semester as a result of participation in the PEX classes. Pearson Product Moment Correlation Coefficients will be used to correlate any relationships that are evident between class attendance and the measured dependent variables: total and regional BMD, and biochemical markers osteocalcin. The significance level was set at $\alpha = 0.05$. A 2x3 Factorial Analysis of Variance with repeated measures on time was used to analyze data for any changes between yoga, CKB, and control group's pre and post measurements. A one-way ANOVA was used to identify if there were any between-group differences for descriptive subject characteristics pre and post intervention, and paired t-tests were used again to observe any differences in post-test demographics within the three groups.

CHAPTER FOUR

RESULTS

Biochemical Marker Osteocalcin

Osteocalcin concentration increased significantly with 12 weeks of a yoga PEX class (pre = 1.14 ± 1.05 ng/mL, post = 3.4 ± 1.3 ng/mL, $p = .000$, see figure 1). Similarly osteocalcin concentrations increased significantly with 12 weeks of a cardio kickboxing (CKB) PEX class (pre = 1.39 ± 1.15 ng/mL, post = 4.17 ± 2.31 ng/mL, $p = .001$, see figure 1). When compared across all three yoga, CKB, and control groups, there was no significance ($p = .071$).

Figure 1. Pre-Post Osteocalcin Concentration Cardio Kickboxing and Yoga

Bone Mineral Density Via Dual Energy X-Ray Absorptiometry Scan

Pre and post measurements of bone mineral density (BMD) for the yoga group failed to be significant for total body ($p = .383$) and hip ($p = .305$) measurements. In fact, measurements at the spine for this particular exercise group revealed a significant decrease ($p = .009$) in bone mineral density. Similarly, BMD for the CKB group proved to be insignificant for total body ($p = .524$), hip ($p = .433$), and spine ($p = .062$) measurements. When compared across all three yoga, CKB, and control groups, there were no significance for the total body ($p = .845$) and spine ($p = .789$) measurements. Bone mineral density was observed to be increased at the hip ($p = .519$) in the yoga and CKB groups compared among both groups and controls, but failed to be statistically significant. Pre measurements began and ended higher in the CKB group than in the yoga and control groups, and yoga post measurements proved to be higher than controls when these two groups possessed relatively equal baseline measurements.

Percent Attendance

No significances were revealed by correlation for percent change in osteocalcin concentration ($r = 0.082$, $p = .780$), total body DEXA scan ($r = -0.365$, $p = .200$), spine DEXA scan ($r = -0.356$, $p = .212$), and hip DEXA scan ($r = -0.28$, $p = .333$) to percent attendance in the yoga group. Similarly, no significance was revealed for percent change in osteocalcin concentration ($r = -0.132$, $p = .652$), total body DEXA scan ($r = 0.354$, $p =$

.214), spine DEXA scan ($r = -0.36$, $p = .207$), and hip DEXA scan ($r = -0.331$, $p = .248$) to percent attendance in the CKB group. See figures in Appendix II.

Subject Characteristics

After the 12 week intervention period there were no between-group significant differences for post height ($p = .596$), weight ($p = .194$), percent body fat ($p = .224$), or lean body mass ($p = .457$). There were no significant pre-post differences within the cardio kickboxing group for weight ($p = .092$), percent body fat ($p = .318$), or lean body mass ($p = .407$), or the yoga group for weight ($p = .103$), percent body fat ($p = .195$), or lean body mass ($p = .452$). Similarly, there were no pre-post significant differences within the control group for weight ($p = .450$), percent body fat ($p = .984$), or lean body mass ($p = .243$).

CHAPTER FIVE

DISCUSSION

The purpose of this research was to assess the efficacy of select physical activity classes. Specifically we intended to determine the effect of these exercise classes on bone mineral density (BMD) as measured through Dual Energy X-Ray Absorptiometry (DEXA) scans, and analysis of a biochemical marker in the blood, osteocalcin, associated with bone formation. We hypothesized that osteocalcin concentration and BMD when measured by DEXA scan would increase after completion of a yoga and cardio kickboxing (CKB) PEX class. We also hypothesized there would be a significant increase in BMD and osteocalcin concentration in students enrolled in the CKB class compared with students enrolled in the yoga class. Finally we hypothesized that more frequent class attendance would correlate with increased measures of bone formation. The cardio kickboxing students had 29 classes that they were to attend, and the yoga students had 28 classes that they were to attend. Results suggested these classes did have a significant effect on osteocalcin concentration for the yoga and CKB PEX classes; however, BMD was not increased in any of the tested sites for either class. It also seems more frequent class attendance did not affect bone mineral density or biochemical activity.

