



Original Article

A pilot study of gentle yoga for sleep disturbance in women with osteoarthritis

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ARTICLE INFO

Article history:

Received 19 July 2010

Received in revised form 4 September 2010

Accepted 9 September 2010

Keywords:

Sleep

Insomnia

Osteoarthritis

Aging

Yoga

Complementary therapies

ABSTRACT

Objectives: The purpose of this study was to test the feasibility and acceptability of a gentle yoga intervention for sleep disturbance in older women with osteoarthritis (OA) and to collect initial efficacy data on the intervention.

Methods: All participants completed an 8-week yoga program that included 75-min weekly classes and 20 min of nightly home practice. Participants were women with OA and symptoms consistent with insomnia. Symptom questionnaires and 1 week of wrist actigraphy and sleep diaries were completed for 1 week pre- and post-intervention.

Results: Fourteen women were enrolled of whom 13 completed the study (mean age 65.2 ± 6.9 years). Participants attended a mean of 7.2 ± 1.0 classes and practiced at home 5.83 ± 1.66 nights/week. The Insomnia Severity Index and diary-reported sleep onset latency, sleep efficiency, and number of nights with insomnia were significantly improved at post-intervention versus pre-intervention ($p < .05$). Other sleep outcomes (Pittsburgh Sleep Quality Index, Epworth Sleepiness Scale, diary-reported total sleep time and wake after sleep onset) showed improvement on mean scores at post-intervention, but these were not statistically significant. Actigraphic sleep outcomes were not significantly changed.

Conclusions: This study supports the feasibility and acceptability of a standardized evening yoga practice for middle-aged to older women with OA. Preliminary efficacy findings support further research on this program as a potential treatment option for OA-related insomnia.

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1. Introduction

Sleep disturbance is a significant consequence of osteoarthritis (OA), occurring in over 50% of older adults with arthritis [1]. Studies show that persons with OA experience difficulty falling asleep and remaining asleep, awoken too early, and experience light, restless sleep [2–4]. As adults age, sleep is predominated by lighter sleep stages that are easily disrupted by stimuli such as bodily sensations from chronic illness (e.g., arthritis pain) [5]. Furthermore, studies show that sleep disturbance in OA is mediated but not fully explained by arthritis pain [6], indicating that pain relief alone may not be sufficient to reduce sleep disturbance. As women age, they are at particular risk of OA-related sleep disturbance relative to men, as their risk of both OA and age-related sleep disturbance is higher than men [7,8]. Although sedative medications may promote sleep in persons with OA, these medications are associated with numerous side effects and do not address the underlying causes of chronic sleep disturbance [9,10]. Non-pharmacological, lifestyle based interventions such as yoga may offer

a safe and effective alternative for reduction of sleep disturbances in persons with OA.

Yoga is a multimodal complementary and alternative medical (CAM) practice with potential to beneficially affect several factors contributing to OA-related sleep disturbance. Yoga is a complete system of lifestyle, philosophy, and personal health practices based on ancient Indian traditions [11]. In the US, the term “yoga” usually refers to a practice of physical strengthening, stretching, and balancing postures that may be accompanied by breathing practices and meditation. Potential mechanisms by which yoga may reduce OA-related sleep disturbance include: (a) reduction of joint stiffness [11,12], (b) promotion of relaxation [13], (c) reduced physiologic activation [14,15], and (d) direct effects on neurologic sleep-regulating mechanisms including gamma-aminobutyric acid [16] and melatonin [17]. Several yoga studies, mostly small and uncontrolled, have shown improvements in self-report sleep outcomes in persons with insomnia and middle-aged to older adults [18–25].

The purpose of this study was to assess the feasibility and acceptability of a gentle Hatha yoga routine developed specifically to reduce sleep disturbance in middle aged to older adults with OA. The intended effects of the practice were to (1) practice yoga postures to move the joints through a range of motion thereby reducing joint stiffness that could disrupt sleep [11,12] and (2)

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incorporate resting postures and breathing exercises to promote pre-bedtime relaxation [13]. This study adds to the literature data on the feasibility of a specific yoga program practiced pre-bedtime, qualitative data from study participants on the acceptability of the program that will guide future intervention revision and development, and preliminary data on the effects of the targeted intervention on OA-related insomnia.

