

Yoga in Sedentary Adults with Arthritis: Effects of a Randomized Controlled Pragmatic Trial

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ABSTRACT. *Objective.* To evaluate the effect of Integral-based hatha yoga in sedentary people with arthritis. *Methods.* There were 75 sedentary adults aged 18+ years with rheumatoid arthritis (RA) or knee osteoarthritis randomly assigned to 8 weeks of yoga (two 60-min classes and 1 home practice/wk) or waitlist. Poses were modified for individual needs. The primary endpoint was physical health [Medical Outcomes Study Short Form-36 (SF-36) physical component summary (PCS)] adjusted for baseline; exploratory adjusted outcomes included fitness, mood, stress, self-efficacy, SF-36 health-related quality of life (HRQOL), and RA disease activity. In everyone completing yoga, we explored longterm effects at 9 months. *Results.* Participants were mostly female (96%), white (55%), and college-educated (51%), with a mean (SD) age of 52 years (12 yrs). Average disease duration was 9 years and 49% had RA. At 8 weeks, yoga was associated with significantly higher PCS (6.5, 95% CI 2.0–10.7), walking capacity (125 m, 95% CI 15–235), positive affect (5.2, 95% CI 1.4–8.9), and lower Center for Epidemiologic Studies Depression Scale (–3.0, 95% CI –4.8 – –1.3). Significant improvements ($p < 0.05$) were evident in SF-36 role physical, pain, general health, vitality, and mental health scales. Balance, grip strength, and flexibility were similar between groups. Twenty-two out of 28 in the waitlist group completed yoga. Among all yoga participants, significant ($p < 0.05$) improvements were observed in mean PCS, flexibility, 6-min walk, and all psychological and most HRQOL domains at 8 weeks with most still evident 9 months later. Of 7 adverse events, none were associated with yoga. *Conclusion.* Preliminary evidence suggests yoga may help sedentary individuals with arthritis safely increase physical activity, and improve physical and psychological health and HRQOL. Clinical Trials NCT00349869. (J Rheumatol First Release April 1 2015; doi:10.3899/jrheum.141129)

Key Indexing Terms:

YOGA RHEUMATOID ARTHRITIS OSTEOARTHRTIS MOBILITY HRQOL

For people with arthritis, physical activity is essential for optimal disease management and preserving mobility^{1,2}. Exercise helps maintain range of motion, joint stability, and muscle mass, while reducing pain and fatigue^{3,4,5}. The stress reduction associated with exercise can help individuals adaptively cope to living with a painful, chronic illness, and emerging evidence also suggests beneficial effects on systemic inflammation and immune function^{6,7}. However, despite the well-known benefits of physical activity, up to

44% of people with arthritis report no leisure time physical activity⁸ and 76% are inadequately active⁹. Indeed, arthritis appears to be a major barrier to physical activity; among people with heart disease, those with arthritis were 60% more likely to be inactive¹⁰.

Yoga may be well-suited for arthritis by combining physical activity with potent stress management techniques, including breathing, relaxation, and mindfulness¹¹. In 2012, 20 million US adults (nearly 1 in 10) practiced yoga to improve health and fitness, with 40% starting in the past year alone¹². The 2007 National Health Interview Survey listed yoga as the sixth most commonly used complementary health practice among adults¹³. In both healthy and clinical populations, the health benefits of yoga appear to be similar to other forms of exercise^{14,15,16}. The strongest evidence of benefit is for reducing pain [standardized mean difference (SMD) –0.74, 95% CI –0.97 – –0.52], pain-related disability (SMD –0.79, 95% CI –1.02 – –0.56)¹⁷, and improving mood (SMD –0.65, 95% CI –0.89 – –0.42)¹⁸. However, medical professionals may be concerned that yoga's emphasis on changing positions and flexibility could stress vulnerable joints affected by arthritis.

Unfortunately, the evidence base is limited regarding yoga

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in arthritis. We summarized 10 peer-reviewed articles and abstracts of yoga and arthritis through 2010¹⁹; the existing studies, conducted in diverse populations around the world, were mostly of low quality (small samples, nonrandomized trials, heterogeneity of dose, methods, and outcomes) and precluded drawing conclusions. Other reviews of recent trials in rheumatic conditions have noted ongoing concerns with study quality, but the emerging evidence does suggest that yoga may improve arthritis symptoms (pain, stiffness, tenderness), function, and mood^{19,20,21,22}. Given its popularity and availability, well-controlled trials are needed to guide recommendations about yoga in arthritis^{15,20,21,22}.

Hence, our goal was to contribute evidence about outcomes associated with initiating yoga practice in sedentary people with arthritis. An 8-week program was developed, emphasizing individualized adaptations and monitoring, to promote successful transition to home practice. We hypothesized that yoga would improve physical health, fitness, psychological function, health-related quality of life (HRQOL), and arthritis self-efficacy with no worsening of rheumatoid arthritis (RA) disease activity.

MATERIALS AND METHODS

Study design. A parallel-arms pragmatic 8-week randomized controlled trial (RCT) compared Integral-based hatha yoga and waitlist groups. Pragmatic RCT use rigorous methodology (randomization, blinding, allocation concealment) to reduce bias, but allow flexibility in intervention delivery and enhance external validity by testing existing programs in real-world settings and with less stringent inclusion criteria²³. Individuals were randomly assigned 1:1 to yoga or waitlist. This study was approved by the Johns Hopkins Institutional Review Board and registered with clinicaltrials.gov (NCT00349869).

The study was originally for RA; after 31 patients were enrolled, additional funding was secured and the study was expanded to include knee osteoarthritis (OA). Although these diseases have different underlying mechanisms, both result in significant joint pain and disability, and community classes are likely to include people with both conditions. Additional secondary endpoints were added.

We also explored the effects of yoga over time. After completing 8-week followup assessments, waitlisted participants were invited to join upcoming classes. We also completed followup assessments of these participants after 8 weeks of yoga, and of everyone who had completed yoga 9 months after classes had ended.

Participants. Eligibility criteria included (1) patients with RA, age 18–70 years; and patients with OA, 18+; (2) sedentary (physically active for 20 min < 3 times/week); and (3) diagnosed with RA, OA, or probable knee OA as indicated by a positive response to questions used in trials to identify knee OA²⁴. Exclusion criteria were (1) use of cane, walker, or wheelchair; (2) other inflammatory conditions; or (3) surgery within 6 months. For RA, medical clearance was required. Eligibility criteria were deliberately broad to ensure participants reflected typical people with arthritis living in the community. Enrollment occurred from June 2005 through July 2008, and ended when 75 participants had been enrolled.

