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Hatha Yoga for Pediatric Obesity: A Pilot Study

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Abstract

Objective: Little is known about the benefits of yoga for pediatric obesity, and no studies have examined the benefits of yoga for physical activity in either adults or children. The purpose of this pilot study was to examine whether Hatha yoga would improve overall, physical and psychosocial functioning in youth with severe obesity. We also sought to determine whether participants would increase the vigor of, and time spent in, physical activity.

Methods: This study utilized a pre-test/post-test design. Sixteen youth with severe obesity completed an 8 week Hatha yoga intervention involving fifteen, 60-minute classes. Physical and psychosocial functioning, fitness and state-anxiety were assessed at baseline and post-intervention; parents completed proxy-reports of physical and psychosocial functioning at both time points. To assess physical activity, participants wore an Actical Accelerometer for 7 days pre and post-yoga.

Results: Significant improvements were found in: Overall, Physical and Psychosocial functioning, back and hamstring flexibility, and state-anxiety. Changes in the proportion of time spent in both light and moderate levels of physical activity were marginally significant. Although 3 tests of fitness, and time spent in physical activity did not improve significantly, trends were in the expected direction.

Conclusions: Youth with severe obesity may benefit from a Hatha yoga intervention. Yoga may also offer a way to engage in physical activity that is not precluded by bodily pain.

Keywords: Body mass index; Pediatric obesity-psychology; Pediatric obesity-therapy; Pain; Anxiety; Yoga; Pediatric Obesity

Abbreviations: Physical Activity (PA)

Hatha Yoga for Pediatric Obesity: A Pilot Study

In the United States, 17% of 2-19 year olds are obese [1,2], and severe obesity (>99th percentile for gender and age) is the fastest-growing subcategory of pediatric obesity, affecting between 4-6% of youth [3]. Pediatric obesity is associated with functional impairments and disability. Examples include increased pain, impaired cardiorespiratory fitness, decreased muscle strength, inefficient gait, and reduced locomotor capacity [4-7]. For adults with overweight or obesity, yoga has been shown to provide physical and mental health benefits, such as reductions in back and joint pain, weight, depression, stress, and anxiety, and improvements in musculo-skeletal flexibility [8]. Despite these benefits for adults, little is known about the benefits of yoga for youth with obesity [8,9].

In a recent literature review focused on yoga for the management of obesity [8], only 4 studies involved pediatric samples, and only 2 of the studies were focused solely on yoga as the intervention. Yoga related benefits included significant improvements in a variety of metabolic parameters as well as weight loss. While outcomes such as anxiety, depression, self-esteem and mood (among other variables) were assessed, no other significant changes were reported across these studies. These findings are contrary to what would be expected based on the wide-variety of benefits shown for general and clinical pediatric samples [10,11]. However, there is disparity in, and lack of detail about some of the interventions, making it difficult to determine not only whether yoga was effective, but also why no other benefits were found.

Birdee et al. [10] have made an intriguing suggestion regarding the benefits of yoga for children in general: Specifically, these authors have suggested that yoga may increase physical activity and fitness, and may serve as a "gateway" to an active lifestyle, particularly for sedentary youth who might otherwise shy away from intense forms of activity. While the suggestion wasn't specified for youth with obesity, it is plausible that yoga may indeed increase physical activity and fitness in this population. Given the number of obesity-related impairments noted above, and the significantly lower physical fitness levels in obese compared with non-obese youth [12], youth with obesity may benefit from a gateway to more vivorous forms of exercise. Yoga has the potential to increase activity and fitness in a slow, gentle manner, possibly increasing the motivation to continue movement in and outside of classes [8]. Furthermore, pain is a frequent comorbidity of pediatric obesity [5], and when present, has been associated with decreased physical functioning [4,6,7]. Given this barrier to movement and activity, the Hatha style of yoga, based on the principles of BKS Iyengar, may be particularly well-suited as a therapeutic approach to obesity. This style of yoga involves the use of "props" (e.g. mats, blankets, blocks) that allow for a slow and safe practice of the postures

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[13]. Instructions are given throughout classes, and are focused on awareness of muscle and joint activity [13]. Importantly, poses can be tailored to the individual needs of the participant, including pain-related needs [13,14].