2. Methods

2.1. Sample

The study was approved by the University of Washington Human Subjects Institutional Review Board. Subject recruitment and data collection occurred between July 2008 and August 2009. A sample of middle-aged to older women was recruited from the greater Seattle community. Participants were recruited entirely through advertisements in free local publications and through flyers posted in senior centers, community centers, and local businesses. Interested individuals contacted the research staff at the advertised phone number. *Inclusion criteria* were (a) generally healthy women 55–85 years of age, (b) physician-diagnosed OA of any joint, and (c) presenting with a complaint of poor sleep at screening (>30 min to fall asleep, >30 awake during the night, and/or daytime sleepiness). *Exclusion criteria* were (a) acute injury within the past 6 months; (b) inability to stand without assistance; (c) more than 6 sessions of yoga practice within the past 3 months; (d) use of sleep medication that changed within the past 3 months; (e) chronic musculoskeletal disorder other than OA or osteoporosis; (f) untreated or poorly managed medical diagnosis; (g) psychiatric illness requiring new treatment within the past 3 months; (h) diagnosis or clinical signs of a primary sleep disorder (e.g., sleep apnea, restless legs syndrome); (i) consumption of caffeine equivalent of >3 cups coffee/day or alcohol >2 drinks/day at least 4 days/week; (j) and Mini Mental State Exam <26.

2.2. Procedures

Interested individuals contacted the investigators by phone. Following an initial telephone screening, participants were mailed the pre-intervention questionnaires (HAQ-DI, PSQI, ISI, ESS, GDS—see Measures). At Visit 1, participants returned the questionnaires and met with the study nurse (who was also the principal investigator). Visit 1 was held at the University of Washington School of Nursing (SON) Exercise Facility, which was also the location of the yoga classes. Informed consent was reviewed and signed, the study nurse completed a Health and Sleep History and Examination, and the participant was given an overview of the yoga program. During the next 7 days, the participant wore a wrist actigraph and completed the pre-intervention daily sleep diaries. After the pre-intervention assessment, participants were given a yoga mat and blanket for home practice. Participants attended a weekly 75-min yoga class for 8 weeks (Visits 2–9). During these 8 weeks, participants were instructed to complete a 20 min yoga routine each night. After the last yoga class, participants again completed the study questionnaires (HAQ-DI, PSQI, ISI, ESS, GDS) and 7 days of sleep diaries and actigraphy. Participants returned these materials at the post-intervention visit (Visit 10), at which they also completed a semi-structured interview with the PI about their experiences in the study.

2.3. Intervention

The yoga intervention was designed by the PI in collaboration with an experienced yoga teacher, an expert yoga therapist, and

two experienced yoga researchers [26–29]. The sequence was planned to provide gentle stretching and movement of the whole body and to provide calming effects. The program was similar in sequencing to the Essential Low Back Program [30], which was designed by our collaborating yoga expert and has been previously shown to reduce pain-related disability in persons with chronic back pain [31]. Each practice session (at home and in class) started with relaxation and body awareness, and then progressed to seated poses, supine poses, breathing exercises, and deep relaxation. Although the intervention used a general (“Hatha”) yoga approach, many of the poses were influenced by the Viniyoga style that is commonly used in therapeutic yoga. Principles of Viniyoga are appropriate for persons with OA, including modification of poses to maintain healthy joint alignment as well as repetition (rather than holding) of poses to increase blood circulation to muscles and to avoid muscle strain [29].

The class sessions were 75 min, including a 15 min “check-in” and 60 min of yoga practice. During the check-in time, the instructor asked the participants about their experience with their home yoga practice, asked how they were presently doing (including assessing any injuries or safety concerns), and answered any questions participants had about the practice. Details on the 60-min practice sequence are available in the online [Supplementary material](#). The SON Exercise Room, where the yoga classes were held, is a pleasant, well-lit environment. It is designed to accommodate low-impact and yoga interventions, with a rubberized floor and an open practice space able to accommodate 6 participants and a teacher.