Total body BMD remained unaffected by participation in either PEX class. This is in conjunction with findings by McClanahan et al. (2002) who discovered total body BMD of triathletes to remain unaffected after a competitive season. These findings could be due to the fact these participants already possessed an elevated bone mass before screening was conducted, therefore, significant increases in BMD were less likely to be observed. McClanahan and others may have also seen these results because these participants, much like those included in our study had already taken PEX courses similar to those they were enrolled in. Of the total number of PEX students 29% reported already taking the class or participating in similar activities. It is likely that these subjects had already adapted to the type of training and were no longer providing a stimulus great enough to further initiate the breakdown of bone. It should also be noted that our subjects were already enrolled in both classes three weeks prior to baseline testing. Because baseline testing was conducted at a later time it is possible that during this short period of time a bone response could have been initiated. In contrast to our findings, Zribi et al. (2014) did observe significant increases in total body BMD after a 9 week plyometric exercise intervention comprised of two sessions per week at 90 minutes. It is reasonable to assume that this type of plyometric training could have provided a sufficient overload of mechanical stress to evoke osteoclast response, whereas the activities associated with our PEX classes did not.

Bone Mineral Density

Bone mineral density measured at the hip and spine sites failed to increase after completion of either yoga or CKB PEX classes. Hawley et al. (2011) conducted a study observing BMD in response to 24 weeks of resistance training in both college-age men and women. Researchers found results to be significant for sites hip and spine in the male population, but not the female population. We may have found similar outcomes within our study due to the population tested. Women seem to have a lesser ability than men to build up the bone matrix due to hormonal influences than men do not experience. Hawley and others identified the spine and hip as sites that are particularly high in trabecular bone, which is marked by higher surface area exposure and thus higher remodeling rates, therefore they respond more rapidly to changes in lifestyle. Although we tested these sites with this research in mind, it is also a probability that the type of physical activity being carried out in the PEX classes failed to activate the specific sites that were tested. It should be recognized though, despite the spine not being significant, the CKB class seemed to maintain BMD at this site when the subjects within the yoga class seemed to experience decreases. This is very likely due to the nature of the PEX classes. The CKB demands an upright posture while resisting repetitive forces being applied against the upper body. Activation of lower lumbar skeletal muscles such as the quadratus lumborum and multifidus muscles are required to hold this particular stance and withstand this type of outside force. The use of these muscles reacting against the lumbar spine could have increased causation of bone density maintenance

for this particular site within the CKB group. Yoga, considered a low impact physical activity particularly on the lower back, fails to provide reaction forces great enough to be effective at increasing bone mineral density, possibly resulting in the decrease at this site seen within our study.

Osteocalcin

Results were significant for osteocalcin concentration after completion of both yoga and CKB classes. Maïmoun et al. observed similar results of osteocalcin concentrations in male triathletes after investigating a competitive season of a training period of at least 5 months. Their results were significant, but difficult to truly compare to our study due to differences in population, timeline, and protocol. Our results were more related to findings by Shen et al. (2007) who examined a biochemical significant after a Tai Chi intervention. This intervention was performed for 24 weeks, 3 sessions per week, 40 minutes each session. Although Shen and others conducted testing for 24 weeks rather than our 12 weeks, researchers reported elevated biochemical activity after just 6 weeks of exercise. Zribi and others also found results related to our own. They observed a 6% increase in osteocalcin concentrations after a 9 week plyometric training intervention including early pubertal males. Our study detected almost a 200% increase in biomarker concentration (yoga 200%, CKB (198%). This considerable increase is most likely the result of our female subject population. Males tend to experience

advanced bone growth later than females, and therefore continue to develop bone throughout later adult life. The women included in our group possessed an average age of $21 \pm .7$. This is the ideal age for women to begin approaching peak bone mass, and leads us to assume it is the reason why osteocalcin activity was so elevated in these individuals. Our results as well as results by Maïmoun et al. and Shen et al. can lead to the conclusion that biochemical activity of markers associated with bone formation such as osteocalcin may be more sensitive to an outside stimulus acting on bone.