Innovative and informed interventions are urgently needed to alter the trajectory of the current pediatric obesity epidemic [15]. However, as Tsiros [6] points out, weight loss takes time; therefore we need to develop interventions that in the interim will rapidly improve functioning and in turn, reduce disability. To that end, this is the first study to examine whether Hatha yoga will improve physical and psychosocial functioning in youth with obesity. This is also the first study with either adults or children to determine whether Hatha yoga will influence Physical Activity (PA), including the potential to increase time spent being physically active, as well as potentially increasing the level of PA. A secondary aim of the study was to determine whether yoga would reduce pain in participants with pain at baseline.

Materials and Methods

Participants

The yoga classes were capped at a maximum of 20 students to allow for individualized instruction; therefore, this study included 2 separate waves. Care was taken to ensure that physical activity (PA) assessments took place during the active school year. Participants were recruited via the weight management clinic located in Children's Hospital of Wisconsin. The NEW Kids (Nutrition, Exercise, and Weight management) Program provides multidisciplinary care for children 2-18 years old with obesity-related medical comorbidities. Referral criteria for the program include a BMI ≥ 95th percentile and at least a medical comorbidity [16].

Participants were recruited at a NEW Kids orientation meeting (once monthly) and from initial NEW Kids clinic appointments. Medical clearance was obtained from the child's primary care doctor or from a nurse practitioner in the clinic, respectively. For all participants, exclusion criteria included current back or neck pain, spinal injuries or spinal surgeries, neck injuries, and any identified physical limitations that the practitioner deemed to preclude yoga participation, such as orthopedic injuries. No participants were excluded for this latter reason. The study received approval from the hospital Institutional Review Board.

Measures

Physical activity: Physical activity was monitored by an omni directional accelerometer (Actical model #198-0200-00; Philips Respironics, Bend, OR). The Actical is a valid measure of PA in children 7 – 18 years [17]. It records accelerations in the range of 0.05–2.0 g and is sensitive to movements in the range of 0.5–3.0 Hz. The Actical has an internal time clock and a 64 KB memory and measures the magnitude of acceleration and deceleration associated with body movements at a sampling rate of 32 Hz. The recorded signals are scored as "counts" summed over a user-defined epoch (60 seconds). Participants were given detailed verbal and written instructions. To guide the analysis, participants were asked to complete an activity diary each night of wear. Average wear counts per minute was used to assess change in overall activity.

Physical functioning: A licensed physical therapist conducted the standardized physical functioning tests. Testing was done at the yoga studio immediately before the first and final classes. The tests included:

- YMCA V-Sit and Reach (Flexibility-Lower Back and Hamstrings) [18]

Participants sat on the floor with the measuring line between their legs behind the baseline with heels 8-12" apart. Participants slowly reached forward completing 3 tries and the best of 3 was used as the "score." The distance (cm) reached is reported.

- Presidential Fitness Challenge Timed Bent-Knee Sit-Ups (Strength) [18]

The total number of sit-ups completed with proper form in 1 minute is reported.

- Presidential Fitness Challenge Push-Ups (Strength) [18]

The number of 90 degree angle push-ups completed with proper form (at a rate of one completed push-up every three seconds) is reported.

- YMCA Step Test (Cardiovascular or Endurance Fitness) [19]

For a 3-minute period, participants were required to complete an alternating stepping cadence (stepping up with 1 foot, followed by other foot and stepping down with 1 foot followed by other foot) to a metronome set at 96 beats per minutes (stepping rate of 24 steps per minute). Within 5 seconds of completion of this 3 minute task, the participant's heart rate at the radial artery was counted for 1 full minute. The recovery heart rate (RHR; beats per minute) is reported.

Demographics: Participants provided age, gender, and indices of pain in the past 2 weeks. Height and weight were measured on the first and last nights of yoga using a Scale-tronix scale with a built in stadiometer. Body Mass Index (BMI) was defined as weight (kg)/height $(m)^2$. Parents provided participant ethnicity and parental educational level.

Holistic Health Questionnaire (HHQ; [20]): This measure was used to assess prior experiences with Complementary and Alternative Medicine (CAM) modalities. Six questions assessed post-intervention benefits (pain, sleep, stress, social status, and self-esteem) and pleasantness of yoga (1-7 Likert scale; 1 = will not help, or very unpleasant; 7 = definitely help, or extremely pleasant). Open ended questions assessed ease and difficulty of yoga practice and other changes related to the intervention.

