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An Evaluation of Select Physical Activity Exercise Classes on Bone Metabolism

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ABSTRACT

International Journal of Exercise Science 11(2): 452-461, 2018. Weight-bearing physical activity can optimize bone mass early in life and prevent the development of osteoporosis. However, less is known about the potential benefits of non-weight-bearing activities. The purpose of this study was to assess the efficacy of structured physical activity classes on bone metabolism. Twenty-eight premenopausal women, aged 18–35 years who were either enrolled in a yoga class (n=14) or cardio-kickboxing class (n=14) voluntarily consented to participate. Both classes were introductory classes meeting twice per week for 50 min per session for 12 weeks. Anteroposterior spine (L1-L4), hip (dual femur), and total body bone mineral density (BMD) was measured in both groups pre and post intervention using dual-energy X-ray absorptiometry (DXA). Pre and post blood samples were drawn for measurement of serum osteocalcin (OC) by enzyme-linked immunosorbent assay (ELISA) in each group. Baseline subject characteristics including age, height, weight, body fat percentage, and lean body mass did not differ between groups. BMD levels did not increase but were held stable over the course of the intervention. Yoga increased OC by 68% ($P < 0.001$) and cardio-kickboxing increased OC by 67% ($P < 0.001$) over the course of the 12-week classes. While 12 weeks of yoga and cardio-kickboxing were insufficient to induce BMD changes, OC levels reflect the bone formation process was initiated, but not yet complete. Increased OC levels suggest the selected physical activity classes provided enough of a stimulus to precipitate a future response of bone growth, assuming exercise training remains constant.

KEY WORDS: Bone mineral density, osteocalcin, college-aged women, osteoporosis, yoga, kickboxing

INTRODUCTION

Osteoporosis causes premature disability for approximately 10 million people in the United States; an additional 18 million more have low bone mass, placing them at increased risk for the disease (14). Of the diagnosed population, 80% are women (14), thereby rendering them more prone to osteoporotic fractures and breaks, particularly of the hip and spine (1). Although osteoporosis is rare in young women, osteopenia, the precursor of osteoporosis, is not (10). Young women who are osteopenic and do not attain a high peak bone mineral density (BMD) are at risk for developing osteoporosis (8). Therefore, to reduce the risk of developing osteopenia or osteoporosis, the attainment of high peak bone mass during young adult life is critical. Physical activity (PA) helps optimize this peak bone mass and assists in maintenance of BMD.

Generally, PA that elicits high impact forces on the body is likely to promote greater increases in BMD, while PA that elicits low impact forces will result in smaller gains, if any. Furthermore, certain types of PA differentially affect bone growth. For example, walking (23) and running (6) can increase BMD of the tibia (26), whereas dancing (9) and power and strength training (11) have been shown to be beneficial for the hip and lumbar spine. Swimming and cycling, however, have been regarded as less beneficial due to their low impact (non-weight bearing) nature (7). The impact of other activities, such as cardio-kickboxing (CKB) and yoga, remain unclear because they have not been directly studied in terms of their effect on bone health and metabolism. Since they are unique in their level of impact, it is difficult to generalize findings regarding the effect of other types of PA on bone health to these types of exercise. Additionally, CKB and yoga are becoming increasingly popular, especially among young women, so it is important to determine the extent to which they influence bone health and metabolism.

Accordingly, the purpose of this study was to test the hypothesis that 12 weeks of twice weekly yoga and CKB would be sufficient to increase BMD in 18–35-year-old women, but greater changes would be observed after CKB. Considering the means by which PA increases BMD, previous literature has monitored specific biochemical markers associated with bone turnover, such as serum osteocalcin (OC), because it is more sensitive to changes than radiological technology (2). Therefore, an additional purpose was to test the hypothesis that the exercise intervention would increase serum OC levels; again, greater changes were expected after CKB compared to yoga.

