

Research

The Effect of Yoga on Markers of Bone Turnover in Osteopenic Women: a Pilot Study

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Abstract: *Weight-bearing exercise is recommended to improve bone density. Hatha Yoga is a popular form of weight-bearing exercise that includes physical postures, stretching, breathing, and relaxation. We hypothesized that Hatha Yoga would have beneficial effects on bone turnover markers. We conducted a small feasibility pilot study with a prospective, pre-post design comparing markers of bone turnover before and after Yoga training in sedentary osteopenic postmenopausal women. Markers of bone formation were measured with serum bone-specific alkaline phosphatase (BAP). Measures of bone resorption were measured with urinary type I collagen cross-linked N-telopeptide (uNTX). Seven participants completed a 12-week series of one hour per week Yoga classes, in addition to home Yoga practice. We analyzed the correlation between time spent on Yoga and time spent on other weight-bearing exercise and change in bone turnover markers. The amount of Yoga practice was significantly correlated with BAP levels ($r = 0.68$, $p = 0.09$). A weaker, non-significant correlation was found between the amount of Yoga practice and uNTX levels ($r = -.54$, $p = .21$). Compared to Yoga, other physical activities were less correlated with BAP and uNTX levels. Yoga may have beneficial effects on bone turnover in osteopenic postmenopausal women.*

Keywords: *Yoga, exercise, osteopenia, osteoporosis, bone turnover*

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Introduction

Osteoporosis is one of the most common skeletal disorders. Today in the United States, 10 million individuals have osteoporosis and 34 million more have low bone mass, or osteopenia, the precursor to osteoporosis.¹ Of the people affected by this problem, 68% are women.¹ Osteoporosis is characterized by low bone mass and microarchitectural disruption, leading to less structural support and an increased fracture risk.² Hip fracture specifically has been shown to be a major problem, leading to increased morbidity and

mortality.³ In addition, osteoporotic fractures are responsible for a large portion of healthcare spending. In 2005, the healthcare cost of osteoporosis was an estimated \$19 billion.⁴ Efforts to prevent fracture by treating and preventing osteoporosis are critical to reducing this common cause of morbidity, mortality, and health service utilization.

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Interventions for Osteopenia and Osteoporosis

Several modalities of treatment are used to prevent the bone loss and increased fracture risk associated with osteopenia and osteoporosis. Bisphosphonates, selective estrogen receptor modulators, and calcitonin are commonly used in postmenopausal women.⁵⁻⁷ Calcium and vitamin D supplementation of approximately 1500 mg/day and 400 IU/day respectively may all increase bone mineral density to a small extent.⁸

Weight-bearing exercise is another treatment modality that is often recommended to improve bone density. Exercise can reduce fracture risk by increasing bone density, improving muscle mass and strength, and improving dynamic balance.⁹ An exercise as simple as regular walking may decrease the risk of hip fracture in postmenopausal women compared to those who do not walk for exercise.¹⁰ The benefits of physical fitness can be attained not only through traditional forms of exercise such as aerobics, weight-lifting, jogging, and walking but also through nontraditional forms of exercise. For example, one study found that Tai Chi exercise helped retard bone loss in weight-bearing bones in postmenopausal women as assessed by repeat DEXA scan after 12 months of Tai Chi exercise.¹¹

Yoga as an Intervention for Osteopenia

Hatha Yoga is an exercise modality that has been rapidly gaining popularity in Western culture as a means to achieve physical fitness. There are now an estimated 18 million U.S. practitioners, up from 6 million in 1994.¹² Yoga is available at community centers, churches, and workplaces, in addition to standard fitness facilities and Yoga centers.

Yoga is considered by many to mainly improve flexibility. However, many Yoga poses require considerable strength to maintain. In one study, participants showed increased muscular strength and endurance after an eight-week Yoga program.¹³ In addition to improving strength and flexibility, Yoga has been described as beneficial in a variety of medical conditions, including asthma, coronary artery disease, hypertension, and osteoarthritis.¹⁴⁻¹⁵

In light of its ability to increase muscular strength, Yoga may, like other forms of exercise, lead to beneficial effects in treating osteoporosis and osteopenia, such as the ability to retard bone loss and prevent fractures. We designed this study to test the hypothesis that osteopenic women who practice Yoga for 12 weeks would show improvement in

clinically important markers of bone turnover. We planned a pilot feasibility study to determine study logistics, barriers to participation, and effect size. Because we had not studied Yoga in this population, we wanted to explore how well the study would be able to recruit participants and minimize attrition. Due to limited funding, we chose the design to be pre-post, with each subject functioning as his or her own baseline control.