Recruitment and allocation. Participants were recruited from arthritis clinics, private practices, and using local flyers. The Maryland Arthritis Foundation Chapter also publicized the study in newsletters. Potential participants were screened by phone and eligible persons provided written consent and underwent baseline assessments. Rheumatologists and all assessors remained blinded to treatment assignment.

Simple random assignment was done by a third party using a Web-based

randomizer; allocation sequence was concealed from all study team members by using sequentially numbered, sealed opaque envelopes that were opened by the coordinator once baseline assessments were completed. Yoga classes began once 12–15 people were available (i.e., had been randomized after baseline and/or completed waitlist).

Treatment arms. Yoga consisted of 60-min classes held twice weekly for 8 weeks at 2 hospital-affiliated fitness centers in Baltimore, Maryland, USA. The program was designed by a registered yoga therapist (SM) with input from the Johns Hopkins Arthritis Center faculty. Two yoga therapists with 10+ years of experience taught the classes. Yoga therapists have additional training to address the needs of people with diverse conditions/abilities.

Each class began with questions/comments (5 min), breathing exercises and chanting (5 min), warm-up and moving sequence (surya namaskara, 15 min), and isometric poses (asanas, 20 min) to increase strength, flexibility, and balance. Classes ended with deep relaxation (sivasana, 10 min), a closing chant, and meditation (5 min). See Appendices for sample class and modifications. Poses included gentle forward bends, backbends, twists, balances, standing, sitting, and lying poses, and were modified for individuals at the discretion of the teacher and/or participant. Complexity of poses and intensity was standardized to allow gradual progression. Eight weeks was selected for the intervention because this provides sufficient time to introduce independent practice and is a common duration of introductory classes. Props included blocks, straps, blankets, and chairs. Participants were encouraged to try new skills, but to remain safe and avoid discomfort. Written instructions with pictures for home practice and selected readings describing potential benefits of yoga components (breathing, meditation, mindfulness) were provided weekly. Home practice evolved gradually to develop the skills and confidence for longterm adherence. Participants were asked to keep arthritis medications constant and were queried regularly by coordinators about any changes.

The waitlist group received usual care for 8 weeks. They were asked to maintain current levels of physical activity and inform coordinators of changes in health or arthritis medications. After Week 8 assessments, they were invited to participate in upcoming classes.

Dependent measures. Measures were obtained by blinded assessors at baseline, Week 8, and 9 months (yoga only) at the Johns Hopkins Bayview General Clinical Research Center.

The primary endpoint was the Medical Outcomes Study Short Form-36 (SF-36) physical component summary (PCS) at Week 8. The SF-36 assesses 8 domains with higher scores representing better HRQOL. The PCS and mental component scores (MCS) differentially weight all scales using a t-score metric (mean 50 and SD 10). The PCS, which emphasizes physical function, fulfilling physical roles and bodily pain, is reliable (ICC 0.81) and responsive to change (SRM 0.61)^{25,26}.

Exploratory endpoints included fitness, psychological function, and HRQOL. Using standardized protocols, flexibility was measured using a sit-and-reach box²⁷, balance with 1-leg stance (OLS; maximum 30 s), and strength with a hand dynamometer²⁸. For each measure, the best of 3 attempts was recorded. The 6-min walk²⁹ measured walking capacity.

The SF-36 MCS provided an overall index of mental health. Depressive symptoms were assessed using the 11-item Center for Epidemiologic Studies–Depression Scale (CES-D)³⁰ that has a similar factor structure and properties as the original scale and is validated in arthritis³¹. The Positive and Negative Affect Scale (PANAS) assessed mood. The PANAS is reliable ($r = 0.86$ and 0.87 for PA and NA) and internally consistent ($\alpha = 0.86$ – 0.90 for PA and 0.84 – 0.87 for NA)³². Stress was measured with the Perceived Stress Scale, which is reliable ($r = 0.84$ – 0.86) and correlates moderately with number and effect of life events ($r = 0.33$ – 0.49)³³. The Arthritis Self-efficacy Scale, which measures confidence to manage arthritis, is internally consistent ($r = 0.94$) and reliable ($r > 0.85$)³⁴. For RA, 28 tender and swollen joint counts were conducted by trained assessors, and participants completed the 100 mm patient's global assessment (PtGA) visual analog scale. Attendance was recorded at classes.

Statistical analysis. Our study was designed and powered to detect an 8-point

difference in PCS between groups. (The minimal clinically important difference for RA is 5.) A sample size of 30/group was sufficient to detect this difference, assuming an SD of 11 points, power of 80%, and significance of 5%.

Groups were compared on sociodemographic and SF-36 scores by arthritis type using Student t tests and chi-square tests. To assess the effect of missing data for variables added after the study began, we compared characteristics of the first 31 participants with the last 44, and also used multiple imputation and last observation carried forward (LOCF).

The primary RCT analysis was ANCOVA by group with adjustment for baseline values (Model 1). In Model 2, we also added adjustment for age. Baseline covariates were chosen to improve the precision of estimates; age was explored given its associations with outcomes and because of chance imbalances between groups despite randomization³⁵ after first testing for homogeneity of regression slopes by treatment. Paired Student t tests also explored within-group differences after 8 weeks of yoga and 9 months later.

RCT data were analyzed based on treatment assignment. Because this was an exploratory study, we did not control for multiple comparisons. All analyses were performed using IBM SPSS, version 21.

RESULTS

Of 103 people who contacted the research team, 19 were ineligible because of current physical activity (11), recent/planned surgery (5), and use of assistive devices (3); 9 declined because of time requirements (Figure 1). Thus, 75 participants were randomly assigned to yoga (n = 40) or waitlist (n = 35). Participants were mostly middle-aged (mean ± SD, 52 ± 12 yrs), female (96%), and white (55%), with 39% black. About half (51%) were college-educated and 49% had RA with an average duration of 9 ± 9 years.