Pediatric Quality of Life Inventory v 4.0 (Peds QL [21]): Participants and parents completed age and respondent appropriate versions. The PedsQL is a brief, 23-item measure, widely used to assess functioning in four domains, including physical, emotional, social, and school functioning. Respondents are asked to indicate "how much of a problem" each item has been during the past month. Total scores range from 0 to 100, with higher scores indicating increased functioning. The measure has high validity and reliability [21]. For the current sample, internal consistency was excellent (Baseline Chronbach's α: Parent = 0.92; Participant = 0.93).

Spielberger State Anxiety Inventory-Child (STAI-C-S [22]): The STAI-C-S is a self-report measure of anxiety designed to assess state (transitional emotional response) anxiety in youth. It contains 20 items that ask the participant to rate the frequency with which he or she experiences anxiety symptoms. Each statement begins with "I feel…." and participants check an end to the statement on a 3-point scale (1=not scared, 2=scared, 3=very scared). Higher scores indicate higher levels of anxiety (Total scores range from 0 to 60). For the current sample, the STAI-C-S demonstrated excellent internal consistency (alpha coefficient = .94, baseline).

5 min	Warm-up
45 – 50 min	Adho Mukha Virasana (Downward Facing Hero)
	Supta Baddha Konasana (Reclined Bound Angle Pose)
	Supta Padangusthasana (Reclined Leg Stretch 1)
	Parsva Supta Padangusthasana (Sideways Reclined Leg Stretch 2)[*]
	Adho Mukha Swanasana (Downward Facing Dog)
	Uttihitatrikonasana (Extended Triangle Pose)[*]
	Setu Bandha Sarvangasana (Bridge Shoulder Stand)
	Janu Sirsasana (Head to Knee Pose)[*]
	Halasana (Plow Pose)
	Viparita Karani (Inverted Lake Pose)[§]
5-10 min	Restoration and quiet meditation – Corpse Pose

To increase the demand of the practice, after the 3rd class, 3 of the "pre-requisite" asanas[*] were dropped and a more advanced asana[§] was added.

Table 1: Yoga curriculum.

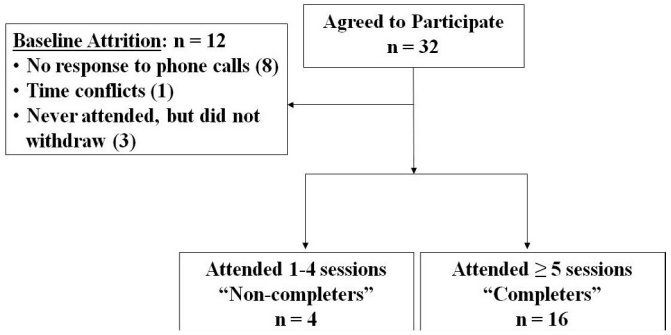

Figure 1: Participant flow.

Procedure

General procedure and incentives

Questionnaires and the Actical with wear instructions and an activity diary were mailed to participants prior to the first yoga class. PA was assessed with the Actical device 7 consecutive days prior to the first class and 7 consecutive days following the last class. Youth were compensated $45 throughout the study ($10 for completion of questionnaires at weeks 1 and 8, and $25 for returning the Actical at the conclusion of the study). Parents were compensated with a $10 gas card at weeks 4 and 8.

Yoga curriculum

The yoga classes were taught by a practitioner trained in the Hatha style of yoga, with over 24 years of teaching experience. The bi-weekly, 60 minute classes took place across an 8 week period, for a total of 15 classes. Consistent with the style of yoga detailed by B.K.S. Iyengar, the protocol incorporated the use of mats, blankets, straps, blocks, and chairs, which allowed for the adaptation of each asana, both for therapeutic purpose and individual need [13,23], making it a safe form of physical activity [13].

The yoga curriculum is shown in Table 1. The curriculum was designed to "strengthen and lengthen," primarily focusing on the physicality of yoga practice. That is, asanas were chosen specifically to strengthen the upper and lower extremities and core muscles, as well as to increase overall flexibility. Classes included instruction/demonstration of each asana, followed by participant practice. The instructor actively modified poses where necessary and gave instruction on breathing technique throughout.

