

Effect of a Gentle Iyengar Yoga Program on Gait in the Elderly: An Exploratory Study

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ABSTRACT. DiBenedetto M, Innes KE, Taylor AG, Rodeheaver PF, Boxer JA, Wright HJ, Kerrigan DC. Effect of a gentle Iyengar yoga program on gait in the elderly: an exploratory study. *Arch Phys Med Rehabil* 2005;86:1830-7.

Objective: To determine if a tailored yoga program could improve age-related changes in hip extension, stride length, and associated indices of gait function in healthy elders, changes that have been linked to increased risk for falls, dependency, and mortality in geriatric populations.

Design: Single group pre-post test exploratory study. A 3-dimensional quantitative gait evaluation, including kinematic and kinetic measurements, was performed pre- and postintervention. Changes over time (baseline to postintervention) in primary and secondary outcome variables were assessed using repeated-measures analysis of variance.

Setting: Yoga exercises were performed in an academic medical center (group classes) and in the subjects' homes (yoga home-practice assignments). Pre- and postassessments were performed in a gait laboratory.

Participants: Twenty-three healthy adults (age range, 62–83y) who were naive to yoga were recruited; 19 participants completed the program.

Intervention: An 8-week Iyengar Hatha yoga program specifically tailored to elderly persons and designed to improve lower-body strength and flexibility. Participants attended two 90-minute yoga classes per week, and were asked to complete at least 20 minutes of directed home practice on alternate days.

Main Outcome Measures: Peak hip extension, average anterior pelvic tilt, and stride length at comfortable walking speed.

Results: Peak hip extension and stride length significantly increased ($F_{1,18}=15.44$, $P<.001$; $F_{1,18}=5.57$, $P=.03$, respectively). We also observed a trend toward reduced average pelvic tilt ($F_{1,18}=4.10$, $P=.06$); adjusting for the modifying influence of frequency of home yoga practice strengthened the significance of this association (adjusted $F_{1,17}=14.30$, $P=.001$). Both the frequency and duration of yoga home practice showed a strong, linear, dose-response relationship to changes in hip extension and average pelvic tilt.

Conclusions: Findings of this exploratory study suggest that yoga practice may improve hip extension, increase stride length, and decrease anterior pelvic tilt in healthy elders, and that yoga programs tailored to elderly adults may offer a cost-effective means of preventing or reducing age-related changes in these indices of gait function.

Key Words: Aged; Biomechanics; Gait; Exercise; Hip; Pelvis; Rehabilitation; Yoga.

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HIP EXTENSION RANGE is significantly reduced in older persons and has been strongly associated with risk for recurrent falls.^{1,2} The age-related decline in hip extension is the only joint parameter to demonstrate a consistent change in elderly populations.^{1,2} Reduced hip extension is accompanied by a compensatory increase in anterior pelvic tilt^{1,2} and may be the primary mechanism underlying the age-related reduction in stride length, a hallmark of diminished walking performance in the elderly¹ and an important predictor of falls, dependency, institutionalization, and mortality in elderly populations.³⁻⁷ Interventions that can reverse or attenuate these age-related gait changes may thus not only increase mobility, autonomy, and quality of life (QOL), but also help reduce the morbidity and mortality associated with falls in the elderly.⁸

Of particular interest in this regard is yoga, an ancient Indian discipline of the body, mind, and spirit, dating back to at least 2000 BC, that is gaining increasing popularity in Western industrialized countries as a means of alleviating stress and improving balance, flexibility, and muscle strength.⁹⁻¹¹ Yoga is simple to learn and can be practiced even by very elderly, ill, or disabled persons.¹² Requiring little equipment and personnel to sustain, yoga may offer an especially promising and cost-effective means of reducing impairment associated with gait problems in the elderly. Yoga exercises are routinely used in India to manage joint contractures caused by poliomyelitis and other disorders.^{13,14} Yoga programs have also been shown to improve balance and coordination in elderly patients with stroke,¹⁵ and to improve grip strength,¹⁶⁻¹⁹ reduce pain,^{17,18} and increase range of motion (ROM)^{17,19} in people with rheumatoid arthritis,^{16,19} osteoarthritis,¹⁷ and carpal tunnel syndrome.¹⁸ In a small, uncontrolled U.S. study of healthy young adults, Tran et al²⁰ found that yoga increased both isokinetic and isometric muscle strength and improved joint flexibility. Similarly, controlled studies of healthy children and adults in India have shown yoga to increase grip strength¹⁶ and to enhance flexibility and joint extension.²¹

A growing body of research suggests that yoga-based interventions are readily accepted by older adults, and may improve a range of health outcomes in elderly populations. Yoga programs have been shown to enhance mood²²⁻²⁶ and QOL^{22,27} and to reduce fatigue,²⁵ sleep disturbance,²⁷ symptoms of stress,^{27,28} and somatic complaints^{22,28} in elderly persons; and to improve metabolic and physiologic profiles, to reduce med-

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ication use, and to enhance health outcomes in older adults with cardiovascular disorders^{23,26,28} or diabetes.^{1,29} To our knowledge, however, no published studies to date have examined the potential beneficial effects of yoga on age-related gait changes in older adults.