Of the last 44 enrolled, 67% had OA; the mean age of those enrolled when recruitment was expanded was significantly higher than the original cohort, but did not differ on other sociodemographic or arthritis variables (data not shown). Yoga participants were significantly younger than waitlist, but did not otherwise differ (Table 1). Participants

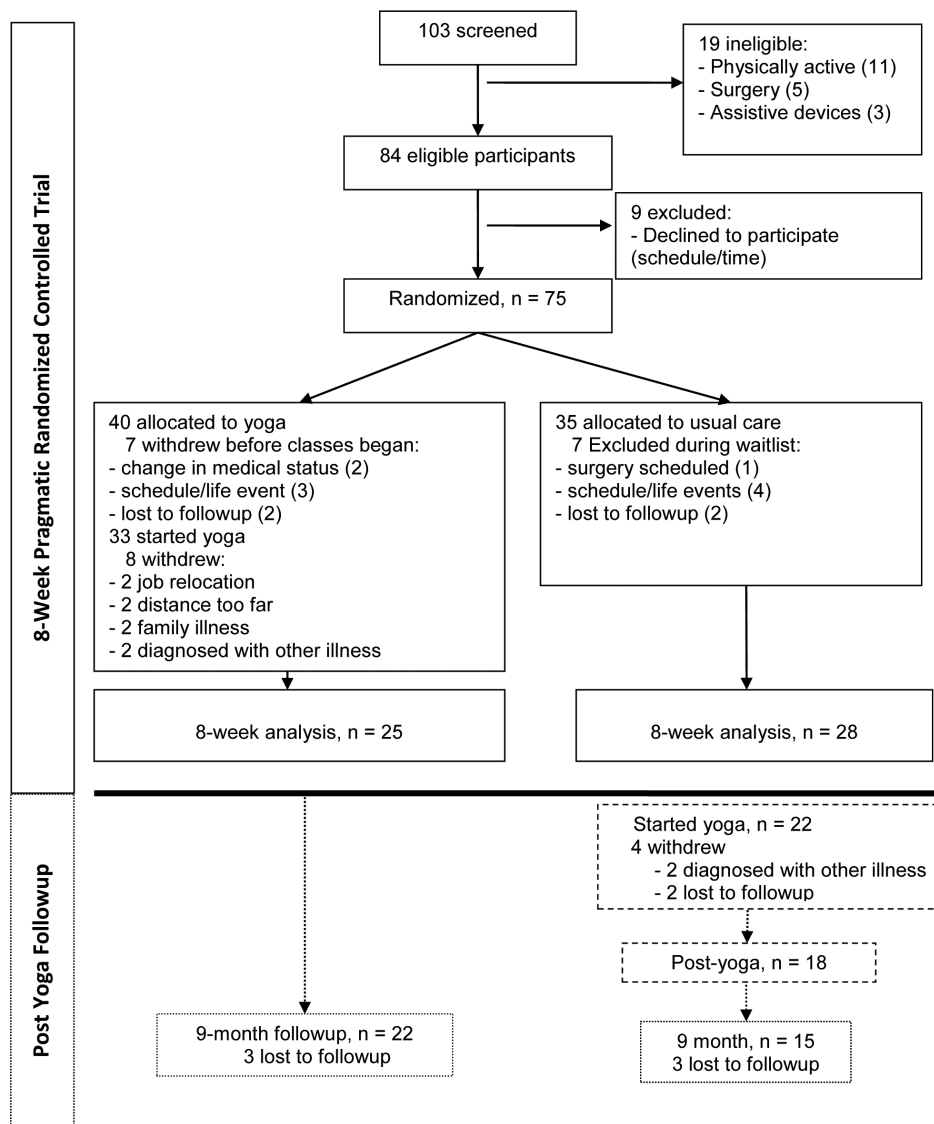


Figure 1. Flow of yoga and usual care participants throughout an 8-week randomized controlled trial and 9-month followup (yoga participants only).

Table 1. Baseline characteristics of participants. Values are mean \pm SD or % unless otherwise specified.

Value	Yoga, n = 40	Waitlist, n = 35
Age, yrs	49.2 \pm 13.2	55.9 \pm 8.9
Female, n (%)	40 (100)	32 (91)
Race		
White	57.5	51.4
Black	37.5	40.0
Other	5.0	8.6
College graduate	47.5	55.9
RA diagnosis	55	43
Disease duration, yrs	9.9 \pm 8.7	8.6 \pm 9.4

RA: rheumatoid arthritis.

with RA were significantly younger and had significantly lower SF-36 MCS, general health, social function, and mental health scores (Table 2).

Among 40 yoga participants, 7 withdrew (see Figure 1 for reasons) between baseline and the start of classes, and 8 withdrew during the intervention. Thus, Week 8 data were available for 25 participants. Most who completed yoga (22, 79%) attended at least 12/16 classes. Of 35 people in the waitlist group, 7 withdrew; Week 8 data were available for 28 people. Study completers did not differ significantly from withdrawals by age, sex, education, diagnosis, disease duration, pain, or physical function, but were more likely to be minorities (OR 4.3, 95% CI 1.5–12.4). The most common reasons for withdrawal were life events and scheduling.

Physical health and fitness. At Week 8, in adjusted analyses (Model 1), the mean PCS score for yoga was 6.5 points higher than waitlist ($p < 0.001$; Table 3); this 0.7 SD difference is both statistically and clinically meaningful and

persisted with adjustment for age (Model 2). Walking capacity was also significantly higher for yoga (125 m); there was a trend ($p = 0.056$) for sit-and-reach scores to also being higher. OLS and grip strength did not differ between groups. In Model 2, with additional adjustment for age, differences in flexibility reached statistical significance; however, 6-min walk, grip strength, and balance were not significantly different between groups. Results were similar using LOCF (data not shown).

Psychological function. At Week 8, with adjustment for baseline, the yoga group reported significantly fewer depressive symptoms (CES-D) and higher positive affect (PANAS). However, groups did not differ on SF-36 MCS, negative affect, perceived stress, or arthritis self-efficacy. Results were unchanged with adjustment for age.

HRQOL. At Week 8, adjusted analyses showed yoga participants reported significantly less impairment on SF-36 role physical, body pain, general health, vitality, and mental health scales, with trends ($p < 0.08$) evident in physical function and role emotional. Within groups, yoga improved significantly on all SF-36 scales, except role emotional, while scores were essentially unchanged in waitlist. Significant differences were evident in the same SF-36 scales, except general health with further adjustment for age.

In 25 participants with RA, we also explored changes in joint counts and PtGA scores (Table 4). Swollen and tender joint counts decreased and PtGA scores improved in both groups, and were not statistically different in baseline-adjusted analyses between groups at Week 8.