Clinically Relevant Outcomes for Women with Osteopenia

The development of osteopenia and osteoporosis are strongly related to the changes in bone turnover that occur with aging. One study showed that rates of bone formation (BAP) and resorption (uNTX) are high in elderly women, with bone resorption increasing more than bone formation, and acting as the major determinant of bone mass.¹⁶

Biochemical markers of bone formation and resorption may play an important role in monitoring therapy. In a recent review of clinical studies in which bone turnover markers were measured after beginning treatment with a bisphosphonate, the suppression of bone turnover markers occurred after as little as three months of therapy. This suppression in bone turnover markers was also associated with reduction in risk for fracture.¹⁷ Bone turnover markers, such as bone-specific alkaline phosphatase (BAP) and urinary type I collagen cross-linked N-telopeptide (uNTX), can be used to assess in the relatively short term whether bone turnover is being positively or negatively affected by an intervention.¹⁸

In the present study, we compared baseline levels of bone turnover markers with bone turnover markers at the end of the intervention and follow-up.

Methods

Participants

Women were eligible for enrollment if they had osteopenia diagnosed by DEXA scan (T score of -1.0 to -2.5). They were also required to express willingness to participate in the 12-week Yoga class, undergo testing of bone turnover markers before and after the Yoga intervention, and provide a self-assessment on quality of life after completing the intervention. All participants were advised to begin or continue taking calcium (1500 mg) and vitamin D (400 IU) supplements, as these supplements are standard of care for postmenopausal women with osteopenia. These supplements would be expected to have a minimal effect on markers of bone turnover.

Patients were excluded from the study if their osteopenia was a result of some other known process, such as hyperparathyroidism, metastatic bone disease, multiple myeloma, or chronic steroid use. We also excluded women who were currently taking bisphosphonates, calcitonin, serum estrogen receptor modulators (SERMs), or hormone replacement therapy (HRT), or if they had taken these agents in the past three months. Women already performing Yoga or another regular exercise regimen (defined as 30 minutes most days of the week) were excluded as well. Patients with contraindications to Yoga such as recent surgery, acute sciatica, herniated discs, joint replacements, glaucoma, or severe uncontrolled hypertension were not eligible to participate in this study. In addition, patients who reported limitations in their activity due to chronic pain or joint problems were not permitted to participate in the study. The University of Pittsburgh Institutional Review Board approved the protocol prior to initiation of study procedures, and all participants gave written informed consent.

Baseline Measurements

Upon enrollment, baseline levels of the serum bone formation marker, bone-specific alkaline phosphatase (BAP), and the urinary bone resorption marker, urinary N-telopeptide (uNTX), were measured in all participants via standard process at the University of Pittsburgh Medical Center. Once a cohort of ten participants had been recruited, the Yoga class series began. If participants waited at least eight weeks from the time of enrollment to the start of the classes, we measured bone turnover makers again prior to starting the Yoga classes. Participants were interviewed regarding consumption of alcohol, caffeinated beverages, and tobacco.

The Yoga Intervention

All of the participants received medical clearance from their physicians to participate in the Yoga practice without any restrictions to their spinal movements (spinal flexion, extension, rotation, and lateral flexion). Yoga classes occurred once a week for 12 weeks and were taught by a 200-hour Registered Yoga Teacher (RYT) (Author: LMB). Each class lasted 60 minutes and was taught in a beginner-level YogaFit format. The foundation of a YogaFit practice makes safety a priority. All poses taught in a YogaFit practice utilize proper body mechanics and modifications to promote safety and well-being. Each participant was encouraged to participate at her level of comfort and ability, avoiding any hyperflexion or hyperextension of the spine and joints. The Yoga instructor guided the practice and facilitated the participants practice using tactile, visual, and verbal cueing.