In this preliminary study, we examined the influence of a gentle Iyengar Hatha yoga program on key markers of gait impairment in a sample of healthy elderly subjects. Specifically, we tested the hypothesis that a gentle 8-week yoga program designed to increase lower-body strength and flexibility would increase peak hip extension, reduce anterior pelvic angle, and increase stride length—important determinants of gait function and stability in the elderly. We also evaluated the secondary hypotheses that structured yoga practice would improve other, age-related indices of gait function, including comfortable walking speed, peak ankle plantarflexion, and peak ankle joint power generation.

METHODS

Healthy, nonobese adults aged 62 and older and naive to yoga were recruited through advertisements in university publications and flyers displayed in senior centers, grocery stores, buses, and other public places. Eligibility to participate in the study was determined by screening questionnaires and physical examination. Exclusion criteria included an asymmetric gait pattern, use of an assistive device for walking, evidence of neuromuscular illness, major orthopedic diagnosis in the lower back, pelvis, or lower extremities, severe rheumatoid arthritis or osteoarthritis that would cause discomfort during the yoga exercises, acute medical illness, and symptomatic heart or lung disease. Because excessive soft tissue reduces the reliability of marker placement and kinematic measurement, obese individuals (body mass index [BMI], $\geq 30 \text{ kg/m}^2$) were excluded from the study. The study was approved by the University of Virginia School of Medicine Institutional Review Board and informed consent was obtained from all who volunteered for enrollment. Twenty-three participants were enrolled in the yoga exercise program, 19 of whom completed the 8-week course. Three enrollees discontinued after 1 ($n=2$) or 2 ($n=1$) sessions, reporting that the room was too crowded or the exercises too challenging. One participant, who cited high satisfaction with the program, left after the fifth yoga class because of unexpected family obligations. Those who discontinued the study did not differ from those completing the study in age ($71.75 \pm 2.7 \text{ y}$ vs $70.7 \pm 1.37 \text{ y}$; $t=.33$, $P=0.7$), BMI ($25.6 \pm 1.1 \text{ kg/m}^2$ vs $26.0 \pm 0.7 \text{ kg/m}^2$, $t=0.2$, $P=0.9$), or sex distribution (Fisher exact test, $P=0.5$).

Participants attended two 90-minute Iyengar Hatha yoga classes each week, and were asked to complete a minimum of 20 minutes of yoga practice at home every other day (5 times/wk). Each group session included a standard yoga routine of gentle, supervised Hatha yoga postures and breathing exercises designed for beginners and specifically tailored for elderly persons. Props (blankets, chairs, blocks) were used as needed to support participants in any yoga positions that were difficult or uncomfortable for them and to minimize risk of overstretching or injury. Each session began with yoga warm-up and centering poses, followed by a series of more active yoga exercises. Yoga breathing exercises (Pranayama) were performed in conjunction with specific seated and supine poses. Every session terminated with standard yoga relaxation exercises, including shavasana (corpse pose). Yoga postures in the program included: centering (in cross-legged position), finger and toe weaving, virasana (hero pose), vajrasana (thunderbolt pose), tadasana (mountain pose), table pose (including leg-lifts), salabhasana (locust pose), padangusthasana (holding the