Yoga group. At Week 8, 22 of 28 waitlist participants (79%) began yoga. Characteristics were similar between waitlist participants who did and did not start yoga (data not shown).

Table 2. Participant characteristics by arthritis type. Values are the mean \pm SD or n (%) unless otherwise indicated.

Variable	RA, n = 37	OA, n = 38	p
Age, yrs	46.6 \pm 12.1	57.9 \pm 8.7	< 0.001
Female	36 (97)	36 (95)	0.572
College graduate	20 (54)	19 (50)	0.831
Minority	14 (38)	20 (53)	0.198
Disease duration, yrs	8.5 \pm 7.6	10.1 \pm 10.2	0.431
SF-36 component scores			
PCS	34.1 \pm 10.9	35.5 \pm 9.8	0.568
MCS	48.6 \pm 12.4	54.4 \pm 9.9	0.032
SF-36 scales			
Physical function	57.7 \pm 24.6	49.6 \pm 21.5	0.142
Role physical	34.1 \pm 38.4	43.4 \pm 37.5	0.305
Bodily pain	48.0 \pm 19.1	53.7 \pm 17.4	0.193
General health	46.7 \pm 24.3	66.7 \pm 18.2	0.000
Vitality	45.6 \pm 21.2	51.1 \pm 20.2	0.272
Social function	62.9 \pm 24.7	79.6 \pm 22.6	0.004
Role emotional	68.7 \pm 42.4	71.1 \pm 40.4	0.811
Mental health	69.7 \pm 21.1	80.1 \pm 13.1	0.014

RA: rheumatoid arthritis; OA: osteoarthritis; SF-36: Medical Outcomes Study Short Form-36; PCS: physical component summary; MCS: mental component summary.

Table 3. Physical health, fitness, psychological function, and HRQOL by group at baseline and Week 8 of RCT. Values are the mean ± SD unless otherwise specified.

Variable	Yoga, n = 25 [^]			Waitlist, n = 28 [∞]			Week 8 Difference, mean (95% CI)		
	Week 0	Week 8	p [†]	Week 0	Week 8	p [†]	Unadjusted	Model 1 [*]	Model 2 ^{††}
SF-36 physical component	36.3 ± 10.4	43.4 ± 9.0	0.002	33.9 ± 10.5	35.3 ± 11.0	0.345	8.1 (2.5–13.7)	6.5 (2.0–10.7)	6.5 (1.9–11.0)
Fitness									
Sit and reach, cm	–2.8 ± 5.2	0.1 ± 5.1	0.000	–5.6 ± 6.2	–4.2 ± 6.2	0.260	4.5 (1.0–8.1)	2.7 (–0.1–5.5)	3.0 (0.2–5.9)
One-leg stance*, s	25.6 ± 9.5	26.4 ± 9.1	0.464	19.8 ± 10.2	20.5 ± 10.6	0.656	5.8 (–0.5–12.2)	2.0 (–2.4–6.4)	1.9 (–2.6–6.4)
Grip strength, kg	25.5 ± 8.0	25.8 ± 8.2	0.815	24.3 ± 9.4	24.5 ± 10.1	0.643	1.2 (–4.7–7.1)	–0.1 (–2.5–2.3)	–0.2 (–2.7–2.4)
6-min walk, m	1450 ± 248	1588 ± 243	0.000	1508 ± 337	1494 ± 302	0.782	94 (–58–247)	125 (15–235)	101 (–14–217)
Psychological function									
SF-36 mental component	51.1 ± 13.0	55.4 ± 8.1	0.074	52.4 ± 9.7	51.6 ± 12.1	0.592	3.8 (–1.9–9.4)	4.1 (–0.4–8.7)	3.0 (–1.7–7.7)
CES-D	6.7 ± 5.5	3.7 ± 3.0	0.003	8.4 ± 6.4	7.8 ± 6.0	0.176	–3.8 (–6.5 – –1.1)	–3.0 (–4.8 – –1.3)	–2.6 (–4.4 – –0.7)
PANAS									
Positive affect*	20.6 ± 8.3	27.1 ± 5.8	0.001	25.4 ± 5.8	24.6 ± 8.3	0.549	2.2 (–1.9–6.3)	5.2 (1.4–8.9)	5.3 (1.4–9.2)
Negative affect	7.2 ± 6.5	5.5 ± 6.1	0.190	5.7 ± 5.2	6.6 ± 5.8	0.318	–0.5 (–4.0–2.9)	–2.0 (–4.7–0.7)	–1.0 (–3.7–1.8)
Perceived stress scale	15.5 ± 5.0	13.1 ± 5.6	0.131	14.6 ± 21.0	15.0 ± 21.0	0.612	–1.6 (–4.9–1.7)	–2.4 (–5.4–0.6)	–2.2 (–5.3–1.0)
Arthritis self-efficacy scale	59.4 ± 8.9	64.8 ± 13.1	0.046	55.5 ± 15.8	58.8 ± 16.4	0.287	5.5 (–4.5–15.4)	3.2 (–5.5–12.0)	4.3 (–4.4–13.1)
SF-36									
Physical function	59.0 ± 19.4	68.8 ± 22.9	0.024	53.4 ± 24.7	55.0 ± 29.3	0.573	13.8 (–0.8–28.4)	8.8 (–1.1–18.7)	8.4 (–2.0–18.8)
Role physical	36.0 ± 36.9	78.0 ± 34.9	0.000	41.1 ± 38.0	45.5 ± 41.4	0.485	32.5 (11.2–53.7)	34.9 (15.7–54.0)	34.6 (14.2–54.9)
Bodily pain	52.2 ± 18.9	63.1 ± 20.6	0.015	49.3 ± 17.8	50.0 ± 21.1	0.790	13.1 (2.5–23.7)	11.4 (2.6–20.2)	9.6 (0.5–18.7)
General health	61.3 ± 20.6	68.9 ± 17.3	0.012	52.6 ± 24.4	55.0 ± 22.7	0.394	13.8 (2.8–24.9)	7.7 (0.5–15.0)	6.5 (–1.5–14.4)
Vitality	49.8 ± 21.2	63.4 ± 19.3	0.002	50.9 ± 20.3	52.7 ± 18.9	0.554	10.7 (0.2–21.3)	11.3 (2.9–19.8)	9.2 (0.4–17.9)
Social function	72.0 ± 24.5	83.0 ± 21.0	0.052	68.3 ± 26.0	72.3 ± 30.1	0.142	10.7 (–3.8–25.2)	8.1 (–2.8–19.1)	8.3 (–3.3–20.0)
Role emotional	73.3 ± 40.8	89.3 ± 26.7	0.110	71.4 ± 41.3	72.6 ± 40.6	0.861	16.7 (–2.1–35.5)	16.1 (–1.8–33.9)	12.3 (–6.3–30.9)
Mental health	72.8 ± 17.6	81.9 ± 13.1	0.013	77.9 ± 17.1	74.6 ± 21.1	0.140	7.3 (–2.5–17.0)	10.8 (3.4–18.3)	8.9 (1.4–16.3)