METHODS

Participants

Twenty-eight women, 18–35 years, were recruited to participate in this study. An *a priori* power analysis (19) indicated a minimum of 12 subjects per group was sufficient to detect a moderate interaction effect ($d = 0.6$) (20), assuming power ≈ 0.8 and $\alpha = 0.05$. Each subject must have been either enrolled in a yoga class (n=14) or a CKB class (n=14) offered through the university physical activity program. Subjects were excluded if they had previously taken either of the classes. All subjects reported maintaining a consistent diet and PA level for the prior 6 months. No subjects reported the use of any medication with the potential to affect bone metabolism such as a calcium or multivitamin supplement; all reported having a normal menstrual cycle, and none had been diagnosed formerly with osteoporosis/osteopenia or low BMD. Less than half of the women in each group reported taking any form of oral contraceptive medication (yoga = 43%; CKB = 38%). All subjects were instructed not to alter their diets or activity levels beyond participation in the classes throughout the 12 weeks. Prior to both dual energy X-ray absorptiometry (DXA) scans, all subjects signed an informed consent certifying that they were aware of the risk associated with exposing a fetus to radiation in the event they were pregnant or trying to become pregnant. Procedures were approved by the Institutional Review Board.

Protocol

Weight was measured in kilograms by the DXA device (Lunar Prodigy, General Electric Healthcare, Madison, WI). All subjects were recruited from the same CKB or Hatha yoga classes. Both classes were introductory classes which met twice per week for 50 min per session for 12 weeks. A typical CKB class session varied as the semester progressed by continually adopting new and more complex upper and lower body movements. Hatha style yoga was implemented in the yoga classes because it is less vigorous than other styles and good for beginners. Classes consisted of practicing basic yoga postures, breathing exercises, and meditation techniques. Within a week after the conclusion of the 12-week period, subjects reported back to the laboratory and procedures were repeated for BMD and OC assessment. Average (± SD) percentage of classes attended were as follows: yoga = 76 ± 15%; CKB = 78 ± 10%.

Table 1. Descriptive characteristics of subjects were assessed before and after 12 weeks of either cardio-kickboxing or yoga class.

	Pre	Post
Weight (kg)*		
Yoga	60.5 ± 14.1	59.6 ± 13.9
Cardio-kickboxing	71.6 ± 20.1	70.5 ± 19.2
Body Fat (%)		
Yoga	35.0 ± 9.6	34.2 ± 8.8
Cardio-kickboxing	40.1 ± 6.3	39.6 ± 6.9
Lean Body Mass (kg)		
Yoga	36.5 ± 5.1	36.7 ± 5.5
Cardio-kickboxing	39.9 ± 6.7	38.7 ± 8.0

*p = 0.02 for main effect of time

One to three days prior to the start of the activity classes, DXA scans of the anteroposterior spine (L1-L4), hip (dual femur), and total body were performed on a single day by the same investigator. Subjects were scanned following the manufacturers recommendations using standard positioning protocols. Previous work has shown the Lunar Prodigy DXA to provide good reliability for bone mineral content (intraclass correlation coefficient [ICC] = 0.99, standard error of measurement [SEM] = 0.04 kg) (15). The instrument was calibrated each day before use and standard procedures were always followed, including: removal of all body jewelry, voiding the bowels, and emptying the bladder if possible. Subjects were instructed to maintain normal hydration levels. On the same day of the DXA scans, fingerstick blood samples (600 µL, Multivette 600, Sarstedt, Fisher Scientific, Pittsburgh, PA) were obtained to assess OC concentrations. All blood samples were taken in the morning. Serum was extracted after the samples were centrifuged. Red blood cells were then discarded and serum stored in a -80 °C freezer until OC concentrations were analyzed using a commercially available enzyme-linked immunosorbent assay (ELISA) kit (Affymetrix eBioscience, Santa Clara, CA, USA) according to the manufacturer's specifications. All assays were performed using an Epoch microplate reader (Biotek U.S., Winooski, VT). A fasting state was recommended, but not required prior to DXA scans or blood samples. Rather, subjects were asked to report the use of any medication with the potential to affect bone metabolism such as a calcium or multivitamin supplement. These guidelines were necessary because some multivitamins contain biotin which can interfere with the OC assay.