During the 8-week yoga program, participants were instructed to practice yoga for 20 min at home nightly about an hour before bedtime. Participants were not restricted from practicing more than 20 min if they wished. Participants were given an instructional handout with explanations and diagrams and an audio CD to guide home practice. The audio CD was 20 min long to help participants achieve this desired minimum level of daily practice. Materials were specifically developed by the PI for this study. Participants were enrolled in two cohorts. The first cohort ($n = 8$, October to December 2008) was taught by a certified yoga instructor, an older woman with experience teaching yoga to older adults. The instructor for the first cohort was trained by the PI. To insure consistent instruction, the PI visited the first three classes and every few classes thereafter. The PI also met with the instructor weekly to address questions and check on adherence to the instruction protocol. The second cohort ($n = 6$, June to August 2009) was taught by the PI, also a certified yoga instructor with clinical/research experience with persons with arthritis.

2.4. Measures

2.4.1. Feasibility and acceptability measures

Recruitment and retention were reported through descriptive summaries. Protocol adherence was measured by class attendance and self-reported home practice. A semi-structured interview was conducted and audio recorded at the post-intervention visit to collect participants' perspectives on the acceptability of the intervention and the feasibility of the study procedures.

2.4.2. Sleep and symptom outcomes

2.4.2.1. Symptom questionnaires. At pre- and post-intervention, participants completed standardized questionnaires to assess their sleep, functional status, and mood. Overall sleep quality was measured using the *Pittsburgh Sleep Quality Index (PSQI)*, a widely-used 18-item questionnaire that assesses sleeping patterns and difficulties over the past month. PSQI is scored 0–21, with scores >5 reliably differentiating between persons with and without sleep disorders [32]. The PSQI has strong internal consistency (Cronbach's $\alpha = 0.80$) and construct validity (moderate to high

correlations with sleep quality questionnaires) [33]. General insomnia symptoms were measured with the *Insomnia Severity Index (ISI)*, a 7-item questionnaire commonly used in the clinical evaluation of insomnia symptoms over the past week [34,35]. The ISI is scored from 0 to 28, with higher scores indicating more severe insomnia symptoms. Internal consistency of the ISI is 0.74 and concurrent validity with sleep diaries has been shown [34]. The daytime impact of participants' sleep disturbance was measured using the *Epworth Sleepiness Scale (ESS)*, an 8-item questionnaire (scored 0–21) on which individuals rate their current sleep propensity (i.e., how likely the individual is to “doze”) in every-day situations [36,37]. ESS has high internal consistency (Cronbach's alpha = 0.88) and test–retest reliability over 5 months ($r = 0.81$) [34]. ESS scores are reliably higher in persons having conditions known to cause daytime sleepiness (e.g., sleep apnea) [37]. Arthritis-related functional disability and pain were measured with the *Health Assessment Questionnaire (HAQ)*. The HAQ contains a Disability Index (HAQ-DI) and numeric (0–100) ratings of pain and global health over the past week. The HAQ-DI contains 20 items on which individuals rate their functional limitations, required assistance, pain, and health over the past week. The overall HAQ-DI is scored 0–3 with higher scores indicating greater limitation [38,39]. The HAQ-DI has been shown to have convergent validity with objective functional measures, i.e., walking time [40]. Depressed mood was measured with the *Geriatric Depression Scale (GDS)*, a 15-item scale designed for use with older adults [41,42]. Because age-related health problems may produce many of the same physical symptoms as depression, the GDS was designed to avoid confounding physical symptoms of depression with physical symptoms of other health conditions. The GDS is scored 0–15, with higher scores reflecting greater depressive symptoms. The GDS has strong internal consistency (Cronbach's alpha = 0.77) and high convergent validity with other depression scales [43].

2.4.2.2. Pre-intervention and post-intervention sleep diaries. Participants completed daily sleep diaries for 7 days pre- and post-intervention. Participants reported joint pain, daytime sleepiness, sleep quality (SQ), and refreshment using a 100 mm Visual Analog Scale. They also reported bedtime, time of arising, time in bed (TIB), sleep onset latency (SOL), and wake after sleep onset (WASO). Total sleep time (TST) was calculated (TIB – SOL – WASO – time between awakening and arising) as was sleep efficiency (SE = TST/TIB * 100). The number of nights out of the week (7 nights) with insomnia (SOL or WASO > 30 min, or SE < 85) was calculated.