Values significantly different ($p < 0.05$) from baseline in unadjusted and adjusted models are shown in bold face. [^] n = 19 and [∞] n = 24 for hand grip, sit and reach, one-leg stance, perceived stress, and arthritis self-efficacy outcomes. [†] p value within groups from baseline. ^{*} Model 1 adjusted for baseline value. ^{††} Model 2 adjusted for baseline value and age. ^{*} Week 0 scores significantly different ($p < 0.05$) between groups at baseline. HRQOL: health-related quality of life; RCT: randomized controlled trial; SF-36: Medical Outcomes Study Short Form-36; CES-D: Center for Epidemiologic Studies–Depression Scale; PANAS: Positive and Negative Affect Scale.

Table 4. Change in tender and swollen joints and patient’s global assessment (PtGA) scores in RCT participants with RA. Values are the mean ± SD unless otherwise specified.

Variable	Yoga, n = 11		Difference (95% CI)	Waitlist, n = 14		Difference (95% CI)	Week 8 Between Group Differences, mean (95% CI)	
	Week 0	Week 8		Week 0	Week 8		Unadjusted	Model 1 [*]
Tender joints, 28-count	10.4 ± 7.5	4.5 ± 6.9	–5.9 (–9.8 – –2.0)	8.1 ± 8.3	3.5 ± 5.8	–4.6 (–9.4–0.3)	1.0 (–4.3–6.2)	0.1 (–4.7–4.8)
Swollen joints, 28-count	8.3 ± 4.6	4.1 ± 4.8	–4.2 (–7.9 – –0.5)	7.7 ± 7.3	3.6 ± 5.2	–4.1 (–8.5–0.2)	0.5 (–3.7–4.7)	0.4 (–3.7–4.4)
PtGA	36.8 ± 8.0	19.4 ± 14.5	–17.4 (–33.2 – –1.6)	37.2 ± 24.0	12.7 ± 12.5	–24.5 (–39.9 – –9.1)	0.1 (–16.5–16.7)	6.8 (–3.4–17.3)

Week 8 scores significantly different ($p < 0.05$) from baseline are shown in bold face. Model 1: ANCOVA adjusted for baseline value. RCT: randomized controlled trial; RA: rheumatoid arthritis.

Overall, of 55 who began yoga, 44 (80%) completed Week 8 testing. PCS, all fitness (except OLS), psychological, and SF-36 measures (except role emotional) improved significantly (Table 5). Followup data were available on 37 participants (67%) 9 months after completing yoga. Improvements were still evident in PCS, sit-and-reach, 6-min walk, CES-D,

positive and negative affects, perceived stress, and SF-36 physical function, role physical, bodily pain, and vitality scales.

Adverse events. No adverse events were specifically associated with yoga. The 7 events (1 each) reported to the Internal Review Board for the yoga group (not attributed to

Table 5. Physical health, fitness, psychological function, and HRQOL in all yoga participants at Week 0, Week 8, and 9 months. Values are the mean \pm SD unless otherwise specified.

Variable	Week 0, n = 55	Week 8, n = 40	Mean Difference (95% CI)	9 Mos, n = 37	Mean Difference From Baseline (95% CI)
SF-36 PCS	34.8 \pm 10.4	42.9 \pm 9.1	7.4 (4.4–10.4)	42.5 \pm 10.5	5.3 (2.8–7.9)
Fitness					
Sit and reach, cm	–3.9 \pm 4.1	–2.2 \pm 6.5	2.3 (0.7–3.9)	1.7 \pm 4.9	5.6 (2.9–8.3)
One-leg stance, s	22.6 \pm 10.1	23.5 \pm 10.0	0.9 (–1.5–3.3)	25.9 \pm 7.5	1.0 (–1.7–3.7)
Hand grip, kg	25.1 \pm 8.7	25.5 \pm 9.5	0.2 (–1.2–1.5)	26.0 \pm 9.7	0.2 (–2.0–2.3)
6-min walk, m	1468 \pm 314	1566 \pm 275	77 (5–150)	1588 \pm 252	115 (5–225)
Psychological function					
SF-36 MCS	52.0 \pm 12.3	55.8 \pm 8.0	3.3 (0.2–6.4)	54.0 \pm 10.1	0.8 (–2.7–4.4)
CES-D	7.5 \pm 5.8	4.4 \pm 3.8	–2.6 (–4.2 – –1.0)	5.0 \pm 4.5	–1.9 (–3.1–0.7)
Positive affect	21.2 \pm 7.7	27.9 \pm 7.1	5.7 (3.1, 8.3)	27.2 \pm 4.8	5.0 (2.3–7.7)
Negative affect	5.9 \pm 5.1	4.4 \pm 4.8	–2.2 (–3.8 – –0.6)	4.7 \pm 5.4	–1.9 (–3.4 – –0.3)
Perceived stress	15.4 \pm 4.4	12.0 \pm 4.8	–3.0 (–5.3 – –0.7)	12.2 \pm 3.5	–4.2 (–6.7 – –1.7)
Self-efficacy	58.9 \pm 13.4	66.8 \pm 12.3	4.8 (3.6–9.3)	65.1 \pm 13.3	2.3 (–2.5–7.1)
SF-36					
Physical function	54.4 \pm 23.2	67.1 \pm 23.9	10.3 (4.2–16.3)	66.3 \pm 22.0	7.5 (1.1–13.9)
Role physical	36.4 \pm 39.3	76.3 \pm 34.9	38.1 (24.5–51.8)	72.8 \pm 38.6	27.9 (14.9–41.0)
Pain	50.5 \pm 19.5	63.3 \pm 17.2	11.9 (5.5–18.2)	61.8 \pm 19.5	7.0 (0.5–13.5)
General health	56.7 \pm 21.6	67.6 \pm 17.9	8.3 (4.2–12.3)	65.5 \pm 18.4	4.1 (–0.4–8.6)
Vitality	49.4 \pm 19.4	64.2 \pm 18.1	12.6 (7.0–18.2)	60.3 \pm 18.7	6.5 (0.9–12.0)
Social function	71.6 \pm 27.8	85.9 \pm 19.6	12.5 (4.0–21.0)	84.2 \pm 21.6	5.5 (–3.6–14.6)
Role emotional	74.5 \pm 38.5	86.7 \pm 29.0	10.0 (–2.6–22.6)	81.4 \pm 34.0	3.9 (–8.8–16.7)
Mental health	73.9 \pm 19.7	82.2 \pm 14.7	8.3 (3.5–13.1)	79.4 \pm 16.1	4.0 (–1.5–9.5)