Statistical Analysis

All data are expressed as mean ± standard deviation (SD) and an α level of 0.05 was used for all statistical analyses. BMD and OC concentrations were analyzed pre- and post-exercise classes. A 2 × 2 (time × group) mixed model ANOVA was used to analyze differences among group means for BMD and OC as well as subject characteristics. All data were normally distributed according to the Kolmogorov-Smirnov test ($p > 0.05$). Levene's test for homogeneity of variance revealed no significant differences in residual variance between groups for any of the dependent variables.

RESULTS

Groups were not different (all $p > 0.05$) and there were no significant interactions (all $p > 0.05$) with respect to percent body fat or lean body mass. Subjects did, however, lose weight after 12 weeks of a yoga or CKB class, indicated by a significant main effect for time ($p = 0.02$). Table 2 shows total body, hip, and spine BMD values for each group before and after the intervention. Changes in BMD (Figure 2) over the 12 weeks ranged from 0.00-0.03 g/cm^2 and were not statistically significant for either treatment ($p > 0.05$ for interaction). OC levels increased 67% over the course of the intervention (Figure 1), but groups were not different ($p = 0.44$).

Table 2. Bone mineral density (g/cm^2) before and after 12 weeks of either cardio-kickboxing or yoga class meeting 50 min twice weekly.

	Pre	Post
Total Body		
Yoga	1.18 ± 0.10	1.17 ± 0.10
Cardio-kickboxing	1.19 ± 0.08	1.19 ± 0.08
Spine		
Yoga	1.21 ± 0.14	1.18 ± 0.13
Cardio-kickboxing	1.24 ± 0.11	1.22 ± 0.12
Hip		
Yoga	1.02 ± 0.13	1.02 ± 0.13
Cardio-kickboxing	1.04 ± 0.11	1.04 ± 0.12

The physical activity classes did not affect bone mineral density at any of the sites (all p > 0.05).