2.4.2.3. Wrist actigraphy. Objective sleep outcomes were measured with Actiwatch actigraphs (Mini-mitter Company, Inc., Bend, OR). Participants wore the actigraphs on the same 7 nights that they completed the sleep diaries. These devices are piezo-electric accelerometers about the size of a watch and are worn on the non-dominant wrist. The Actiwatches were set to record activity counts in one-minute epochs. Actiwatch activity counts represent both the occurrence and magnitude of arm movements. Data were analyzed using Actiware version 5.57 (Mini-mitter Company, Inc., Bend, OR). Bedtime and rise-time were entered in the software based on participant's sleep diary entries. Each epoch was scored as sleep or wake using the automatic algorithm in the software (set to a medium sensitivity threshold). Sleep onset and offset were scored as the first/last 10 min of the sleep record scored as sleep with ≤ 1 epoch scored as wake. Sleep outcomes included the same variables reported in the sleep diaries: SOL, WASO, TST, and SE.

2.5. Data analysis

All data were double-entered in Microsoft Excel and were analyzed using Statistical Package for the Social Sciences (SPSS)

version 17.0. Feasibility outcomes (e.g., class attendance, home yoga practice) were descriptively summarized. The post-intervention interviews were transcribed and checked against the original recording. Themes were analyzed and descriptively summarized, including the number of participants who commented on major themes [44]. Pre- and post-intervention sleep diary data were averaged over each week. Pre- and post-intervention scores on the questionnaires, diaries, and actigraphy were compared using paired *t*-tests (or Wilcoxon signed-ranks tests for skewed data). All tests were two-tailed. Given the exploratory nature of the study, a significance level of .05, unadjusted for multiple testing, was set for all tests; trends are reported.

3. Results

3.1. Feasibility

3.1.1. Recruitment and sample characteristics

A total of 96 individuals contacted the research staff (details on recruitment are available in the online [Supplementary material](#)). Fourteen women were enrolled, but one dropped out due to a work schedule conflict. Given that the study was a pilot, the remainder of the manuscript reports demographics and clinical characteristics for only the 13 eligible participants who completed the treatment protocol. Mean age of the participants was 65.2 ± 6.9 years (range 57–82 years). The participants were mostly well-educated (mean 15.9 ± 3.0 years). Somewhat more than half the sample was not currently in a relationship ($n = 7$) versus married/partnered ($n = 6$). Participants were White ($n = 10$), African American (2), and Latina (1). The most commonly reported joints affected by OA (9 participants reported >1 affected area) were the knees ($n = 9$), followed by the hip (5), spine (5), hand (1), and elbow (1).

3.1.2. Adherence

Attendance at the yoga classes was high. Participants who completed the program ($n = 13$) attended an average of 7.2 ± 1.0 of the 8 classes (range 5–7 classes). The most common reason for absence was travel ($n = 4$), followed by no given reason ($n = 2$), or personal reasons ($n = 2$, reasons: surgery, emergency home repair). Participants practiced at home a mean of 5.83 ± 1.66 nights per week and $83.13 \pm 13.52\%$ of their total nights in the study. The mean duration of home practice sessions was 22.59 ± 6.20 min.

3.1.3. Interview responses

Participants were asked general questions. Nine of the participants stated, unsolicited, that they enjoyed the yoga program. Opinions on whether the practice improved their sleep varied, with some participants describing improved sleep ($n = 4$) or reporting no change ($n = 4$); the others did not mention sleep changes in their interviews. Other benefits of the yoga practice noted in the interviews included relaxation ($n = 5$) and reduced joint pain ($n = 9$). Of those reporting reduced pain, several experienced reduced shoulder pain ($n = 7$), although none specifically had arthritis in this joint. Two participants reported no reduction in pain, and the others did not mention pain in their interviews.