Data Analysis

Descriptive statistics were utilized to characterize the sample and check for normality. Means (± SD) and ranges were used to provide information on participants' past alternative medicine use, and to describe expectations and change scores. Where the data were skewed, medians and Interquartile range (IQR) are reported. Acceptability of the intervention was based on attendance and quantitative assessments of the benefits associated with the yoga intervention, as well as on qualitative responses from participants and parents. Paired Wilcoxon tests were conducted to determine pre- to post-yoga changes in physical and psychosocial functioning. To analyze pre- to post-yoga amount and levels of PA, we downloaded the Actical data for further processing using KineSoft software version 3.3.52 (KineSoft, Loughborough, UK). Accelerometer data files were included if they had at least 1 day with ≥10 hours of wear time. Time spent in different PA intensity categories was based on the application of count thresholds obtained from calibration studies that related accelerometer counts to measured activity energy expenditure in children. Intensity thresholds were calculated similar to the methods of Troiano et al. [24]; that is, a weighted average of the available ambulatory-only regression equations from 2 published pediatric studies [17,25] was used.

Regression equation: $y=1756.91x - 3719.72$ $r^2=0.99$ where, y=counts/minute & x = METs

The resulting cutpoints were 1551-6822 counts per minute for moderate intensity and ≥6822 counts for vigorous intensity, corresponding to MET values of 3-6 for moderate intensity and >6 for vigorous intensity activities. Pragmatic cutpoints of 0-200 counts per minute were used to delineate sedentary time (<1.5 METs). Lastly, the light intensity cut point ranged from 200-1551 counts per minute (1.5-3.0 METs). Total PA time at each intensity level is the sum of the minutes at a given intensity while the accelerometer is worn. Given the exploratory nature of this analysis, Cohen's d was calculated for pre-post yoga changes $p \leq 0.10$ or better. IBM SPSS v 20 was used to conduct all analyses.

Results

Participants

Thirty-two participants consented to the study. "Completers" were defined as those who attended ≥ 5/15 classes. Completers did not differ from non-completers on participant age, gender, or ethnicity, nor on parental education level (all p's > .05). The final sample of completers consisted of 16 youth, 9 males/7 females, with an average age of 13.4 (11 – 17) years. The BMI for all participants was above the 95th percentile for age and gender [26].

As expected, weight did not change significantly ($p > .05$) from pre- (Mdn 34.82; 29.5 – 38.8) to post- (Mdn 33.59; 29.65 – 40.84) intervention. Ethnicity: the majority of participants reported African-American/Black (n=6), 4 reported Caucasian/White, 3 Mixed, 2 Hispanic/Latino, and 1 Middle Eastern. Parent's mean educational level was 12.6 (± 2.7) years (Range 10 – 20 years). The majority (14 out of 16) of children had no prior experience with yoga.

Acceptability

Figure 1 shows participant flow. Overall, attendance to the yoga sessions was moderate. Twelve (37.5%) did not attend any classes, 4 (12.5%) attended 1 to 4 sessions, while 16 youth (50%) were completers, attending 7 – 15 yoga sessions.

	Participant	Parent
How much do you think yoga helped you/your child with pain?	5.0 (4.0 – 7.0)	5.5 (5.0 – 6.8)
How much do you think yoga helped with your/your child's sleep?	5.0 (3.0 – 7.0)	5.0 (4.3 – 7.0)
How pleasant was this experience for you/your child?	7.0 (6.0 – 7.0)	6.0 (5.3 – 7.0)
Would you or your child try yoga again to help deal with pain?	Yes: 13/15 No: 2/15	Yes: 11/12 No: 1/12
Would you recommend yoga to another family to treat their child's pain?	Yes: 13/15 No: 2/15	Yes: 12/12

Scale = 0 ("not at all" or "Extremely Unpleasant") to 7 ("Definitely help" or "Extremely Pleasant").
Median (IQR)

Table 2: Quantitative assessment of the yoga experience by participants and parents.