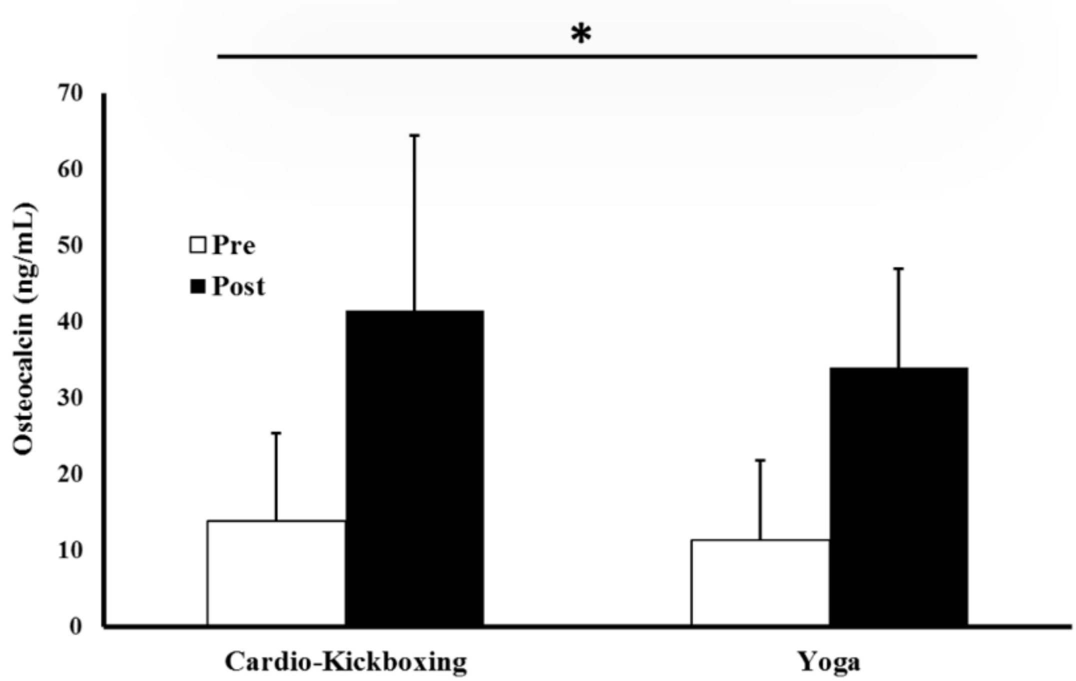

Figure 1. Blood osteocalcin concentrations significantly increased from baseline after 12 weeks of either cardio-kickboxing or yoga class meeting 50 min twice weekly. *p < 0.05 for main effect of time