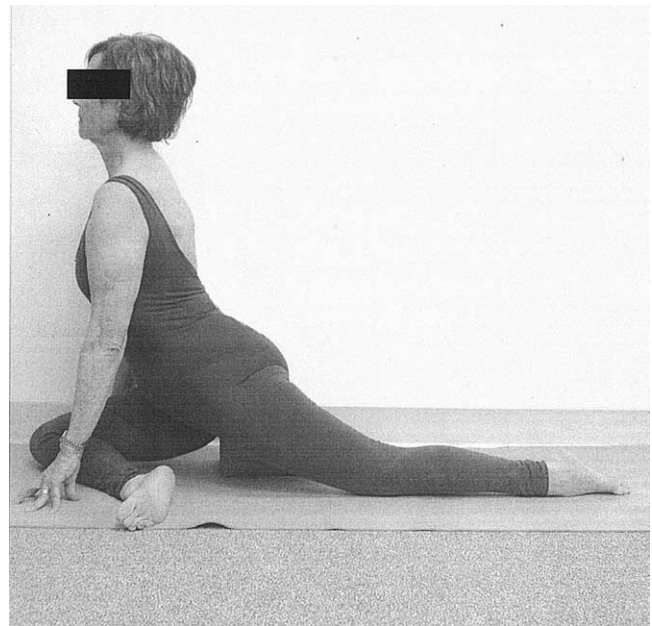


Fig 1. Hip stretch pose.

big toe pose), supta padangusthana (holding the big toe lying down pose), uttitha hasta padangusthasana (extended holding the big toe pose), supta baddha konasana (lying down bound angle pose), eka pada bhekasana (1-leg frog pose), and shavasana (corpse pose). Poses specifically targeting the pelvic region were incorporated into each session. These included rajakapotasana (pigeon or hip stretch pose; [fig 1](#)), parsvotanasana (flank stretch; [figs 2, 3](#)), virabhadrasana (warrior pose), and surya namaskar (modified sun salutations using a chair, see [fig 4](#); or a prop, see [figs 5, 6](#)).

Home practice sessions alternated between 2 standard beginner yoga routines, each comprising a subset of the group session poses and exercises. Participants received detailed, illustrated homework assignments after each group yoga class to assist them with their home practice sessions, and completed daily logs to monitor frequency and duration of practice, and to document problems, progress, and other experiences with their home sessions.

Study participants underwent a full pelvic and lower-extremity kinematic and kinetic evaluation while standing and walking at comfortable walking speeds within the week before and after the 8-week exercise program. The kinematic and kinetic gait study was performed at the University of Virginia Department of Physical Medicine and Rehabilitation's Gait and Motion Analysis Laboratory by an evaluator who was blinded to each participant's pre-yoga intervention values. Subjects were asked first to stand and then walk along a 10-m walkway and kinematic and kinetic data from 3 complete gait strides were recorded. A 10-camera video-based motion analysis system (Vicon 624 system)^a was used to measure the 3-dimensional position of infrared reflective markers, at 120 frames/s, attached to the following bony landmarks on the pelvis and lower extremities during walking: bilateral anterior superior iliac spines, lateral femoral condyles, lateral malleoli, forefeet, and heels. Additional markers were placed over the sacrum and rigidly attached to wands over the midfemur and midshank. Pelvic and joint angular motion were reported in reference to a comfortable barefoot standing condition, with zero defining the averaged standing joint angle.