Limitations

Limitations of this study include the nature of our control group, our proposed timeline, subject population, physical activities chosen, and unaccounted factors capable of influencing osteocalcin. A control group was included, but consisted of students recruited from advanced Kinesiology classes at the University of Nevada, Las Vegas. Although these students reported to be recreationally trained with no intent to alter their physical activity regimen we can consider the option that because of their major of study promoting bodily awareness they may have been more inclined to be physically active and more cognizant of dietary intake. For example 33% of our controls reported taking a multivitamin supplement while only 21% of PEX students reported taking this type of supplement. We also consider our timeline of 12 weeks to be a limitation for this study. Regarding the standard lifecycle of bone, 12 weeks is too short

to observe bone growth via DEXA scan. The lifecycle of bone is known to be typically 17 weeks long. During this time we see the bone undergo a series of changes beginning with the initial phase of bone breakdown where over time we see bone become worn and eroded away in sites exposed to outside force. When this wear and tear reaches a certain point two weeks of bone resorption will occur followed by two weeks of excavation and then approximately 13 weeks of bone formation. The bone formation phase is the longest phase in the cycle and exceeds our intervention period. Our subject population of only women aged 18-34 years of age also serves as a limitation. Women reach peak bone mass before age 30 and experience initial decline by the age of 40 followed by a 3-5 year acceleration in bone loss after menopause. In fact, by the age of 90 a woman will have lost 20% of peak cortical bone and 50% of peak trabecular bone mass. Much of this bone loss in the female population is credited to age-related hormonal changes that influence bone density, such as reduced estrogen and testosterone production. It is important to note though, that hormonal changes can be induced by medications as well such as oral contraceptives. Fifty percent of PEX students and 25% of the control group reported currently taking medications including oral contraceptives, steroid inhalers, or antibiotics. Diet also strongly influences the body's ability to build the bone matrix and is an important factor to consider for our study because 35% of PEX students and 16% of controls reported changing their diets within 6 months prior to testing. As adults age they are less able to absorb vitamin D which is a nutrient crucial to proper bone formation due to its influence on calcium absorption which assists in the process of bone formation. We did not incorporate a

post-study questionnaire in addition to the pre-study questionnaire. This could have assisted in providing insight on the dietary intake of our subjects, and should be noted as a limitation to this study. Without assessing the dietary intake of each of our subjects is it uncertain to what extent their diets played a role in failure to increase bone density within the 12 week period. We chose to observe a yoga and CKB PEX class because these are two exercises that are yet to be clearly defined within the literature. Total body, hip, and spine sites were not affected by either intervention. Bone mineral density increases as a reactive mechanism to protect the body against an outside force. According to Wolf's Law bone becomes stronger and thicker when it reacts against an outside stimulus and thinner and weaker when it has nothing to react against. It is likely that yoga and CKB did not produce enough force to initiate the breakdown of bone in these certain sites, therefore, new bone did not need to be formed. For future research an appropriate control group should be considered as well as an expanded timeline to allow a sufficient amount of time for bone formation.

Osteocalcin is a vitamin K dependent protein found on the surfaces of osteoblast cells and reflects their biosynthetic activity. The activity of osteocalcin is dependent on vitamin K's addition of carbon dioxide in a process known as carboxylation. Although osteocalcin depends on vitamin K for activation it is not directly affected by the vitamin; rather, it merely influences the degree of carboxylation of osteocalcin, or how much carbon dioxide is added which then affects the activity of the osteoblast cells. If vitamin K determines carboxylation of osteocalcin resulting in effects on osteoblast activity, changes in the concentration of osteocalcin could propose bone formation responses to

vitamin K. Within this study dietary intake was not accounted for. Therefore the possibility of vitamin K effecting osteocalcin levels is difficult to determine. Future studies should incorporate dietary intake analysis in conjunction with osteocalcin analysis.

Conclusions

In conclusion, our study was able to confirm select physical education activity classes can initiate significant responses of the biochemical marker osteocalcin. This information provides useful insight concerning bone formation, notably in a short time frame where significant increases in BMD are unlikely to be detected. Our results provide evidence that both cardio kickboxing and yoga practice for a 12 week period can have beneficial effects on osteocalcin and it can be speculated that both activities promote future bone formation. As a predisposed population, these findings are important for college-aged females in the prevention of bone-related diseases or injuries.