The practice included body awareness exercises, standing poses, sitting poses, twists, one-leg and two-leg balancing poses, gentle inversions, and relaxation exercises. The poses were specifically chosen as most likely to benefit but not injure osteopenic women. We created a weight-bearing sequence using poses that give maximal bone loading with body weight. The sequence also included quadruped positions and preparations for forearm balances to enhance weight-bearing in the arms, while the gentle inversions were to promote weight-bearing on the middle thoracic spine. A breathing practice began each session, and a relaxation practice concluded each session; positive affirmations were incorporated throughout the practice.

Participants were asked to practice the Yoga poses for 30 minutes on most days of the week. We created a 30-minute audio CD for the participants' home practice. We also gave participants a handout of the Yoga sequence with photographs of the poses and a diary to record their home practice.

Safety Monitoring

For this short-term pilot study, we did not have an interim data analysis or a formal data safety monitoring board. Instead, the Yoga instructor (LMB) was prepared to report any possible injuries or unexpected events to the principal investigator (JB). No injuries or unexpected events were observed or reported by the participants at any time during or after the 12-week session. The principal investigator, who was not involved with the Yoga intervention, also reviewed the participants' medical charts after the class series had finished.

Outcomes

Upon completion of the 12-week Yoga course, repeat serum measurements of the bone turnover markers, BAP and uNTX, were obtained from participants within one week of the final Yoga class. The change in bone turnover markers between enrollment and class completion was our primary outcome measure. The secondary outcome was compliance with the Yoga program as assessed by attendance at class and the Yoga diary.

Statistical Analysis

Baseline and post-Yoga levels of our primary outcomes, serum BAP and urinary NTX were calculated and averaged. In addition, we calculated each individual's percent change in bone turnover marker levels and correlated these changes in bone turnover markers with the amount of Yoga practice reported by the participants. We also included potential

confounders such as current or past cigarette smoking and alcohol and caffeine consumption, as individuals with these risk factors may show less improvement in their bone turnover markers. Because of the limited number of participants and the pilot nature of this underpowered study, more complex modeling and analyses were not possible.

Results

Participant Recruitment and Retention

Nineteen participants were screened. A total of 13 participants were enrolled in the study. Prior to the start of the Yoga intervention, five participants withdrew from the study. All cited “too little time for participation” as the reason for withdrawal. Eight participants completed the Yoga class series. Characteristics of the eight participants completing the Yoga classes are summarized in Table 1.

| Characteristic | Mean (SD) |
|-------------------------------|--------------|
| Age | 55 (4.5) |
| BMI (kg/m ²) | 28.6 (10.4) |
| T-score | -1.69 (0.37) |
| Cigarettes (#/day) | 0 |
| Alcoholic beverages (#/week) | 0.5 (1.1) |
| Caffeinated beverages (#/day) | 1.5 (0.9) |
| uNTX before Yoga | 27.0 (8.7) |
| BAP before Yoga | 10.8 (3.0) |
| Yoga (minutes) | 11.4 (7.1) |

Table 1. Descriptive characteristics of enrolled participants.

Bone Turnover Markers

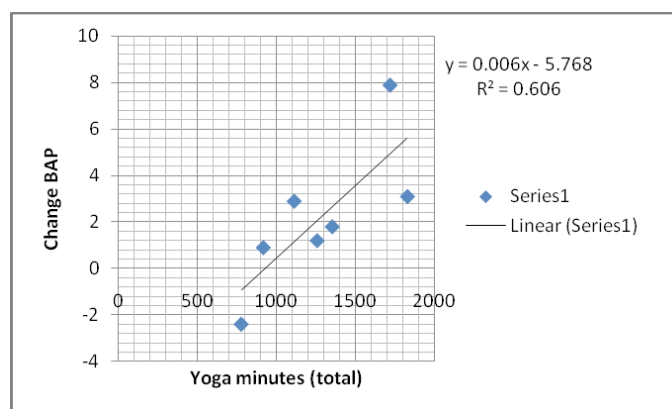
For the eight participants who completed the Yoga series, follow-up bone turnover marker measurement was scheduled within one week of the final Yoga class. This follow-up bone turnover marker measurement was obtained for seven of the eight participants (87.5%).