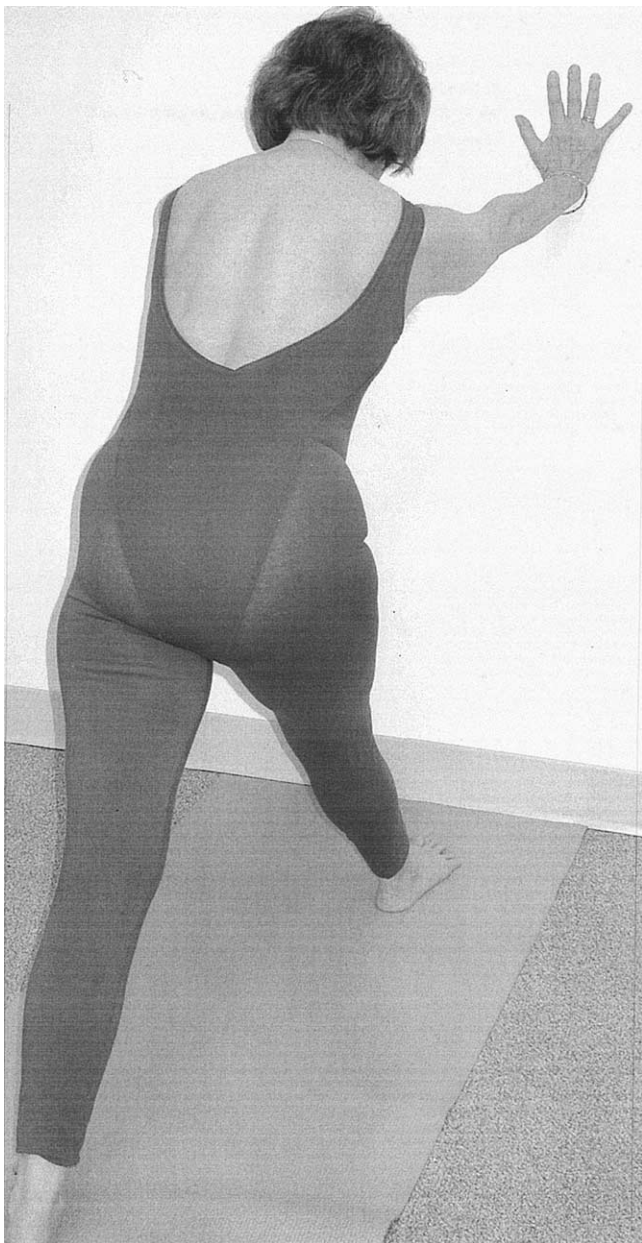


Fig 2. Modified flank stretch (parsvotanasana).

Ground reaction forces were measured synchronously with the motion analysis data using 2 staggered force platforms^b imbedded in the walkway. The locations of the force platforms in the global reference plane were predetermined by acquiring coordinates of markers placed on their corners. Joint torques in each plane and joint powers in the sagittal plane were calculated using a commercialized full-inverse dynamic model per Vicon Clinical Manager.^a Accordingly, joint torque and power calculations were based on the mass and inertial characteristics of each lower-extremity segment, the derived linear and angular velocities and accelerations of each lower-extremity segment, as well as ground reaction force and joint center position estimates. Joint powers were normalized for body weight and height and were reported as external in watts per kilogram meters. Previous studies have shown the kinematic and kinetic measurements to be valid and reliable.³⁰⁻³²

Stride length and gait speed were obtained using the force platform and kinematic information to define initial foot contact times and distance parameters. Average pelvic and lower-extremity joint kinematic and kinetic values for each subject for the pre- and posttreatment conditions were obtained from 3 trials (average of both right and left lower extremities providing an average of 6 values for each condition). Kinematic and kinetic data were graphed over 2% intervals of the gait cycle. Four kinematic and kinetic values were specifically assessed: peak hip extension, average anterior pelvic tilt, peak ankle plantarflexion, and peak ankle plantarflexion power generation.



Fig 3. Flank stretch (parsvotanasana).

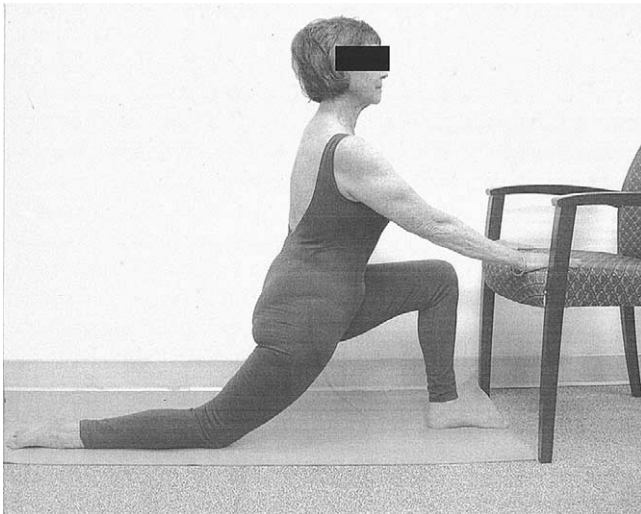


Fig 4. Modified sun salutation (using a chair).

At the last yoga class, participants were also asked to complete a structured questionnaire regarding their experiences with the program.

Data were analyzed using SPSS, version 11.2.^c Potential differences in baseline characteristics of attriters versus nonattriters were evaluated using Student *t* tests (independent samples). Repeated-measures analyses of variance (ANOVAs) were performed to assess the independent effects of the 8-week yoga program on change over time (baseline to 8wk) in the primary outcome variables—peak hip extension, stride length, and average pelvic tilt—and in the related secondary outcome variables—comfortable walking speed, peak ankle plantarflexion, and ankle power generation. Previous studies have shown that walking speed,³³ ankle plantarflexion,² and ankle joint power^{2,33} were reduced in healthy elderly versus young adults.



Fig 5. Modified sun salutation (using a prop).