Values significantly different ($p < 0.05$) from baseline are shown in bold face. HRQOL: health-related quality of life; SF-36: Medical Outcomes Study Short Form-36; PCS: physical component summary; MCS: mental component summary; CES-D: Center for Epidemiologic Studies–Depression Scale.

yoga) included bruising (workplace accident), ovarian cancer recurrence, bladder cancer, tendinitis, hyperthyroidism, allergic reaction, and new RA diagnosis (study end). No adverse events occurred in the waitlist group.

DISCUSSION

To date, this is the largest RCT of OA and RA, and to our knowledge the first to assess physical health and fitness using self-reported and performance measures along with psychological function and HRQOL. This is only the second study in arthritis (of 20 published to date) to include safety data. As compared to waitlist, yoga was associated with substantial improvements in physical and general health perceptions, physical roles, walking, pain, energy, and mood. Regular yoga practice was not associated with worsening joint symptoms or adverse events. Indeed, in RA, swollen and tender joint counts decreased significantly with yoga, though a similar trend was evident in the waitlist.

Although 24% dropped out of yoga, persistence was still higher than in many exercise programs³⁶, with most attending the majority of classes. The most common reason people withdrew was because of time/schedule conflicts. Other studies^{37,38} have also reported higher rates of adherence to yoga than studies with clinical populations where $< 50\%$ continue exercising by 3 months³⁹. Reducing inactivity is an important public health challenge, especially in arthritis, where only 1 in 4 are meeting activity guidelines⁹. Notably,

80% of the waitlist group opted to take yoga. Assessments 9 months later indicated the durability of most improvements.

At Week 8, the 6.5-point difference between groups in PCS indicated important improvements in health. PCS scores reflect physical function, role physical (work and daily activity impairments because of physical health), pain, and energy. Indeed, in the yoga group, 16/44 (36%) improved 1 category or more on the SF-36 self-rating of health. We noted a trend toward improved physical function with yoga at Week 8, as have others^{37,40,41,42}, though not all⁴³. When we pooled data from all yoga completers, there were significant improvements in all HRQOL scales except role emotional, which was already close to population norms at baseline.

We hypothesized that yoga would lead to improved flexibility, balance, and strength. Flexibility, which has not been previously evaluated in arthritis, improved with practice, although differences were not statistically significant ($p = 0.056$). Because loss of joint mobility is common in arthritis, preserving range of motion is important for maintaining mobility. However, yoga was not associated with improved balance, in contrast to the findings by others⁴⁴, perhaps because baseline values were already high. For example, 45% of participants scored at maximum levels (30 s) at baseline; among those with scores < 30 s, 54% improved with yoga. Tai chi also may enhance balance and reduce the risk of falls in arthritis⁴⁵. Future yoga studies should further evaluate

flexibility and balance. We also did not find improvements in grip strength; Garfinkel, *et al* also found no change in grip strength with yoga in hand OA⁴⁶, although this has been reported by others in RA^{47,48}. However, grip strength assesses upper limb strength and may not adequately characterize muscle strength of the entire body. Yoga targets many muscle groups, and many poses do not directly involve the upper limbs.

Pain, one of the most widely studied outcomes in yoga, improved significantly with yoga. Some^{37,41,42,44,46} though not all^{42,43,49} have reported similar results. Yoga was associated with positive affect and fewer depressive symptoms, findings also reported by some^{37,40,44}, though not all^{42,50}. In contrast to Evans, *et al*³⁷, self-efficacy was not significantly different between groups, perhaps because both groups improved.

In RA, significant reductions in joint counts were observed in both groups. One other study reported reductions in joint counts⁴³; another found no change in C-reactive protein (CRP) with 1 week of yoga at a residential camp⁴⁹. Together, these results suggest that yoga is unlikely to worsen disease activity. Sensitive measures, such as erythrocyte sedimentation rate, CRP, and interleukin 6, should be included in larger samples to evaluate the effect of yoga on systemic inflammation and immune reactivity.

A strength of our study was the controlled pragmatic study design. Randomization, blinding, concealment of treatment allocation, and use of flexible standardized protocols to guide progression increase confidence in our results. Including typical sedentary participants with RA and OA, evaluating classes specifically designed to promote independent practice, offering the program in community settings, and evaluating the effect on HRQOL increase the applicability and relevance of results. Although our program was developed by a multidisciplinary team (rheumatologists, psychologists, public health, and exercise scientists) and tailored for arthritis, we used common yoga poses and practices and a class length found in many introductory classes. Participants were taught to assess how they felt at each class and to adjust their practice accordingly. We also explored clinician-measured (fitness and clinical signs) and patient-centered (mood, stress, self-efficacy, symptoms) outcomes to gain insight into how yoga may affect health and well-being. Data collected on waitlist participants who later completed yoga supported the RCT findings, and many trends became statistically and clinically significant. In focus groups on RA stiffness that we conducted after five years, several participants commented that yoga had played a pivotal role in changing how they viewed their functioning, capabilities, and attitudes toward living with RA; they credited yoga with helping them maintain a more active lifestyle.