APPENDIX

Institutional Review Board Approval

Biomedical IRB – Full Board Review Approval Notice

NOTICE TO ALL RESEARCHERS:

Please be aware that a protocol violation (e.g., failure to submit a modification for any change) of an IRB approved protocol may result in mandatory remedial education, additional audits, re-consenting subjects, researcher probation, suspension of any research protocol at issue, suspension of additional existing research protocols, invalidation of all research conducted under the research protocol at issue, and further appropriate consequences as determined by the IRB and the Institutional Officer.

DATE: September 16, 2014

TO: **Dr. James Navalta**, Kinesiology and Nutrition Sciences

FROM: Office of Research Integrity - Human Subjects

RE: Notification of IRB Action
Protocol Title: **An Evaluation of Select Physical Activity Exercise (PEX) Classes on Markers of Bone Mineral Density**
Protocol #: 1407-4880
Expiration Date: September 15, 2015

This memorandum is notification that the project referenced above has been reviewed and approved by the UNLV Biomedical Institutional Review Board (IRB) as indicated in Federal regulatory statutes 45 CFR 46 and UNLV Human Research Policies and Procedures.

The protocol is approved for a period of one year and expires September 15, 2015. If the above-referenced project has not been completed by this date you must request renewal by submitting a Continuing Review Request form 60 days before the expiration date.

PLEASE NOTE:

Upon approval, the research team is responsible for conducting the research as stated in the protocol most recently reviewed and approved by the IRB, which shall include using the most recently submitted Informed Consent/Assent forms and recruitment materials. The official versions of these forms are indicated by footer which contains approval and expiration dates.

Should there be *any* change to the protocol, it will be necessary to submit a **Modification Form** through ORI - Human Subjects. No changes may be made to the existing protocol until modifications have been approved by the IRB. Modified versions of protocol materials must be used upon review and approval. Unanticipated problems, deviations to protocols, and adverse events must be reported to the ORI – HS within 10 days of occurrence.

If you have questions or require any assistance, please contact the Office of Research Integrity - Human Subjects at IRB@unlv.edu or call 895-2794.

Office of Research Integrity - Human Subjects
4505 Maryland Parkway • Box 451047 • Las Vegas, Nevada 89154-1047
(702) 895-2794 • FAX: (702) 895-0805

INFORMED CONSENT

Department of Kinesiology and Nutrition Sciences

INFORMED CONSENT FORM

TITLE OF THE STUDY: An Evaluation of Select Physical Activity Exercise (PEX) Classes on Markers of Bone Mineral Density

INVESTIGATOR/S: Dr. James Navalta

CONTACT INFORMATION: If you have any questions or concerns about the study, please contact **Dr. Navalta at (702) 895-2344**.

For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted you may contact the **UNLV Office of Research Integrity – Human Subjects Research at (702) 895-2794**.

Purpose: We want to see if participating in select Physical Activity classes provides a benefit in terms of bone health.

Participants: You are being asked to participate in the study because you are a female, are currently enrolled in a PEX course, and are between the ages of 18 and 35 years old. Please be aware that participation in this study is not a required part of the PEX course that you are taking. You will be excluded from the study if you are pregnant or think you may be pregnant.

Procedure: If you volunteer, you will be asked to come to the Exercise Physiology Laboratory once toward the beginning of the semester, and once toward the end of the semester to provide a finger-stick blood sample, fill out food/ medication/supplementation surveys, and to have a DEXA scan.

The finger-stick blood draws of 600 microliters (approximately one-tenth of a tsp each time) will be taken for bone health indicators.

A DEXA scanner will be used to make certain body measurements. The DEXA is a diagnostic X-ray device. You will not be allowed to participate in this study if you are pregnant. The reason for this is that bone mineral density is determined using the DEXA scanner, a diagnostic X-ray device. The UNLV Radiation Safety Office has developed the UNLV Reproductive Health Program to ensure that people occupationally exposed to radiation at UNLV are aware of the risks associated with their exposure. In addition, the principles of radiation protection require that ALL doses (this includes medical examinations) be kept As Low As Reasonable Achievable (ALARA). This is of particular concern in a study such as this because a developing fetus is especially sensitive to radiation exposure in the first trimester of pregnancy. The dose that a subject receives from the evaluation of bone mineral density is approximately three (3) millirem. Three millirem is less than 1% of the dose that we receive annually as a result of living in Las Vegas and is 0.6% of the limit for exposure of declared pregnant radiation workers. The investigators recognize that the risks of participation in this study are very low, but they do not wish to expose a fetus to any unnecessary radiation. For any female, there is a possibility that you are pregnant but do not know that you are. If it is found that you are pregnant after the study, you should know that the potential for damage of the exposed fetus is extremely low. Concern for damage to an exposed fetus is typically expressed at a dose level of greater than 5000 millirem. The International Commission on Radiological Protection recommends that a one time fetal dose should not exceed 10000 to 20000 millirem.

