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Yoga as an Intervention to Promote Bone and Mental Health in Adolescent Females with Anorexia Nervosa: A Pilot Study

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Abstract

In this randomized pilot study, we examined the effects of a yoga intervention on axial and peripheral bone mineral density (BMD), disordered eating cognitions, anxiety, and depression in adolescent girls with anorexia nervosa (AN). Fifteen young women aged 13–18 years with AN or atypical AN were randomized to either a Yoga group (n=7), including twice-weekly yoga for 24 weeks plus standard outpatient care, or Non-Yoga group (n=8), who received standard outpatient care alone. Data from anthropometrics, mental health and eating behaviors questionnaires, dual energy x-ray absorptiometry and peripheral quantitative computed tomography measurements were obtained at baseline and six months. The adjunct of yoga to standard treatment resulted in statistically significant improvement of axial BMD, depression, and disordered eating cognitions,

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in comparison to the Non-Yoga group. In conclusion, a gentle yoga intervention may be beneficial for improving bone and mental health in adolescent females with AN.

Keywords

eating disorders; bone density; yoga; depression

Introduction

Adolescents with AN are at risk for medical comorbidities, including decreased bone mineral density (BMD) and mental health challenges (Golden et al., 2015). There is a pressing need to expand available treatment options and improve health outcomes.

Individuals with AN may experience long-term complications due to nutritional deficits. Low BMD is a primary concern due to possible irreversible skeletal deficits (Golden et al., 2015; Misra & Klibanski, 2014). Although recovery from AN leads to restoration of many hormonal changes, low BMD can persist following achievement of a normal body mass index (BMI) and resumption of menses (Golden et al., 2015; Misra & Klibanski, 2014). Importantly, the pubertal years are critical for bone accrual and the achievement of peak bone mass (Misra & Klibanski, 2014).

The most important treatment strategy for managing a low BMD in adolescents with AN is return to and maintenance of a normal weight, hormonal balance, and regular menses (Golden et al., 2015; Misra & Klibanski, 2014). Regular physical activity has been shown to have a positive effect on bone recovery and skeletal strength during adolescence (Gordon et al., 2017). Yoga not only strengthens joints and muscles around bones, but promotes stress reduction, and introduces physical postures that increase flexibility, coordination, and strength that when coupled with breathing practices and meditation, diminish anxiety (Ostermann et al., 2019; Rizzuto et al., 2021).

Most affected individuals with AN experience anxiety, depression, or both (Golden et al., 2015). Recent studies have shown that yoga helps decrease food preoccupation and disordered eating cognitions (Borden & Cook-Cottone, 2020; Carei et al., 2010) and may also help decreasing anxiety, depression, and body image disturbance in adolescent girls with AN (Hall et al., 2016; Rizzuto et al., 2021). Although yoga has been used in previous studies as an intervention to examine mental health outcomes, to our knowledge this study is among the first to examine the effects of this intervention on bone density and mental health outcomes in adolescents with AN. The aim of this pilot study was to examine the effects of a twice weekly yoga intervention on axial and peripheral BMD of adolescent females with AN and evaluate its effects on anxiety, depression, and disordered eating cognitions.

Materials and Methods

Fifteen young women, age 13–18 years, diagnosed with AN and treated in an outpatient eating disorders (ED) program were enrolled in an IRB-approved randomized controlled trial. All participants met DSM-5 (American Psychiatric Association, 2013) criteria for AN

or Atypical AN and were hemodynamically stable. Exclusion criteria included: concomitant chronic disease, severe depression, use of hormonal contraceptives, hospitalization, pregnancy, or carriers of orthodontic material.