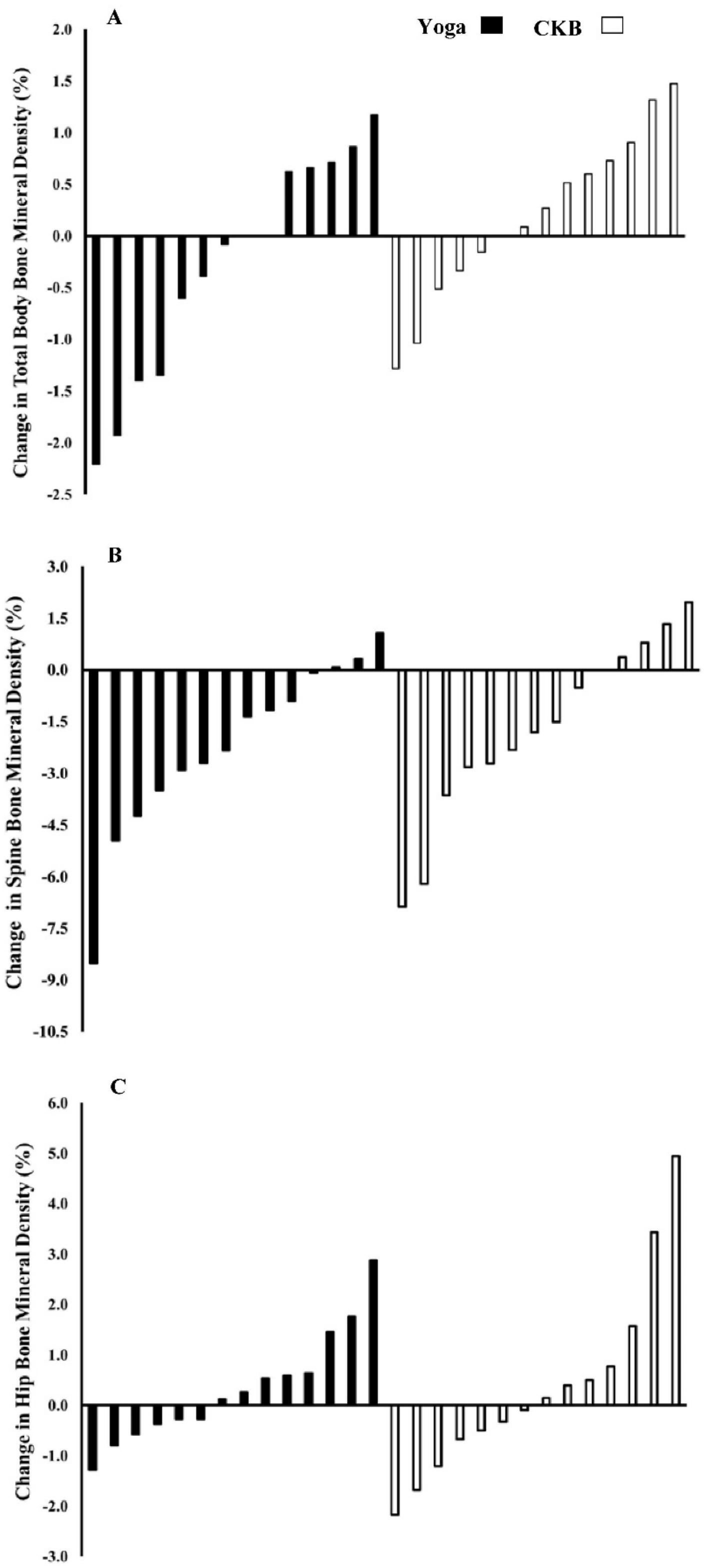

Figure 2. Individual percent changes in bone mineral density for sites A) Total Body; B) Spine; and C) Hip after 12 weeks of either cardio-kickboxing (right) or yoga (left) class meeting 50 min twice weekly.

DISCUSSION

We hypothesized BMD and OC levels would increase in women after 12 weeks of a yoga or CKB class. We also hypothesized there would be a greater increase in BMD and OC levels for those enrolled in the CKB class compared with those enrolled in the yoga class. However, the data did not support these hypotheses as BMD did not differ between yoga and CKB groups at any site scanned or pre to post intervention for either group. While BMD was not affected by either exercise regimen, OC concentration increased over time in both yoga and CKB groups. Our findings are in contrast to studies investigating effects of weight-bearing exercise on BMD. Zribi et al. (29) found a plyometric training program performed twice per week for 90 minutes each session resulted in increased total body BMD and serum levels of biomarkers, including OC, known to reflect bone growth. Authors attributed the results to the high bone strain rates and ground reactive forces associated with this form of exercise. Similarly, high impact, high-intensity resistance training performed three days per week was shown to positively affect femoral neck and lumbar vertebrae BMD in premenopausal women (6). On the other hand, the lower impact nature of the exercises and lesser frequency and duration of the sessions in the current study may explain the contrasting findings.
Somewhat unexpectedly, our findings also differ from those involving low- or non-weight-bearing exercise. Low impact T'ai Chi positively impacted BMD in women with osteoarthritis (25). Likewise, walking increased BMD in postmenopausal women with osteoporosis (26), as well as premenopausal women not considered osteoporotic (12). In a cross-sectional comparison, female swimmers were found to have greater radial and lumbar BMD compared to cross-country runners, who had greater lower-body BMD (22). Despite these contrasting findings, our results were consistent with those of Yoo et al. (25) where a 12-week walking program with ankle weights was used to assess fall-related fitness and psychological factors and bone metabolism. While BMD remained unchanged for all sites except for a significant decrease in BMD of the femoral Ward's triangle, OC concentration was significantly elevated from baseline.

Given the impact of other non-weight bearing exercise on BMD and markers of bone turnover, it is not clear why there was no effect of neither yoga nor CKB on BMD in the present study. Yoga exercise has been shown to be useful for flexibility, balance, and strength in young women (5), while CKB has been shown to improve power, anaerobic fitness, speed and agility (18). In other studies, involving a positive effect of low intensity activity, the subjects were either arthritic, osteoporotic, or osteopenic, whereas in the present study the subjects were young and asymptomatic. It may be that low impact exercise, such as yoga and CKB, is more beneficial for individuals with compromised bone health. Further research is necessary to substantiate this assertion, however.

While yoga and CKB did not benefit bone health over the 12 week length of the current study, these exercises have been proven to aid in the improvement of other aspects of health and physical fitness. Donahoe-Fillmore et al. (5) studied young women participating in yoga training twice per week and a walking program three times per week, for seven weeks. The yoga program significantly increased both right and left hamstring flexibility by 13% and 19%, respectively, after the 7-week intervention. Ouerqui et al. (18) noted significantly improved upper-body muscle power, aerobic power, anaerobic fitness, flexibility, speed and agility after 5 weeks of kickboxing performed three days per week with each session lasting 60 minutes in duration. Improved muscle power, or an increase in lean muscle mass, may also positively influence bone because of its effect on the mechanostat set-point and bone quality and size (17).