Initials _____

Page 1 of 2

An Evaluation of Select Physical Activity Exercise (PEX) Classes on Markers of Bone Mineral Density
Department of Kinesiology and Nutrition Sciences
Dr. Navalta: (702) 895-2344

*Approved by the UNLV IRB. Protocol 1407-4880
Received: 09-11-14 Approved: 09-16-14 Expiration: 09-15-15*

TITLE OF THE STUDY: An Evaluation of Select Physical Activity Exercise (PEX) Classes on Markers of Bone Mineral Density

Certain guidelines are recommended before the DEXA scan, including: drinking plenty of water for normal hydration, eating your normal diet (no fasting is required), removal of all body jewelry, and voiding the bowels (using the bathroom).

Investigators will also have access to the participants PEX class attendance. This will be the only data collected from the PEX classes and will be requested from instructors after the semester has ended.

Risks: You might feel minor pain and/or discomfort during the blood draw, but all equipment will be sterile. There is the possibility of bruising and swelling around the area of the blood draw. The radiation exposure of the DEXA scan is minimal and is approximately the same amount of radiation you receive living in Nevada for less than 3 days.

Benefits of Participation: You will be able to receive free information regarding your bone health and body composition. It is possible that information from this study will provide information about the beneficial effect of participating in structured physical activity classes.

Cost /Compensation: There will not be any financial cost to you to participate in this study. It is estimated that the study will take no more than two hours of your time during the two laboratory visits; however you will not be paid for your time.

Participation: Your participation in this study is completely voluntary. You may refuse to participate in this study or in any part of this study and you may withdraw at any time without prejudice to your relations with the University. You are encouraged to ask questions about this study prior to the beginning or at any time during the study. You will be given a copy of this form.

Confidentiality: All information gathered in this study will be kept completely confidential. Only those persons who are directly related to this study (i.e.: researchers, data analysts) will have access to your data. No reference will be made in written or oral materials, which could link you to this study. All records will be stored at UNLV for a period of 3 years. After 3 years, any documentation with identifiable information (e.g., name) will be destroyed. Unidentifiable data will be stored in locked storage indefinitely.

Freedom to Consent: I have read the above information carefully and I am aware of the tests/procedures to be performed. Knowing these risks and having the opportunity to ask questions, I agree (consent) to participate in this study. With this freedom to consent, I have a right to withdraw from this study at any time without prejudice. I am at least 18 years old and a copy of the informed consent has been given to me.

Prior Signature of the Participant

Date

Signature of Witness

Date

Post Signature of the Participant

Date

Signature of Witness

Date

Initials _____

Page 2 of 2

An Evaluation of Select Physical Activity Exercise (PEX) Classes on Markers of Bone Mineral Density
Department of Kinesiology and Nutrition Sciences
Dr. Navalta: (702) 895-2344

*Approved by the UNLV IRB. Protocol 1407-4880
Received: 09-11-14 Approved: 09-16-14 Expiration: 09-15-15*

Bone Mineral Density Questionnaire

BONE MINERAL DENSITY QUESTIONNAIRE

Department of Kinesiology & Nutrition Sciences

**TITLE OF STUDY: An Evaluation of Select Physical Activity Exercise (PEX)
Classes on Markers of Bone Mineral Density**

INVESTIGATOR(S): Dr. James Navalta and Tori Stone

For questions or concerns about the study, you may contact Dr. Navalta at **895-2344**.

Purpose of the Study

You are invited to participate in a research study. We want to see if participating in select Physical Activity classes provides a benefit in terms of bone health.

To better evaluate your participation in this study, please answer the following questions. You may choose to not answer any question.

1. Have you changed your diet significantly in the last 6 months? If yes, what changes did you make?
2. Are you currently taking any medications? If yes, what is it and how long have you been taking it? What is the dosage?
3. Are you currently taking a multivitamin supplement? If yes, how long have you been taking a multivitamin? Which multivitamin are you taking?
4. Have you previously taken or are you currently taking a calcium supplement? If yes, what dose and for how long have you been taking a calcium supplement?
5. Have you ever been diagnosed with low bone mineral density? Are you currently undergoing treatment for osteopenia or osteoporosis?
6. Have you significantly changed your level of physical activity in the past 6 months? If yes, describe the changes you made.
7. Have you had a DEXA scan within the previous 6 months? If yes, when?