Although our study provides preliminary evidence that yoga appears to be acceptable to people with arthritis and

does not aggravate joint disease, caution is warranted. A longer period of practice might produce further gains, though potentially with an increased risk of injury. Despite improvements after 8 weeks, significant impairments were still evident in physical function, role physical, pain, general health, and energy. Classes were taught by experienced yoga therapists in community hospital fitness settings. Because classes began once ~15 participants were available, the length of time between baseline assessment and the start of yoga classes varied. We did not stratify by diagnosis, randomization did not result in group equivalence in age, and our sensitivity analyses used methods assuming data were missing at random, which we did not confirm. We cannot determine whether some yoga elements had more benefit than others, or the extent to which the yoga group experienced greater social support. Research to replicate and extend these findings across settings, instructors, and in diverse groups is ongoing. Inclusion of biomarkers may provide additional insight. Larger trials with active comparators are needed to establish the relative efficacy of yoga versus traditional exercise and other mind-body practices.

Our study contributes preliminary new evidence that sedentary individuals with RA and knee OA can safely learn to practice yoga in classes led by trained instructors who provide close supervision and individual attention. Eight weeks of classes and home practice was associated with clinically significant improvements in physical and mental health, fitness, psychological function, and HRQOL, with no adverse outcomes. Additional studies with active comparison groups in diverse settings and other forms of arthritis are necessary to support these findings and establish the benefits of yoga in relation to traditional exercise in people with arthritis.

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REFERENCES

1. American College of Rheumatology Subcommittee on Osteoarthritis Guidelines. Recommendations for the medical management of osteoarthritis of the hip and knee: 2000 update. *Arthritis Rheum* 2000;43:1905-15.
2. American College of Rheumatology Subcommittee on Rheumatoid Arthritis Guidelines. Guidelines for the management of rheumatoid arthritis: 2002 update. *Arthritis Rheum* 2002;46:328-46.
3. Fransen M, McConnell S. Exercise for osteoarthritis of the knee. *Cochrane Database Syst Rev* 2008;4: CD004376.
4. Juhl C, Christensen R, Roos EM, Zhang W, Lund H. Impact of exercise type and dose on pain and disability in knee osteoarthritis: a systematic review and meta-regression analysis of randomized controlled trials. *Arthritis Rheumatol* 2014;66:622-36.
5. Cramp F, Hewlett S, Almeida C, Kirwan JR, Choy EH, Chalder T, et al. Non-pharmacological interventions for fatigue in rheumatoid arthritis. *Cochrane Database Syst Rev* 2013;8:CD008322.
6. Hurley MV, Mitchell HL, Walsh N. In osteoarthritis, the psychosocial benefits of exercise are as important as physiological improvements. *Exerc Sport Sci Rev* 2003;31:138-43.

7. Petersen AM, Pedersen BK. The anti-inflammatory effect of exercise. *J Appl Physiol* 2005;98:1154-62.
8. Centers for Disease Control and Prevention (CDC). State-specific prevalence of no leisure-time physical activity among adults with and without doctor-diagnosed arthritis—United States, 2009. *MMWR Morb Mortal Wkly Rep* 2011;60:1641-5.
9. Hootman JM, Macera CA, Ham SA, Helmick CG, Sniezek JE. Physical activity levels among the general US adult population and in adults with and without arthritis. *Arthritis Rheum* 2003;49:129-35.
10. Centers for Disease Control and Prevention (CDC). Arthritis as a potential barrier to physical activity among adults with heart disease—United States, 2005 and 2007. *MMWR Morb Mortal Wkly Rep* 2009;58:165-9.
11. Sharma M. Yoga as an alternative and complementary approach for stress management: a systematic review. *J Evid Based Complementary Altern Med* 2014;19:59-67.
12. Yoga in America - 2012. [Internet. Access February 24, 2015.] Available from: www.yogajournal.com/article/press-releases/yoga-journal-releases-2012-yoga-in-america-market-study
13. Barnes PM, Bloom B, Nahin RL. Complementary and alternative medicine use among adults and children: United States, 2007. *Natl Health Stat Report* 2008;12:1-23.
14. Raub JA. Psychophysiologic effects of Hatha Yoga on musculoskeletal and cardiopulmonary function: a literature review. *J Altern Complement Med* 2002;8:797-812.
15. Bartlett SJ, Moonaz SH, Mill C, Bernatsky S, Bingham CO 3rd. Yoga in rheumatic diseases. *Curr Rheumatol Rep* 2013;15:387.
16. Patel NK, Newstead AH, Ferrer RL. The effects of yoga on physical functioning and health related quality of life in older adults: a systematic review and meta-analysis. *J Altern Complement Med* 2012;18:902-17.
17. McCall MC, Ward A, Roberts NW, Heneghan C. Overview of systematic reviews: yoga as a therapeutic intervention for adults with acute and chronic health conditions. *Evid Based Complement Altern Med* 2013;2013:945895.
18. Büssing A, Ostermann T, Lütke R, Michalsen A. Effects of yoga interventions on pain and pain-associated disability: a meta-analysis. *J Pain* 2012;13:1-9.
19. Haaz S, Bartlett SJ. Yoga for arthritis: a scoping review. *Rheum Dis Clin North Am* 2011;37:33-46.
20. Uhlig T. Tai chi and yoga as complementary therapies in rheumatologic conditions. *Best Pract Res Clin Rheumatol* 2012;26:387-98.
21. Sharma M. Yoga as an alternative and complementary approach for arthritis: a systematic review. *J Evid Based Complementary Altern Med* 2014;19:51-8.
22. Cramer H, Lauche R, Langhorst J, Dobos G. Yoga for rheumatic diseases: a systematic review. *Rheumatology* 2013;52:2025-30.
23. Treweek S, Zwarenstein M. Making trials matter: pragmatic and explanatory trials and the problem of applicability. *Trials* 2009;10:37.
24. Altman R, Asch E, Bloch D, Bole G, Borenstein D, Brandt K, et al. Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Diagnostic and Therapeutic Criteria Committee of the American Rheumatism Association. *Arthritis Rheum* 1986;29:1039-49.
25. Ware JE Jr, Kosinski M, Keller SD. SF-36 physical & mental health summary scales: a user's manual. Boston: The Health Institute, New England Medical Center; 1994.
26. Hurst NP, Ruta DA, Kind P. Comparison of the MOS short form-12 (SF12) health status questionnaire with the SF36 in patients with rheumatoid arthritis. *Br J Rheumatol* 1998;37:862-9.
27. Wells KF, Dillon EK. The sit and reach: a test of back and leg flexibility. *Res Q Exerc Sport* 1952;23:115-8.
28. Mathiowetz V, Weber K, Volland G, Kashman N. Reliability and validity of grip and pinch strength evaluations. *J Hand Surg Am* 1984;9:222-6.
29. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002;166:111-7.
30. Kohout FJ, Berkman LF, Evans DA, Cornoni-Huntley J. Two shorter forms of the CES-D (Center for Epidemiological Studies Depression) depression symptoms index. *J Aging Health* 1993;5:179-93.
31. Rhee SH, Petroski GF, Parker JC, Smarr KL, Wright GE, Multon KD, et al. A confirmatory factor analysis of the Center for Epidemiologic Studies Depression Scale in rheumatoid arthritis patients: additional evidence for a four-factor model. *Arthritis Care Res* 1999;12:392-400.
32. Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. *J Pers Soc Psychol* 1988;54:1063-70.
33. Cohen S, Williamson G. Perceived stress in a probability sample of the United States. In: Spacapan S, Oskamp S, eds. *The social psychology of health: the Claremont Symposium on applied social psychology*. Newbury Park: SAGE Publications Inc.; 1988:31-67.
34. Lorig K, Chastain RL, Ung E, Shoor S, Holman HR. Development and evaluation of a scale to measure perceived self-efficacy in people with arthritis. *Arthritis Rheum* 1989;32:37-44.
35. Yu LM, Chan AW, Hopewell S, Deeks JJ, Altman DG. Reporting on covariate adjustment in randomised controlled trials before and after revision of the 2001 CONSORT statement: a literature review. *Trials* 2010;11:59.
36. Dishman R. Determinants of participation in physical activity. In: Bouchard C, Shepard R, Stephens T, Sutton J, McPherson B, eds. *Exercise, fitness, and health*. Champaign: Human Kinetics; 1990:75-102.
37. Evans S, Moieni M, Lung K, Tsao J, Sternlieb B, Taylor M, et al. Impact of iyengar yoga on quality of life in young women with rheumatoid arthritis. *Clin J Pain* 2013;29:988-97.
38. Flegel KE, Kishiyama S, Zajdel D, Haas M, Oken BS. Adherence to yoga and exercise interventions in a 6-month clinical trial. *BMC Complement Altern Med* 2007;7:37.
39. Woodard CM, Berry MJ. Enhancing adherence to prescribed exercise: structured behavioral interventions in clinical exercise programs. *J Cardiopulm Rehabil* 2001;21:201-9.
40. Kolasinski SL, Garfinkel M, Tsai AG, Matz W, Van Dyke A, Schumacher HR. Iyengar yoga for treating symptoms of osteoarthritis of the knees: a pilot study. *J Altern Complement Med* 2005;11:689-93.
41. Ebnezar J, Nagarathna R, Yogitha B, Nagendra HR. Effects of an integrated approach of hatha yoga therapy on functional disability, pain, and flexibility in osteoarthritis of the knee joint: a randomized controlled study. *J Altern Complement Med* 2012;18:463-72.
42. Park J, McCaffrey R. Chair yoga: benefits for community-dwelling older adults with osteoarthritis. *J Gerontol Nurs* 2012;38:12-22.
43. Badsha H, Chhabra V, Leibman C, Mofti A, Kong KO. The benefits of yoga for rheumatoid arthritis: results of a preliminary, structured 8-week program. *Rheumatol Int* 2009;29:1417-21.
44. Bosch PR, Traustadóttir T, Howard P, Matt KS. Functional and physiological effects of yoga in women with rheumatoid arthritis: a pilot study. *Altern Ther Health Med* 2009;15:24-31.
45. Logghe IH, Verhagen AP, Rademaker AC, Bierma-Zeinstra SM, van Rossum E, Faber MJ, et al. The effects of Tai Chi on fall prevention, fear of falling and balance in older people: a meta-analysis. *Prev Med* 2010;51:222-7.
46. Garfinkel MS, Schumacher HR Jr, Husain A, Levy M, Reshetar RA. Evaluation of a yoga based regimen for treatment of osteoarthritis of the hands. *J Rheumatol* 1994;21:2341-3.
47. Haslock I, Monro R, Nagarathna R, Nagendra HR, Raghuram NV.