Question	Parent/Caregiver	Adolescent
Other than pain, what else occurred as a result of the yoga sessions?	"She felt better" "She lost a little weight" "She now thinks it's not just for adults; thinks it helps with stress" "Feeling better about himself and his health and he seems more interested in doing exercise" "Helped him move better" "He's more relaxed" "More flexibility, more energy" "More energy and more confidence" "Increased flexibility, better concentration" "Right after the sessions, she felt more energetic"	"I felt more energized" "It was easier to concentrate and study" "I felt less worry about my weight" "I'm more flexible and not as lazy as before" "Feeling better about self" "I have been in a much better mood and state of mind" "I learned how to relax more" "I have been doing tae kwon do, basketball, and track" "I was more relaxed at school and home" "Calm" "Yoga has helped me with calming down and other things like that" "Able to move more and have no problem holding a certain pose longer" "I feel more relaxed and calm and better about myself" "More flexible" "Immediately following each session, I felt lighter and more energized"
What do you feel made practicing the yoga easier (for your child)?	"The teacher helping her" "She noticed she lost a few pounds" "Thought it helped; liked the group; changed her mind about how helpful" "Feeling good and having more energy" "Other kids her size and age; small setting" "That she could do it without her little brother messing with her away from home" "Dealing with anger" "Other kids and family support"	"More practice" "The encouragement I got from family and friends" "Running and riding my bike" "Exercising and being more healthy" "Being able to take the materials home and practice yoga, using blocks" "It made me tall" "Practicing yoga for me is easy because I'm flexible" "It was away from my brother" "Sleep" "I became more flexible"
What do you feel made practicing the yoga easier (for your child)?(cont.)	"The environment in the class and the friendly people; inspiration" "Small sessions" "Provided space in bedroom" "The breathing"	"The welcoming atmosphere"
What do you feel made practicing the yoga harder (for your child)?	"Does not stretch much" "First time it was difficult, but it got easier" "Pain in knees due to weight" "Trying to deal with school/yoga at the same time" "I don't believe practicing yoga was hard for her, but she was a little less flexible before" "Motivation" "Time management" "Getting her body into the position it needed to be in was painful for her"	"Sitting still" "Nothing. It wasn't hard at all" "No sleep" "Yoga has not been hard at all" "Trying to do the plank poses were hard for me" "With some of the poses introduced came pain in my back, but the pose was adapted for my individual needs and became easier"

Table 3: Qualitative data on the yoga intervention from participants and parents.

We received HHQs from 15/16 participants, and from 12/16 parents. Overall, the intervention was acceptable, with specific benefits noted by participants and parents. Quantitative assessment of the yoga experience (Table 2) showed that the majority of participants benefitted from yoga, with 14/16 indicating that they would try yoga again to help deal with pain and would recommend yoga to another family to treat their pain. Parent results were consistent with self-reports. Qualitative data is presented in Table 3. Among other benefits, participants and parents reported increased energy, improved flexibility, and enhanced self-esteem as a result of the yoga intervention. Ease of yoga practice was attributed to the instructor, the support of other participants, and the use of the equipment at home. Pain and finding time to practice were noted as specific barriers.

Physical activity (PA)

Of the completers, 11 had reliable accelerometry data, with at least 2 valid days pre- and post-intervention. As shown in Table 4, the proportion of time spent in light and moderate PA increased marginally from pre- to post-yoga. Although the percentage of time spent in Sedentary PA did not change, the trend was toward less sedentary time. Additionally, although not significant, wear counts per minute improved.

Standardized physical fitness measures

Analyses of the 4 standardized fitness measures showed that participants significantly improved in hamstring and lower-back flexibility; no other significant changes were observed. Data are shown in Table 5 and Figure 2.

Measure	Pre-yoga Intervention	Post-yoga Intervention	P value	Effect Size
Sedentary (<1.5 METs) (Total min)	0.82 (.71 - .83)	0.77 (.70 - .81)	0.86	--
Light (1.5 - 3.0 METs) (Total min)	0.18 (.17 - .24)	0.19 (.16 - .23)	0.08	0.1
Moderate (3.00-5.99) (Total min)	0.01 (.01 - .04)	0.03 (.02 - .05)	0.08	0.6
Vigorous (≥6 METs) (Total min)	0 (0.0 – 0.0)	(0.0 – 0.0)	--	--
Wear Counts per minute	133.1 (117.6 – 255.6)	208.4 (157.2 – 287.5)	0.21	--

Effect size is reported as Cohen's d, and was calculated for changes associated with a p ≤ 0.10 or better.

Table 4: Median proportion of time (controlled for wear time) spent in each level of PA, and median wear counts per minute before and after the yoga intervention.