Even though BMD at all tested sites was not increased by the yoga or CKB classes, BMD was maintained at all sites. Ryan et al. (23) reported 16 weeks of resistance training did not increase BMD of the lumbar spine, femoral neck, Ward's triangle, and greater trochanter. However, BMD was maintained at these sites, and muscular strength was improved in the sample of healthy, older women (age 62 ± 1 y), suggesting that maintenance of BMD may be just as important as increasing it in terms of prevention of negative health outcomes associated with loss of bone density in advanced age (23).

Baseline OC levels for the subjects in this study were comparable to previously reported values and were within normal range for our age group (27). The inclusion of OC assessment in conjunction with BMD measurement provided additional insight into how the skeletal system was reacting to the imposed stimulus (i.e., yoga and CKB classes). OC was very active in both groups indicating the bone turnover, or breakdown process, was amplified. A high turnover rate suggests both exercise interventions provided enough of a stimulus to the skeleton to trigger the bone remodeling process. Because the first step in the remodeling process is the breakdown of a weak site and the entire lifecycle of bone takes approximately 4 months, the lack of an observed increase in BMD was not irregular. In fact, previous research by Danz et al. (4) found that after an exercise intervention of aerobic and anaerobic work, BMD of the distal radius decreased as a possible result of an increase in OC concentration. In studies with longer intervention periods than that used in the present study, OC concentrations significantly decreased (reflecting a lower bone turnover rate) after an exercise intervention, likely because adaptation had already taken place (3, 26). This effect was observed in work by Yamazaki et al. (23) where OC concentration was elevated during the initial 1-3 months of the exercise intervention followed by a subsequent decrease in OC throughout months 6-12 when exercise training was kept constant, i.e., volume, pattern and mode of exercise did not change. These findings suggest that with a longer intervention, BMD would have likely increased and OC levels decreased in response to yoga and/or CKB, providing evidence that bone adaptation had occurred.

While the OC results indicate that bone metabolism was positively affected by the exercise classes, certain limitations of the study should be acknowledged, such as not recording daily dietary intake or PA outside of class. However, not reporting subjects' PA outside of class was not considered a confounding factor since subjects were instructed to maintain baseline levels of PA for the duration of the study and no increase in BMD was found in either the yoga or CKB group.

Subjects were not required to arrive on the day of testing having fasted overnight and not having engaged in strenuous activity. It is important to note that other than the removal of any metal items from the body area to be scanned, no additional preparation is required for the person being scanned (13). Additionally, Nana et al. (16) showed the amount of measurement error to be trivial for DXA measurements of bone mineral content in women taken after exercise and with ad libitum food and fluid. Finally, the stimulus to bone may have been variable within each class because some subjects may have engaged in class more intensely than others. The timeline of 12 weeks is brief considering the lifecycle of bone and the time course of increased BMD, and low-impact PA performed two days per week for 50 min may not have been a sufficient stimulus to affect bone metabolism. Nonetheless, this was the volume of PA featured in these exercise classes, and the focus of the study was on whether participation in such classes resulted in effects on bone.

In conclusion, while BMD did not change with participation in a 12-week yoga or CKB class, serum OC, which has been associated with bone growth and bone turnover (21, 24, 26, 29), did increase in both the yoga and CKB groups. Some studies have found OC to increase (4, 28, 29), 26) while others have found it to decrease (3, 26), most likely due to the length of the intervention as well as imposed stimuli. It seems that during short interventions, e.g. 12 weeks, OC levels will increase, indicating an increased rate of bone turnover, suggesting a positive impact of these activities on bone health. Future studies should include a control group that is comparable to the population being tested, e.g., similar age, sex, and baseline PA level. Additionally, whether CKB or yoga performed in greater volumes or for longer durations affects BMD remains to be determined.

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