For these 7 participants, the percent change in BAP ranged from -15.8% to 85.9%, with a mean percent change of 25.9% (SD = 32.8). The percent change in uNTX ranged from -60% to 326%, with a mean percent change of 65% (SD = 133.7).

Ideally, bone formation (BAP) will increase and bone resorption (uNTX) will decrease. However, after menopause, rates of bone formation (BAP) and resorption (uNTX) are both high in elderly women, with bone resorption increasing more so than bone formation.¹⁶ The observed change scores

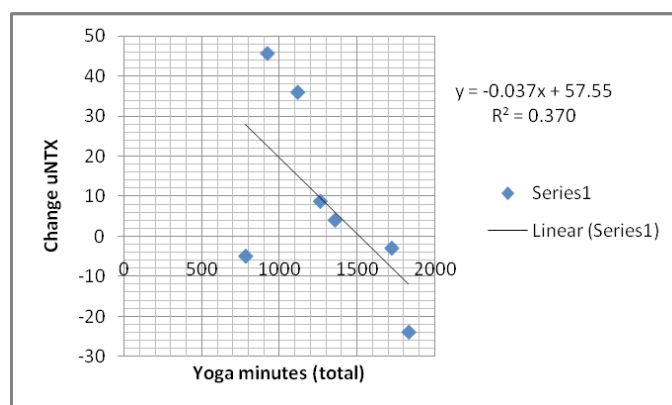
reflect this general trend in the population, with a wide range of changes in both bone formation and resorption.

Because of the small sample size and large range of change, we correlated the amount of Yoga practice with change scores. Figures 1 and 2 show the relationship between minutes of Yoga practiced and change in bone turnover markers. Minutes of Yoga practice, which included class attendance and home practice, was highly correlated with the change in BAP levels ($r = 0.68, p = 0.09$). As Yoga duration increased, bone formation markers increased. A weaker non-significant negative correlation was found between the amount of Yoga practice and change in uNTX levels ($r = -0.54, p = .21$), meaning that as minutes of Yoga increased, the marker for bone resorption decreased somewhat. Although only three participants showed reduction in bone resorption, it appeared that Yoga duration was associated with a trend towards improvement.



$r = 0.68, p = 0.09$

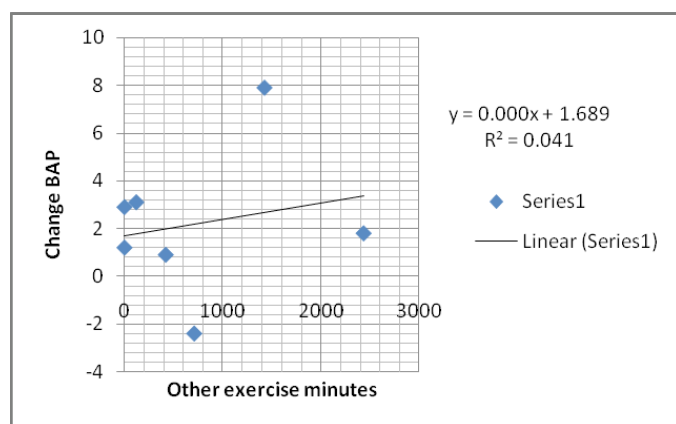
Figure 1. Relationship between change in BAP and total minutes of Yoga practice.



$r = -0.54, p = 0.21$

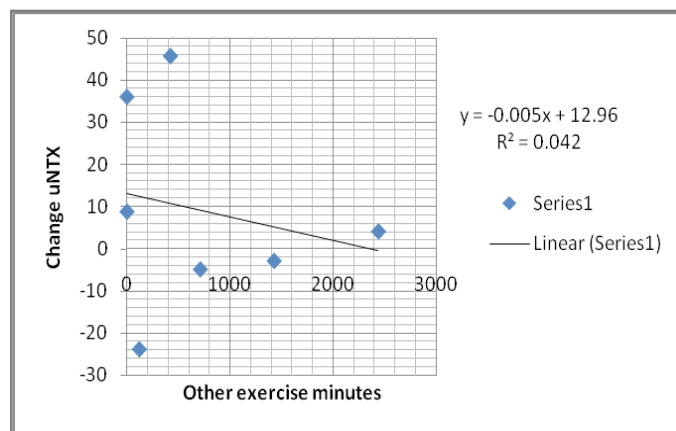
Figure 2. Relationship between change in uNTX and total minutes of Yoga practice