Measure	Pre-yoga Intervention	Post-yoga Intervention	Median Change	P value	n
Sit-to Reach (cm)	4.0 (2.50 – 10.00)	8.00 (5.50 – 11.00)	3.00 (0.00-8.50)	0.02*	13
Push-ups	3.00 (0.00 – 7.00)	5.00 (1.00 – 9.00)	0.00 (-1.00 -4.00)	0.40	13
Sit-ups	21.00 (17.00 – 24.00)	21.00 (14.50 – 30.00)	1.00 (-3.00 – 2.5)	0.65	13
Step Test Recovery Heart Rate (beats/min)	142.00 (128.00 – 149.50)	145.00 (140.00 – 154.00)	5.00 (-6.25 -2.00)	0.33	10†

Pre-post yoga changes analyzed using Wilcoxon-Signed Ranks tests. *p < .05. †3 participants were unable to complete the 3-minute test at baseline, and 2 were unable to complete the test after the intervention.

Table 5: Median (IQR) and Median (IQR) change scores for Physical Functioning outcome measures, pre- and post-yoga intervention.

Measure	Pre-yoga Intervention	Post-yoga Intervention	*Median Change*	*P* value	*n*
Functioning Self-report					
Total	74.25 (57.70-82.88)	84.78 (78.26-88.04)	7.07 (1.09-12.06)	0.01*	12
Physical Functioning	78.13 (65.89-91.41)	87.50 (78.13-100.00)	4.69 (1.12-13.28)	0.01*	12
Psychosocial Functioning	70.83 (53.75-84.58)	81.67 (73.33-86.67)	6.67 (-0.42 – 11.67)	0.03*	12
Emotional	62.50 (42.50-78.75)	75.00 (65.00-95.00)	7.50 (-3.75 – 22.50)	0.10	12
Social	82.50 (62.50-90.00)	90.00 (80.00-100.00)	5.00 (-5.00 – 22.50)	0.18	12
School	62.50 (51.25-82.50)	80.00 (65.00-85.00)	5.00 (1.25 – 18.75)	0.02*	12
Functioning Parent-report					
Total	64.67 (46.64-71.20)	62.50 (51.95-79.35)	9.78 (6.48 – 20.65)	0.01*	11
Physical Functioning	56.25 (53.39-71.88)	65.63 (45.31-82.03)	15.63 (-3.13 – 21.88)	0.09	11
Psychosocial Functioning	65.00 (45.83-72.92)	65.83 (55.18-81.67)	11.67 (8.33-13.33)	0.01*	11
Emotional	62.50 (50.00-73.75)	70.00 (61.25-86.25)	10.00 (5.00-25.00)	0.02*	11
Social	70.00 (45.00-78.75)	72.50 (61.25-87.50)	15.00 (5.00-25.00)	0.01*	11
School	57.50 (31.88-65.00)	50.00 (45.00-91.25)	10.00 (-5.00 – 20.00)	0.07	11
STAI-C Self-report	32.00 (28.50-39.50)	31.00 (27.00-34.00)	-2.00 (-6.00 - -1.00)	0.05*	11

Medians (IQR) of Overall, Physical and Psychosocial functioning outcome measures, pre- and post-yoga intervention. Pre- post-yoga changes analyzed using Wilcoxon-Signed Ranks tests. *p< .05.

Table 6: Changes in Psychosocial and pain-related Functioning for participants completing 5 or more yoga classes.

Physical and psychosocial functioning

Overall, both participants and parents reported significantly improved functioning (Table 6; Figure 3 shows primary outcomes). Large, clinically meaningful [27] improvements were evidenced in self-reports of Total, Physical, and Psychosocial functioning scores, with similar improvements reported by parents. Participants also showed significantly reduced levels of state anxiety.

Pain

Half (8/16) of the completers experienced pain in the 2 weeks prior to the intervention, with reports ranging from 2-14 days (Mdn 5.00; 2.50 – 11.00). Usual pain intensity was moderate and ranged from 2 to 10 out of 10 (Mdn 5.50; 5.00–7.00), with worst pain intensity considered severe, and ranged from 3 to10 out of 10 (Mdn 7.50; 6.25 – 8.75). While one of these pain reports was associated with acute stomach pain, for the majority (7/8 participants), the pain was chronic (i.e. present for ≥3 months). Of those who consented, 2 with chronic pain dropped from the study (1 never attended, 1 attended 4 of the first 5 classes). The 7 participants with chronic pain attended between 8 and 15 of the 15 classes.