Participants were asked “What was your main reason for participating in the study?” Reasons given included learning/practicing yoga ($n = 4$), managing arthritis pain ($n = 4$), improving their sleep ($n = 4$), general arthritis management ($n = 3$), practicing a movement therapy ($n = 2$), relaxation ($n = 1$), and establishing a daily routine ($n = 1$). Several women specifically mentioned enjoying the weekly classes ($n = 8$), particularly because of connecting with the other participants ($n = 5$). Another aspect the class participants enjoyed was having attentive instructors who explained the poses and modified these based on individual capabilities ($n = 5$). But

some participants felt there was too much feedback that disrupted the flow of the classes ($n = 2$). Other challenges noted by participants included finding a location in their homes where they could practice regularly ($n = 2$) and having difficulty practicing in the evening due to fatigue ($n = 4$). Several participants stated that they wished to continue practicing yoga by either continuing to do the study intervention at home ($n = 2$) or finding a class ($n = 4$).

3.2. Effects on sleep and symptoms

3.2.1. Symptom questionnaires

Mean scores on the sleep questionnaires showed improvement at post-intervention (detailed tables on the study outcomes are available in the online [Supplementary material](#)). The change in the ISI was statistically significant (ISI pre-treatment = 15.0 ± 5.7 , post-treatment = 11.4 ± 4.4 ; $t = 2.56$, $p = .025$), but the ESS (pre = 8.2 ± 6.0 , post = 6.9 ± 5.2) and PSQI (pre = 9.3 ± 3.4 , post = 8.9 ± 3.3) were not. The PSQI component scores showed significant improvement on Daytime Dysfunction (pre- and post-treatment means 1.38 and .92; $t = 2.52$, $p = .027$) and non-significant ($p > 0.05$) improvement on Sleep Latency (means = 1.38 and 1.08) and Habitual Sleep Efficiency (means = 1.00 and 0.69). Subjective Sleep Quality showed a modest (1.23 and 1.77) but statistically significant decrement ($t = -2.50$, $p = 0.028$). The other components (Sleep Duration, Sleep Disturbances, and Sleeping Medication Use) did not show clinically or statistically significant changes.

Total disability scores and pain ratings on the HAQ (HAQ-DI, Pain, and Global Health) were not significantly changed. Scores on the GDS were reduced post-intervention (pre = 4.5 ± 0.4 , post = 3.4 ± 2.9). Although the change was not significant for mean GDS scores, the categorization of depression (none, mild, moderate, severe) showed a non-significant trend toward lower symptom categories ($Z = -1.89$, $p = .059$).

3.2.2. Sleep diaries

Diary data were available from 12 participants. Both SOL and SE were significantly improved at post-intervention, with participants reporting shorter SOL (pre = 30.1 ± 21.1 min, post = 14.3 ± 9.3 ; $t = 2.65$, $p = .023$) and higher SE (pre = $75.2 \pm 12.9\%$, post = 84.1 ± 8.9 ; $t = -3.47$, $p = .005$). TST showed a non-significant trend toward improvement (pre = 370.4 ± 84.6 min, post = 407.3 ± 86.1 ; $t = -1.91$, $p = .082$). The number of nights on which participants experienced insomnia symptoms (SOL or WASO > 30 min, or SE < 85%) was significantly reduced from pre- to post-intervention (pre = 4.8 ± 2.1 nights/week, post = 3.0 ± 2.5 ; $t = 3.69$, $p = .004$). Mean WASO, SQ, refreshment after sleeping, average daily joint pain, and daytime sleepiness showed small improvements, but the changes were not statistically significant.

3.2.3. Actigraphy

Actigraphy data were available for analysis from 11 of the 13 participants (2 participants were missing actigraph data due to participant error). Mean values for the sleep outcomes (TST, SOL, WASO, and SE) did not show clinically important improvements or decrements, and differences from pre- to post-intervention were minimal.