TABLES

Pre			
Characteristic	Cardio Kickboxing (n= 14)	Yoga (n= 14)	Control (n= 12)
Age (y)	21.1 ± 1.8	22.7 ± 3.6	21.8 ± 2.1
Height (cm)	163.3 ± 7.9	161.8 ± 5.6	164.6 ± 7.62
Weight (kg))	71.6 ± 19.4	60.5 ± 13.6	65.9 ± 11.1
Body Fat (%)	40.1 ± 6.0	34.9 ± 9.3	35.1 ± 9.9
Lean Body Mass (kg)	39.9 ± 6.5	36.5 ± 4.9	40.2 ± 4.9

Table 1. Baseline Descriptive Characteristics

Post			
Characteristic	Cardio Kickboxing (n= 14)	Yoga (n= 14)	Control (n= 12)
Age (y)	21.2 ± 2.1	22.9 ± 3.6	21.9 ± 2.4
Height (cm)	163.3 ± 7.9	161.8 ± 5.6	164.6 ± 7.6
Weight (kg)	70.5 ± 18.5	59.6 ± 13.4	65.2 ± 11.7
Body Fat (%)	39.6 ± 6.7	34.2 ± 8.5	35.1 ± 9.8
Lean Body Mass (kg)	38.7 ± 7.7	36.7 ± 5.4	39.8 ± 4.8

Table 2. Post-Test Descriptive Characteristics

Warm up	
- Arm Swing	x30
- Arm Circle	x30
- Torso Circles	x30
- Torso Rotation	x30
- High Knee March	x30
- Standing Side Crunch	x60
- Standing Crisscross Crunch	x60
- Up and Out	x60
- Jumping jacks / Jump Rope	x120
Round One	
(Start with left leg forward)	
- Jab + Cross	x10 (switch stance and repeat)
- Jab + Cross + Jab	x10 (switch stance and repeat)
- Jab + Cross + Jab + Ducking Stance Change	x10 (5 on each side)
- Jab + Cross + Uppercut + Uppercut	x10 (switch stance and repeat)
- Hook + Uppercut + Uppercut + Hook	x10 (switch stance and repeat)
- Jab + Hook + Hook + Uppercut + Ducking Stance Change	x10 (5 on each side)
Round Two	
(Start with left leg forward)	
- Shin Block (F) + Jab + Cross + Shin Block (R)	x10 (switch stance and repeat)
- Knee + Knee + Jab + Cross	x10 (switch stance and repeat)
- Knee + Front Kick (F) + Front Kick (R)	x10 (switch stance and repeat)
- High Kick + Knee + Shin Block (F) + Shin Block (R) + Ducking Stance Change	x10
- Front Kick (F) + Jab + Cross + Front Kick (R)	x10 (switch stance and repeat)
- High Kick + High Kick + Uppercut + Uppercut + Knee	x10 (switch stance and repeat)
Cool Down	

Table 3. Sample Cardio Kickboxing Session

Child's Pose	3-5 minutes
Head-to-Knee Pose	1-3 minutes each side
Downward-Facing Dog	1-3 minutes
Standing Forward Bend	1-3 minutes
Reclining Bound Angle Pose	3-5 minutes
Supported Bridge Pose	3-5 minutes
Legs-Up-the-Wall Pose	3-5 minutes
Corpse Pose	10-12 minutes

Table 4. Sample Yoga Session

FIGURES

Figure 1. Pre-Post Osteocalcin Concentration Cardio Kickboxing and Yoga

Figure 2. Yoga Attendance and Osteocalcin

Figure 3. Yoga Attendance and Total Body Bone Mineral Density

Figure 4. Yoga Attendance and Spine Bone Mineral Density

Figure 5. Yoga Attendance and Hip Bone Mineral Density

Figure 6. Cardio Kickboxing Attendance and Osteocalcin

Figure 7. Cardio Kickboxing Attendance and Total Body Bone Mineral Density

Figure 8. Cardio Kickboxing Attendance and Spine Bone Mineral Density

Figure 9. Cardio Kickboxing Attendance and Hip Bone Mineral Density

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CURRICULUM VITAE

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GENERAL INFORMATION

Education

2013-present M.S., University of Nevada, Las Vegas, Las Vegas, NV

Kinesiology: Exercise Physiology

2009-2013 B.S. *Indiana State University*, Terre Haute, IN

Kinesiology, Recreation, and Sport: Exercise Science

Teaching Experience

2014-present Physical Education Activity Instructor, University of Nevada, Las Vegas: PEX 152 *Total Body Conditioning for Women*