In addition to the primary outcome measure of change in bone turnover markers, we also examined compliance with the Yoga regimen by tracking class attendance and consistency of Yoga practice outside of class with the diary. Participants recorded the number of minutes they practiced Yoga each day as well as the number of minutes dedicated to other exercise each day. Over the course of the study, participants practiced Yoga on average 682 minutes, standard deviation 427; the mean number of minutes spent practicing Yoga plus other exercise was 1413, standard deviation 990. Other exercise by this subject population included walking and running. Swimming was not included in the calculation of other exercise, as this is not a weight-bearing activity and therefore not expected to have a significant effect on bone turnover.



$$r = .50, p = 0.27$$

Figure 3. Relationship between change in BAP and total minutes of other exercise.



$$r = -0.42, p = 0.34$$

Figure 4. Relationship between change in uNTX and total minutes of other exercise.

Figures 3 and 4 show the relationship between exercise other than Yoga and change in bone turnover markers. Recall that all of the participants were sedentary prior to the intervention, and any exercise during the Yoga intervention would have represented a change in physical activity. We wanted to account for any possible effects on bone turnover, as well as compare the effects of other exercise and Yoga. Based on statistical correlation testing, exercise other than Yoga was not significantly associated with bone turnover markers compared to Yoga alone (change in BAP related to other exercise, $r = 0.50$, $p = 0.27$; change in uNTX, $r = -0.42$, $p = 0.34$).

Observationally, the Yoga teacher and the participants noted that, as expected, strength and endurance improved. Participants could hold the poses for longer periods of time without muscular fatigue (endurance) and could practice poses that required additional strength (beginning arm balances, quadruped positions).

Discussion

Summary of Findings

Our study was not powered to show a difference in bone turnover markers; rather, we wanted to investigate feasibility and whether a trend toward improvement in bone turnover could be seen. On average, participants in the 12-week Yoga program showed improvement in bone turnover. In addition, minutes spent practicing Yoga positively correlated with increase in bone formation and negatively correlated with increase in bone resorption. These markers trended in the hypothesized directions, toward improvement and reduced risk for osteoporosis. Interestingly, other weight-bearing exercise (e.g., walking) did not show this correlation as strongly.

These findings are encouraging, given the very small sample size. Although the group did not, on average, show a decrease in bone resorption, the finding that several women demonstrated a decrease in the resorption marker is encouraging. In menopause, one would expect a continued increase in bone resorption.

If Yoga protects bones, as we suspect it does based on this preliminary finding, then it may be an ideal form of exercise for the aging population. Yoga is an enjoyable form of exercise for many women, and finding a form of exercise that participants will comply with is key to maintaining health, particularly bone health.

Limitations

The main limitation of our study is the small sample size. Our pilot study had a limited number of participants, and it was not randomized. Lack of a comparison control group

makes it difficult to interpret the effect size compared to the expected outcomes of no intervention or other interventions. However, because all of the women had osteopenia and were inactive, one would expect that without effective intervention, their bone turnover markers would continue to show overall bone resorption. The observed outcomes suggest that the Yoga intervention slowed this expected trajectory.

Lastly, we did not formally measure intake of calcium, Vitamin D, and other bone nutrients. Because all participants were recommended to begin or continue taking calcium and Vitamin D, this intervention alone potentially could have impacted our outcome measures. However, all women of this age are recommended to take calcium and Vitamin D, and not recommending these supplements to women with known osteopenia would have been unethical.

Conclusions

This study lays the groundwork for additional studies investigating the use of Yoga as a form of exercise helpful for osteopenia. Participants at risk for bone loss, such as those in early menopause or on medications such as steroids, could potentially benefit from Yoga and should be included in future studies. As with any clinical population, studies including women with osteopenia must also include standard of care.

In conclusion, it appears that adequate duration of Yoga practice may improve bone health in osteopenic postmenopausal women. Larger, controlled trials assessing the long-term impact of Yoga on bone health are indicated.

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