3.2.4. Cohort differences

Two cohorts were recruited, each of which was taught by a different instructor, although the intervention protocol was standardized. The cohort not taught by the PI was visited several times to check the fidelity to the study protocol, and the instructor was given regular feedback. Exploratory analyses were done to investigate whether the cohort's characteristics differed or whether any systematic differences occurred in treatment effects. No significant cohort differences were found in the demographics. Few outcomes

indicated worse sleep in Cohort 1 at pre-intervention, including the PSQI (mean for Cohort 1 vs. 2 = 10.75 vs. 7.00, $t = 2.23$, $p = .047$), diary-reported WASO (71.59 vs. 21.94 min, $t = 2.27$, $p = .046$), and diary-reported SE (68.78 vs. 84.29, $t = -2.50$, $p = .032$). Pre- to post-intervention change scores for the two cohorts were compared by independent t -tests (or Mann Whitney U if variables were skewed) on all outcomes. None of the change scores were significantly different indicating that no systematic outcome differences occurred due to cohort or instructor.

3.3. Adverse events

Few adverse events (AEs) occurred during the trial, and those that did occur were minor. Of the 14 participants who attended at least one yoga class, 8 experienced an AE that was definitely or probably attributable to the intervention. The most common AE was shoulder soreness ($n = 4$), followed by muscle cramps ($n = 3$), lumbar soreness ($n = 2$), numbness in hands ($n = 1$), and dizziness in supine poses ($n = 1$). The shoulder and lumbar soreness improved in the participants by either modifying the exacerbating pose or simply continuing the yoga practice over time. The muscle cramps occurred in the calf ($n = 2$) or thigh ($n = 1$) and in all cases occurred in bridge pose. By the end of the program, none of the participants experienced cramping in this pose. The participant who experienced numbness had OA in her neck, and this problem resolved by reducing the range of the arm movements during the yoga practice. Finally, the mild vertigo experienced by one participant never fully resolved, but was reduced by elevating her head on a blanket in supine poses.

4. Discussion

Overall, this study demonstrated that an evening yoga practice designed to improve sleep in middle aged to older women with OA was highly feasible and produced promising preliminary efficacy findings. Recruitment and retention were successful, with the study reaching full enrollment and experiencing only one drop-out (92% retention). Participants reported practicing the yoga program at home 83% of their nights in the study, and the mean practice duration (22.6 min) was longer than the time requested by the PI (20 min). Participants reported enjoying the class and desiring to continue yoga practice. Overall, these results support further research on a standardized yoga intervention for sleep disturbance in women with OA.

Our study showed similar retention rates to other studies of yoga for older adults but also produced new feasibility data on adherence of adults with OA to a nightly yoga practice. The mean duration of each practice session was similar to that found in a study of Kundalini Yoga (a style emphasizing meditation and breathing techniques) for persons with insomnia (mean practice = 24.4–28.8 min) [21]. Retention rates of 82–92%, similar to our pilot study, have been observed in a series of yoga studies for health promotion in older adults (Silver Yoga) by Chen and colleagues [22–25,45]. Interventions in these studies ranged from 1 to 6 months ($n = 16$ –204) [22–25]. However, all of these studies were either one group pre-/post-test design or used wait-list controls. These data support the interest of older adults in yoga for health promotion, but such interest may also indicate that retention of participants in studies employing attention-control groups may be particularly challenging in yoga research.

In addition to feasibility, the findings of this pilot study provide preliminary support for the efficacy of a standardized nightly yoga practice in middle aged to older women with OA. Sleep outcomes from questionnaires and diaries showed improvements after treatment, several of which were statistically significant (ISI; sleep

diary SOL, SE, and nights with insomnia). Additionally, depressed mood (GDS) showed a trend toward improvement. Actigraphy-based outcomes were not statistically significant. It is possible that this 8-week pilot study was not long enough to impact actigraphic sleep outcomes. But discordance between subjective and objective measures is common in insomnia, and improvement of subjective sleep alone is of clinical importance for reducing symptoms experienced by patients. The overall outcomes are encouraging given that this feasibility study was not designed for statistical power to detect significant changes in the efficacy outcomes.