2013-present Graduate Assistant, University of Nevada, Las Vegas: *KIN 491 Exercise Physiology Lab; KIN 391 Applied Exercise Physiology*

Grants, Scholarships and Awards

2014 Graduate and Professional Student Association Award; University of Nevada, Las Vegas: An Evaluation of Select Physical Activity Classes (PEX) on Markers of Bone Mineral Density (\$800, funded)

2015 Graduate and Professional Student Association Award; University of Nevada, Las Vegas: Travel funding National American College of Sports Medicine Conference; San Diego, CA (\$375, funded)

2015 Certificate of Participation: Festival of Excellence; Southern Utah

University

Certifications/Training

American Heart Association: CPR and AED certified

Collaborative Institutional Training Initiative:

Biosafety training

Bloodborne Pathogens training

Chemical Hygiene training

Hazard Communications training

HIPAA training

Personal Protective Equipment training

Radiation Safety training

Unsealed Sources training

Memberships

American College of Sports Medicine Midwest Chapter

American College of Sports Medicine Southwest Chapter

RESEARCH

Published Manuscripts

Manning, J.W., Montes, J., Stone, T.M., Rietjens, R.W., Young, J.C., DeBeliso, M., Navalta, J.W. *Cardiovascular and Perceived Exertion Responses to Leisure Trail Hiking*. Submitted to *Journal of Outdoor Recreation, Education, and Leadership* September 2014.

Professional Presentations and Refereed Published Abstracts

Manning, J.W., Trilleras, G., Montes, J., Stone, T.M., Ciulei, M.A., Miller, B.L., Navalta, J.W., DeBeliso, M. Cardiovascular and Perceived Exertion Comparison of Uphill versus

Downhill Portions of a Trail Hike. Annual Meeting of the Southwest American College of Sports Medicine, Newport Beach, CA, 2013.

Montes, J., Manning, J.W., Stone, T.M., Trilleras, G., Miller, B.L., Ciulei, M.A., Rietjens, R.W., DeBeliso, M., Navalta, J.W. Test-retest Reliability of Cardiovascular and Perceived Exertion Responses to Trail Hiking. Annual Meeting of the Southwest American College of Sports Medicine, Newport Beach, CA, 2013.

Stone, T.M., Manning, J.W., Rietjens, R.W., Ciulei, M.A., Miller, B.L., Trilleras, G., Montes, J., DeBeliso, M., Navalta, J.W. Comparison of Cardiovascular and Perceived Exertion Responses to Trail Hiking under Easy and Strenuous Conditions. Annual Meeting of the Southwest American College of Sports Medicine, Newport Beach, CA, 2013.

Stone, T.M., Aylsworth, J.B., Guadagnoli, M., Navalta, J.W. Physiological Measures Associated with Interpolated Memory Tests: A Pilot Study. Annual Meeting of the Southwest American College of Sports Medicine, Costa Mesa, CA, 2014.

Rietjens, R., Stone, T.M., Montes, J., Young, J.C., Tandy, R., Utz, J., Navalta, J.W. Acute Testosterone Responses to Different Resistance Exercise Intensities. Annual Meeting of the Southwest American College of Sports Medicine, Costa Mesa, CA, 2014.

LaComb, C.O., Stone, T.M., Montes, J., Navalta, J.W., Young, J.C. Oral Breathing is More Efficient than Nasal Breathing During Submaximal Treadmill Exercise. Annual Meeting of the Southwest American College of Sports Medicine, Costa Mesa, CA, 2014.

Rietjens, R., Stone, T.M., Montes, J., Young, J.C., FACSM, Tandy, R.D., Utz, J., Navalta, J.W. Acute Testosterone Responses to Different Resistance Exercise Intensities. Annual Meeting of the National American College of Sports Medicine, San Diego, CA, 2015.