The multidisciplinary outpatient care team included an adolescent medicine provider, dietitian, therapist (psychologist or social worker), and psychiatrist. The treatment framework included Family Based Therapy and parents were encouraged to support the nutritional protocol. The Yoga group participated in beginners' level classes using a standardized structure. Instructors had at least 200-hour registered yoga hours and received training by the research team. Yoga was conducted in a large yoga studio and the participants were required to choose from approved low-intensity yoga classes. Classes followed a standardized "yoga class arc structure" which began with initiating the *Yogic process* (release of tension and tightness in the body and gentle breathing meditation) and ended with *Integration* (guided meditation and visualization, and a return to normal breathing). The most active component was *Peak Exploration* which involved balancing poses and sun salutations to improve balance and flexibility.

Seven participants were randomized to the Yoga group (twice-weekly yoga for 24 weeks plus standard outpatient care). Eight participants were randomized to the Non-Yoga group and received standard outpatient care only. Dual-energy x-ray absorptiometry (DXA) was used to measure BMD. We considered a 3% increase in BMD to be clinically significant. Peripheral quantitative computed tomography (pQCT) was used to assess the volumetric density, structural and geometric properties of the bone. DXA and pQCT were performed at baseline and the 6-month visit.

Anthropometric measures and compilation of validated psychological and nutritional Questionnaires were performed at baseline and 6-month visits: State of Mind Questionnaire including the Beck Depression Inventory (BDI) and Eating Disorders Inventory II (EDI-II) for assessing the severity and change of clinical state in AN; Spielberger State-Trait Inventory (to assess anxiety); Eating Attitudes Test 26-Item (EAT-26); and the Eating Disorders Examination Questionnaire (EDE-Q). Nutritional intake was assessed using the Youth/Adolescent Questionnaire (YAQ). Independent sample t-tests were used to evaluate the difference in anthropometric measurements, bone density and mental health questionnaires between the two groups.

Results

There were no significant differences in demographics between the Non-Yoga and Yoga groups, indicating a successful randomization (Table 1). At baseline, the mean age of participants was 16.3 ± 1.3 years (Non-Yoga 16.6 ± 1.2 , Yoga 15.9 ± 1.3 years, $p=0.3$). Mean weight, height, BMI and fat percentage were 51.9 ± 4.7 kg, 163.8 ± 5.4 cm, 19.3 ± 1.3 kg/cm², and $30.9 \pm 3.8\%$ with no difference between the Non-Yoga and Yoga groups. At baseline, 6 participants reported amenorrhea and 7, normal menses [Non-Yoga 1/6 (data not available for 2 participants), Yoga 5/7 participants]. Participants in both groups gained weight (Non-Yoga 1.7 ± 3.2 kg, Yoga 3.1 ± 2.2 kg). However, there were no statistically significant changes

in weight, height, BMI, fat mass and percentage, lean body mass, and nutritional intake between the groups, before and after the intervention.

The participation rate of the Yoga group was 90.5% (range 83–100%). At six months, the Yoga group showed a non-significant positive trend in both body fat and lean body mass measures, compared to the Non-Yoga group (Table 1). While no changes in peripheral BMD (obtained via pQCT) were observed, participants in the Yoga group showed improvement in both axial BMD [$+0.02 \text{ g/cm}^2$ in the Yoga group (mean increase of $+2.48\%$) vs. -0.01 g/cm^2 in the Non-Yoga group (mean decrease of -0.64%), $p < 0.05$] and BMD Z-score of the anteroposterior lumbar spine ($+0.04$ in Yoga group vs. -0.19 in the Non-Yoga, $p < 0.05$). While all Non-Yoga participants' axial BMD Z-score had either decreased or did not change between baseline and 6-month, most ($n=6$, 86%) of the Yoga participants' axial BMD and/or axial BMD Z-score showed significant improvement. Two Yoga participants also improved clinically ($>3\%$ increase in axial BMD). Bone density measures of the Non-Yoga participants, and all but one of the Yoga participants were within normal limits throughout the study. One Yoga participant had a low BMD according to the International Society for Clinical Densitometry (ISCD) criteria and showed improvement in all bone and mental health measures at 6-months.