Discussion

The primary aim of this study was to examine the benefits of a Hatha yoga intervention for youth with obesity. Given that pain is often co-morbid with pediatric obesity [5], a secondary aim was to examine whether our yoga intervention would decrease pain for those reporting pain at baseline. This is the first study to demonstrate significant improvements in self-and parent-reported physical and psychosocial functioning associated with a yoga intervention for youth with severe obesity. Additionally, although this was a pilot study with a small sample size, a large effect size was shown for the participants' post-yoga increase in moderate physical activity (PA) and a small effect size was

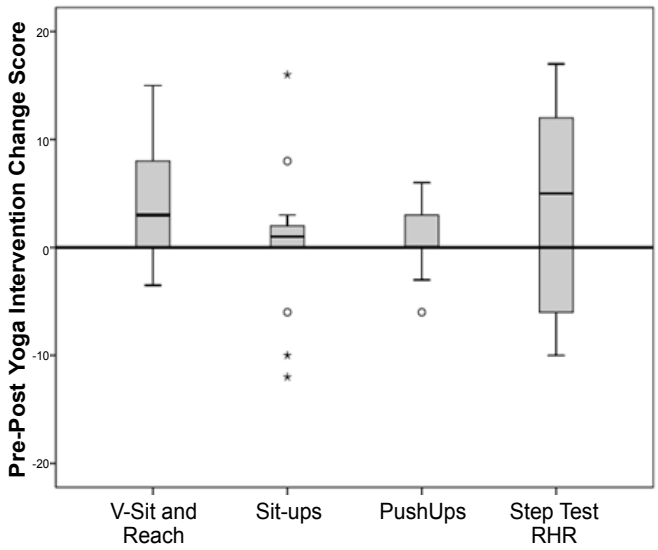

Figure 2: Standardized Physical Fitness Measures

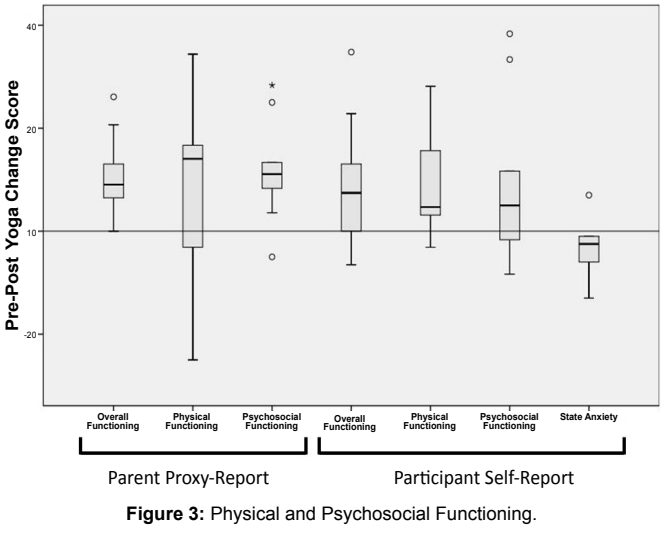

Figure 3: Physical and Psychosocial Functioning.

shown for the participants' increase in light PA, using accelerometry, the "gold standard" for PA assessment. These preliminary findings suggest that Hatha yoga has the potential to play an important role in pediatric obesity.

Acceptability and feasibility

As found in other pediatric yoga studies [14,28], this study suggests that a yoga intervention for youth with obesity is acceptable to both participants and parents. Ratings of post-yoga benefits were high, with specific benefits noted, including increased feelings of energy and ability to concentrate. Several comments point to yoga improving the participant's physical functioning, an increased ability to "move more," and increased flexibility. While yoga may be acceptable for this population, feasibility may be challenged by attrition and class attendance, as shown in previous group-based pediatric yoga trials [14,28]. As outlined in a previous study, additional emphasis upon convenience for families and patient/parent expectations concerning yoga may be keys to reducing attrition and improving class attendance [14]. In addition, no injuries occurred during the course of this study, despite the fact that participants were severely obese (BMI >95th percentile for gender age) and were physically deconditioned. These results support Hatha yoga as a safe form of physical activity for this population.