Stone, T.M., Montes, J., Manning, J., Ciulei, M.A., DeBeliso, M., FACSM, Young, J.C., FACSM, Navalta, J.W. Cardiovascular and Perceived Exertion Responses to Trail Hiking at Elevation. Annual Meeting of the National American College of Sports Medicine, San Diego, CA, 2015.

Montes, J., Wulf, G., LaComb, C.O., Stone, T.M., Mercer, J., FACSM, Navalta, J.W. Effect of Enhanced Expectancies On Maximal Aerobic Capacity In Experience Runners. Annual Meeting of the National American College of Sports Medicine, San Diego, CA, 2015.

Tacad, D.K.M., Manning, J.W., LaComb, C.O., Stone, T.M., Montes, J., Navalta, J.W., DeBeliso, M., FACSM. Test-retest Reliability Of Physiological Responses To Self-pace Trail Hiking. Annual Meeting of the National American College of Sports Medicine, San Diego, CA, 2015.

Navalta, J.W., Manning, J.W., McCune, D., Montes, J., Stone, T.M., LaComb, C.O., Tacad, D.K., Ciulei, M.A., Young, J.C., FACSM, DeBeliso, M., FACSM. Using Hexoskin Wearable Technology to Obtain Body Metrics in a Trail Hiking Setting. Annual Meeting of the National American College of Sports Medicine, San Diego, CA, 2015.

LaComb, C.O., Stone, T.M., Montes, J., Navalta, J.W., Young, J.C., FACSM. Oral Breathing is More Efficient than Nasal Breathing During Submaximal Treadmill Exercise. Annual Meeting of the National American College of Sports Medicine, San Diego, CA, 2015.

LABORATORY EXPERIENCE

- **Thesis: An Evaluation of Select Physical Activity Exercise Classes (PEX) on Markers of Bone Mineral Density**
 - Analyze bone mineral density using Dual Energy X-Ray Absorptiometry scanner in various populations
 - Analyze biochemical markers associated to bone health osteocalcin and bone alkaline phosphatase via finger prick blood draw
- Measure cardiovascular and perceived exertion responses to trail hiking under various working conditions
- Analyze salivary amylase as a biochemical indicator of stress
- Assess pain, physical function, maximal strength and autonomic and vascular variables in relation to disease severity and symptomology in women with fibromyalgia undergoing resistance exercise training alone or combined with Type 3b laser therapy
- Assist with data collection on the effects of static stretching versus proprioceptive neuromuscular facilitation on caloric expenditure and performance during 30-minutes of submaximal work on the cycle ergometer in trained cyclists

- Administration of pulse wave analysis and pulse wave velocity assessments
- VO₂ Maximal and sub-maximal testing on cycle ergometer and treadmill
- Queen's College Step Test, YMCA 3 Minute Step Test, Balke Treadmill Test, and Bruce Treadmill Test
- Performance testing including vertical jump, sit-and-reach, 20 yard sprint, broad jump, Margaria stair test
- Body composition measurements including hydrostatic weighing, BodPod, DEXA scan, skinfolds, Bioelectrical Impedance Analysis, girth measurements
- Ability to independently calibrate all laboratory equipment including metabolic cart, hydrostatic weighing tanks, and BodPod

WORK EXPERIENCE

University of Nevada, Las Vegas

Graduate Assistant August 2013-present

- Provide a structured curriculum for undergraduate exercise physiology lab classes
- Material includes: Resting Metabolic Rate, body composition testing (hydrostatic weighing, BodPod, BIA, DEXA scan, etc.), cardiovascular responses to various exercise regimens progressive and steady-state, VO₂ maximal cycle testing and maximal treadmill testing with various protocols

Union Hospital, Terre Haute, IN

Intern (480 hours) January 2013- May 2013

- Collaborate with certified personal trainers in providing exercise programs and regimens tailored to individual client needs
- Independently formulate personalized work outs and fitness programs
- Conduct both group class and one-on-one personal training sessions
- Experience working with clients of all age groups
- Provide personalized health history assessments including heart and blood pressure measurements, body fat percentages and body mass index calculations

Indiana State University, College of Nursing, Health, and Human Services

Intern (280 hours) October 2012- December 2012

- Assisted strength and conditioning coaches of Indiana State University in providing sport-specific training programs to athletes of the university

Friendship Manor, St. Elmo, IL

Nurses Aid

June 2012- August 2012

- Assist in patient care under supervision of registered nurses

REFERENCES

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