The changes in mental health questionnaires scores between groups are summarized in Table 2. The Yoga group showed statistically significant improvement in the BDI ($p=0.049$) and EDI-II scores ($p=0.02$), as well as trends noted in the EDE-Q eating, shape and weight scores which did not meet statistical significance. No differences in eating habits, anxiety (Spielberger State and Trait scores), or EAT-26 scores were observed.

Discussion

To our knowledge, this pilot study is among the first to explore the introduction of yoga as an effective intervention to improve bone health in adolescent females with AN, as well as an effective adjunctive treatment to improve AN symptoms, anxiety, and depression. Adolescents with AN often attempt to control psychological symptoms through exercise. The substitution of gentle yoga for more strenuous activity may be an alternative strategy as concern arises regarding the impact of caloric expenditure from exercise on weight. Yoga affords an opportunity for engagement in a low impact physical activity, while providing an outlet for anxiety and depression (Borden & Cook-Cottone, 2020; Rizzuto et al., 2021) and the current participants were exceptionally compliant with a yoga intervention.

Previous studies of adults have examined the impact of yoga in augmenting bone health. A ten-year study of 741 adults with documented osteoporosis showed improvement in spinal BMD following a 12-minute daily yoga regimen (Kim et al., 2015). In the current study, axial bone density (lumbar) improved significantly after 6 months of yoga, while all Non-Yoga participants' axial BMD either decreased or did not change. The mean decrease in BMD in the Non-Yoga group may be explained by relative inactivity among the control participants, supporting the potential value of a simple intervention such as yoga. Considering the possible deleterious effects that low energy balance may impose on bone

health during adolescence (Misra & Klibanski, 2014), these findings are encouraging and worthy of further study.

Previous studies exploring yoga on other dimensions of health in the AN population have been few and carried out primarily in adults, but have shown encouraging improvements in disordered eating cognitions, depression, and anxiety (Borden & Cook-Cottone, 2020; Ostermann et al., 2019). Carie et al. implemented a yoga intervention with adolescents diagnosed with AN and showed decreased disordered eating cognitions and food preoccupation after an 8-week intervention (Carei et al., 2010). A pilot study by Hall et al. showed decreased anxiety, depression and disordered eating cognitions after a 12-week yoga intervention, without any adverse effects on weight or BMI (Hall et al., 2016). In the current study, we similarly did not observe weight loss. In our study, weight and BMI increased for both groups. Caloric expenditure in AN is a major concern, and therefore, these trends in weight and BMI in the Yoga group were again reassuring. The safety of yoga as an adjunct treatment for individuals with AN was previously reported in a meta-analysis (Ostermann et al., 2019). Yoga appears to offer a means by which adolescents with AN can engage in physical activity without significant caloric expenditure.

Our pilot study supports yoga as an effective adjunctive intervention to improve AN symptoms among adolescents. Our results showed differences in outcomes for the Yoga and Non-Yoga groups over time in eating psychopathology, with the Yoga group showing improvement in the BDI scores, EDI-II scores and EDE-Q Eating scores. While not statistically significant, the trends in the participants' scores on the Eating, Weight and Shape Concern subscales of EDE-Q appeared to be in line with prior studies (Carei et al., 2010) supporting the hypothesis that yoga might reduce food preoccupation as well as body image concerns.

Despite promising results, this study has limitations. The small sample of participants reduced statistical power to examine fully the effect of this intervention. The results may not be generalizable to inpatient, partial hospitalization, or residential clinical models. Nonetheless, despite the small sample size, encouraging trends were seen in spinal BMD and disordered eating cognitions. The results also suggest that yoga could be used to augment bone health in adolescents with AN independent of their BMD at the initiation of this intervention.