- Measuring the effects of yoga in rheumatoid arthritis. *Br J Rheumatol* 1994;33:787-8.
48. Dash M, Telles S. Improvement in hand grip strength in normal volunteers and rheumatoid arthritis patients following yoga training. *Indian J Physiol Pharmacol* 2001;45:355-60.
49. Telles S, Naveen KV, Gaur V, Balkrishna A. Effect of one week of yoga on function and severity in rheumatoid arthritis. *BMC Res Notes* 2011;4:118.
50. Taibi DM, Vitiello MV. A pilot study of gentle yoga for sleep disturbance in women with osteoarthritis. *Sleep Med* 2011;12:512-7.

APPENDIX 1. Sample class outline.

Questions/comments about article: 5 min
 Warm-up: 10 min
 Body scan and focus
 3 Oms
 Upper body stretches
 Staff with leg lifts
 Inverted plank
 Table and cat-cow
 Downward dog
 Walk to forward fold, hold opposite elbows
 Roll up to mountain for body scan
 Sun salutations (both sides, take notes for home practice): 20 min
 Standing asanas: 5 min
 Balances – tree, king dancer
 Standing poses – warrior II, triangle
 Floor asanas: 10 min
 Lying extended leg pose
 Lying spinal twist
 Head to knee
 Spinal twist
 Yogic seal
 Sivasana: 10 min
 Tense and release
 Progressive body scan
 Breath and mind relaxation
 Closing: 5 min
 Introduce awareness and movement
 Side lying
 Return to cross-legged
 Chant
 Meditation
 HOMEWORK: 10-min timed meditation, 4 sun salutations (can be broken up)

APPENDIX 2. Sample modification of yoga poses for people with arthritis.

Joint	Limitation	Example	Modification
Knee	Extreme flexion Weight bearing	King dancer Table	Use a strap to reduce angle Place blanket under knees
Hip	External rotation to edge of range of motion Flexion beyond 90°	Easy pose Extended leg pose	Blocks under knees Use strap around foot to reduce angle
Wrist	Flexion with weight bearing	Downward dog	Place wedge under palms
Hand	Flattened palms	Prayer position	Rest hands on heart
Shoulder	Arms above shoulder height	Chair pose	Arms extended forward
Ankle	Flexion with weight bearing	Warrior I	Wedge under heel
Foot	Forced arch	Low lunge	Rest top of the foot on the floor