Physical and psychosocial functioning

Large and clinically meaningful improvements were found in self- and parent-reported physical and psychosocial functioning, including a significant decrease in state-anxiety. Among the fitness assessments, although strength and endurance measures did not change, participants showed significantly improved hamstring and lower back flexibility. These findings are consistent with reports of improved functioning associated with yoga interventions for adults with obesity [8] and pain [29]. However, while our findings are consistent with the benefits found in a variety of pediatric yoga studies [10,11,14], they are not consistent with other studies involving yoga for pediatric obesity. Bernstein et al. [8] have recently reviewed the literature on yoga for obese populations, and found only 4 studies that involved pediatric participants. Of these, only 2 studies were solely focused on yoga. While yoga may be an effective component in multi-level interventions, it is clear that more pediatric studies exclusively focused on yoga are needed to better understand the physical and mental health benefits associated with yoga.

Physical activity

While the suggestion that yoga may be a stepping-stone to more physical activity [10] is plausible, no one has examined this hypothesis with either adults or children. Although this pilot study was small and involved a relatively brief intervention, we showed marginally significant increases in time spent in both light and moderate intensity PA, with a large effect size associated with the increase in moderate intensity PA. No previous studies have examined changes in level of physical activity associated with a yoga intervention. While future large scale studies are needed to replicate these findings, these results support the promising role yoga can play in pediatric obesity. If yoga is a stepping stone to greater physical activity, it is plausible to suggest that this may increase opportunities to make behavioral and nutritional changes to reduce weight, and simultaneously reduce the risk of injury.

Pain

A secondary aim of this study was to evaluate the benefits of yoga for youth with co-occurring obesity and pain. The data suggest that yoga may be beneficial for this population in 2 ways. First, yoga may be gentle enough to afford the opportunity to be active despite pain and to do so without exacerbating existing pain. The fact that 7 of 10 youth with chronic pain completed between 53-100% of the classes demonstrates that it is possible to continue participating despite pain. Second, yoga may allow for continued PA because poses can be tailored specifically to individual needs. Importantly, although the data do not suggest a decline in pain overall, they also do not suggest an increase in pain, which can occur when youth with pain become more active [29]. While there is data showing reductions in pain for adults [29], applications of yoga for pediatric pain are limited. Future studies should expand upon the few studies that have shown promising results for pain in youth with chronic pain [13,14,28,30].

While weight loss is the primary goal of obesity interventions [31], there are several reasons for early interventions aimed at improving physical functioning with or without weight loss. First, obesity in children and adolescents is associated with functional disability

[6,7,32,33] as well as with movement-related metabolic costs that are greater than their healthy-weight counterparts [32]. Both are barriers to movement [33], and may act as a source of discouragement for participation in exercise programs [33]. Additionally, weight loss takes time. Given that youth with obesity are at an increased risk for injury [34] and long-term disability, including the risk of degenerative obesity-related musculoskeletal changes, it is imperative that we develop interventions that act quickly to improve functioning and reduce disability in the short-run [6]. The current findings suggest that Hatha yoga may provide a way for youth with obesity to be physically active (despite pain if present), while potentially reducing the risk for injury.

Yoga is a non-invasive intervention with numerous physical and mental health benefits. It is noteworthy that the specific benefits from the current study were observed following 15 yoga classes over a relatively brief intervention period. This highlights the need for future research to replicate these findings, and to carefully examine the dose-response relationship, in order to determine the optimal dose needed to provide both short and long-term benefits. For example, Saper et al. [35] examined once- versus twice-weekly yoga over a 12-week period, for adults with chronic low back pain. The authors found that participation in once-weekly classes afforded similar benefits to twice-weekly classes. To our knowledge, no such data exists for pediatric samples. Additionally, data is lacking on long-term follow-up in pediatric samples. Short and long-term follow-up will be valuable in determining whether the benefits demonstrated in this and other studies can be maintained.

Study Limitations

This pilot had a limited sample size. While control was enhanced by the within-participants design, larger scale studies should be conducted in the future. Further, although students were encouraged to practice yoga at home, we did not assess the amount of time (if any) they practiced yoga outside of class.

Conclusions

These preliminary findings are encouraging, and support the use of Hatha yoga as a safe and promising intervention for improving aspects of physical and psychosocial functioning in severely obese adolescents. Hatha yoga may also be a stepping stone to improvements in Physical Activity. It is critical that we continue to explore the benefits of yoga and other interventions that are both appealing and safe, with particular attention paid to understanding and eliminating barriers to physical activity, such as bodily pain, in this population.

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