This unique pilot study evaluated the short-term outcomes of an adjunctive yoga intervention on bone and mental health in a group of adolescent females in an outpatient ED clinic. The results provide safety and feasibility data regarding an intervention that could be used in clinical care and one that should be replicated in future studies. Menstrual function as a predictor of bone health should be carefully interpreted in future studies since the return of menses can be delayed even after weight has normalized. Future studies of a larger sample size are needed to continue to explore the benefits associated with yoga as an adjunct intervention to standard outpatient care.

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Clinical Significance

- Yoga can safely replace physical activities in adolescents with anorexia nervosa
- Yoga may improve bone health in adolescents with anorexia nervosa
- Yoga has a positive effect on mental health and disordered eating cognitions

Table 1

Changes in anthropometric measures and bone density (axial and peripheral) after six-month intervention:
Non-Yoga vs. Yoga groups

Anthropometrics	Non-Yoga	Yoga	p-value
Weight, kg	1.71	3.21	0.34
Height, cm	-0.08	0.17	0.60
Body mass index (BMI), kg/m ²	0.67	1.14	0.43
Dual Xray Absorptiometry			
Fat, grams	488.60	1920.20	0.20
Lean Body Mass, grams	532.60	1156.90	0.39
Total Body BMD, g/cm ² (Z-score)	-0.0005(-0.03)	0.003(-0.16)	0.67(0.21)
Forearm (Radial)BMD, g/cm ² (Z-score)	0.01(-0.01)	0.00(0.02)	0.55(0.45)
AP, Lumbar Spine BMD, g/cm ² (Z-score)	-0.01(-0.19)	0.02(0.04)	0.03(0.01)
TBLH BMD, g/cm ² (Z-score)	0.00(-0.06)	0.03(-0.1)	0.31(0.73)
Peripheral Quantitative CT			
Tibial Trabecular vBMD, g/cm ³	-6.41	5.94	1.15
Tibial Cortical vBMD (38, 66 [*]), g/cm ³	2.80,5.14	5.74,20.76	0.38,0.14
Tibial Cortical CSA (38, 66 [*]), mm ²	2.14,4.32	-2.65,11.93	0.38,0.34
Radial Trabecular vBMD, g/cm ³	-6.41	5.94	0.16
Radial Cortical vBMD (38, 66 [*])(g/cm ³)	2.66,-5.99	3.59,-1.89	0.87,0.71
Radial Cortical CSA (38, 66 [*])(mm ²)	-0.16,0.42	4.86,-0.31	0.28,0.8

AP-Anteroposterior

TBLH-Total Body Less Head

vBMD-Volumetric Bone Mineral Density

CSA-Cross Sectional Area

* Two radiological slices were obtained at the 38% (distal) and the 66% (proximal) location of tibial/radial length.

Table 2

Changes in mental health questionnaires average scores after six-month intervention: Non-Yoga vs. Yoga groups

	Non-Yoga			Yoga			p-value
	Baseline	6-months	Difference	Baseline	6-months	Difference	
BDI	21.38	15	-6.38	25.14	10.85	-14.28	0.049
EDI-II	8.62	8.62	0	12.14	6.57	-5.57	0.02
EAT-26	23.38	13.88	-9.50	28	13.72	-14.28	0.41
Spielberg State	47.38	42.75	-4.63	50.85	42.57	-8.28	0.41
Spielberg Trait	49.75	47.62	-1.63	51.85	46.71	-5.14	0.31
EDE-Q Restraint	2.02	1.32	-0.70	2.80	1.55	-1.25	0.18
EDE-Q Eating	1.93	1.45	-0.48	2.82	1.42	-1.4	0.1
EDE-Q Shape	3.57	2.94	-0.63	3.94	2.48	-1.46	0.29
EDE-Q Weight	2.92	2.52	-0.40	3.28	2.03	-1.25	0.07

BDI-Beck Depression Inventory

EDI-II-Eating Disorders Inventory

EAT-26-Eating Attitudes Test 26-Item

EDE-Q-Eating Disorders Examination Questionnaire