Research on the Silver Yoga program also examined sleep outcomes (PSQI scores) in older adults, although their sample was not limited to persons with OA. These studies showed improvements in physical outcomes (e.g., range of ROM, balance) as early as 4 weeks, but total PSQI scores were not significantly improved until 6 months of practice. We found improvements in PSQI scores (though not statistically significant) as well as significant improvement in other sleep outcomes after only 8 weeks of practice. The earlier onset of improvement in our study may be explained by inclusion of nightly relaxing practices in the evening yoga routine. Other studies have examined therapeutic yoga interventions designed to improve sleep. The previously discussed study of Kundalini Yoga for adults with insomnia ($n = 40$, mean age 41.1 ± 10.0 years) found significant reduction of diary-reported total sleep time, total wake time, sleep efficiency, sleep onset latency, and wake after sleep onset in those who completed the study ($n = 21$) [21]. The efficacy of the intervention, however, supports inclusion of the yoga elements emphasized—breathing and meditative thought—in interventions for insomnia. The present study included breathing practices and mindful body awareness during relaxation poses. Another RCT found significant improvement in the sleep of older adults, but it employed an intensive therapy that trained participants 60 min per day, 6 days each week for 6 months [18]. The intervention implemented in the present study produced significant improvement, and it was less intensive and time-consuming.

Pain (VAS) and disability (HAQ-DI) scores were not significantly reduced in this study. Disability scores were fairly low and may have encountered a floor effect. Given that other studies of yoga for OA pain found reduction of this symptom [11,12,46], it was expected that the range-of-motion (ROM) exercises in this study would reduce participants' pain. Lack of effect may have been related to inclusion of only mild strengthening exercises. Research has shown strengthening exercises to help with OA pain [47]. A future study might benefit from a greater emphasis on strengthening practices that would increase joint stability.

Few side effects of the intervention occurred, all of which were minor. Safety of the intervention was supported by familiarity of both instructors with the limitations of persons with OA and modifications of yoga to meet such needs. This baseline knowledge will be important for future studies of yoga for OA. In a subsequent randomized controlled trial of the yoga program for sleep in OA, employing knowledgeable instructors and providing training on OA and acceptable modifications of yoga poses will be important for safety and standardization of this trial.

4.1. Limitations

Certain limitations of the study should be addressed in subsequent trials of yoga for OA. The effects of the intervention, although promising, must be interpreted with caution as the study did not include a control group. In particular, the beneficial effects of general activation and social support (i.e., weekly class participation) are unknown. A subsequent study planned by our group will include an attention-control group to control for these factors. Additionally, this study was subject to the common limitations of research involving self-report. Although back-filling of diaries was reduced by col-

lecting these forms weekly, there was still the potential for delayed completion of these forms. Electronic data collection would improve the accuracy of daily sleep and symptom reporting.

5. Conclusions

This feasibility and acceptability study showed that women with OA and sleep disturbance were highly interested in yoga as a potential treatment for their symptoms. Efficacy findings from the study were promising, showing significant improvements in several self-report sleep outcomes. These findings support the feasibility of a randomized controlled trial examining the effect of a yoga intervention on OA symptoms, such as sleep, pain, and depression in middle aged to older adults. Despite a glut of media and published information on yoga, it is difficult for patients and healthcare providers to judge the safety, quality, and potential benefits of any given yoga program or class. A standardized yoga program resulting from this research could provide both patients and practitioners with an evidence-based program that could be systematically implemented in the community setting and widely available as an option for management of sleep disturbances in persons with OA.

Conflict of Interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: [doi:10.1016/j.sleep.2010.09.016](https://doi.org/10.1016/j.sleep.2010.09.016).

Acknowledgements

The authors thank the women who participated in this research. We thank Robin Rothenberg, Cathryn Booth-LaForce, Dorothy Hiestand, and Karen Sherman for providing consultation. We thank Sarah Poppe for helping with data processing. This research was supported by the RAND/Hartford Foundation-funded University of Washington Center for Interdisciplinary Geriatric Research, the UW School of Nursing Department of Biobehavioral Nursing and Health Systems, and the UW Center for Research on the Management of Sleep Disturbance (NIH Grant # 1P30NR011400).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.sleep.2010.09.016](https://doi.org/10.1016/j.sleep.2010.09.016).

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