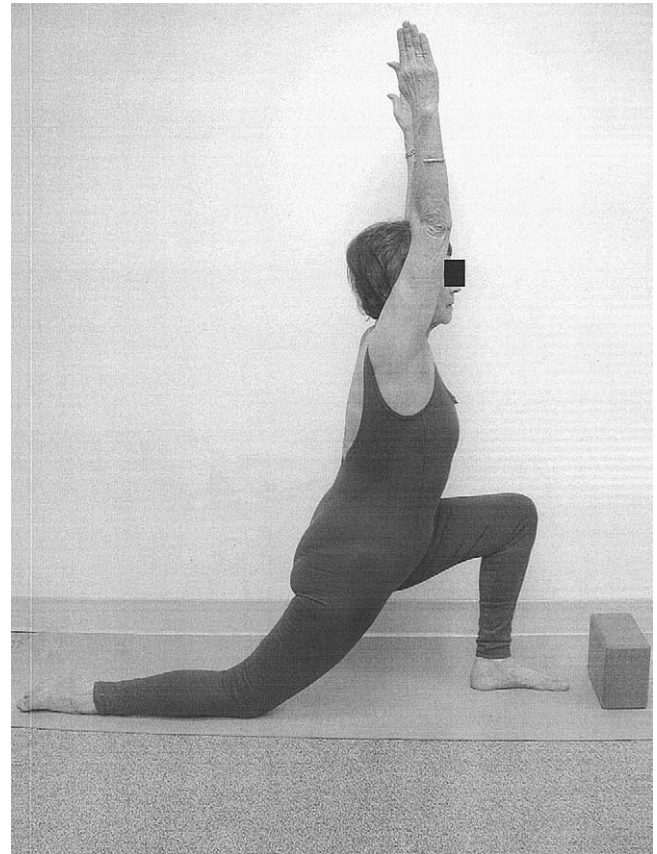


Fig 6. Modified sun salutation (with arms raised, maintaining lunge, and deep even breathing exercise).

Separate repeated-measures ANOVAs were performed to control for the potential confounding or modifying effects of baseline BMI ($<25\text{kg/m}^2$ vs $\geq 25\text{kg/m}^2$), age ($\leq 70\text{y}$ vs $>70\text{y}$), or sex, and to evaluate the influence of frequency and duration of yoga home practice on change in specific gait parameters. Effect size was estimated using the standardized mean change measure.³⁴ The bivariate associations between specific gait parameters and yoga practice were assessed using the Pearson product moment correlation (for normally distributed variables) or the Spearman rank correlation (for variables with evidence of skewing).

RESULTS

Thirteen women and 6 men completed the study. Participants ranged in age from 62 to 83 years of age (average, $70.7 \pm 6.1\text{y}$). Distribution of demographic and anthropometric characteristics of the participants overall and by sex is given in table 1. Weight and BMI did not change significantly over the course of the intervention ($P > .10$). Class attendance was excellent, with 15 of the 19 participants attending every yoga session, and the remaining 4 missing only 1 of the 16 classes. Frequency and duration of home yoga practice, however, varied considerably between subjects. Total reported days of yoga home practice ranged from 13 to 40 (33%–100% of total possible days), and averaged 34.4 ± 1.5 days. Daily reported duration of home practice sessions varied from 12.3 to 60min/day (average, $31.2 \pm 2.5\text{min/d}$).

Relative to baseline values, both peak hip extension and stride length at comfortable walking speed demonstrated sig-

Table 1: Characteristics of the Study Population at Baseline and Anthropometric Characteristics Postintervention

Characteristics	Women (n=13)		Men (n=6)		Total (N=19)	
	Baseline	Post-Yoga	Baseline	Post-Yoga	Baseline	Post-Yoga
Age (y)	70.9±1.8	NA	70.3±2.4	NA	70.7±1.4	NA
Height (cm)	162.3±1.6	NA	174.0±2.2	NA	166.2±2.0	NA
Weight (kg)	66.4±2.5	66.1±2.5	84.7±4.4	83.9±3.7	72.0±3.0	71.7±2.8
BMI (kg/m ²)	25.2±0.8	24.9±0.9	28.0±1.5	27.8±1.3	26.0±0.7	25.9±0.75

NOTE. Values are mean ± standard error (SE).
Abbreviation: NA, not applicable.

nificant increases after the 8-week yoga program (table 2), rising by an average of $3.5^\circ \pm 0.9^\circ$ and 0.05 ± 0.02 m/s, respectively. We also observed a trend toward a decline in average pelvic tilt from baseline to 8 weeks (mean decline, $-1.6^\circ \pm 0.02^\circ$; $F_{1,18}=4.10$, $P=.06$) (see table 2). Analysis of the more motivated participants (described below) considerably strengthened the significance of this latter finding (adjusted F for change in pelvic tilt over time, $F_{1,17}=14.3$, $P=.001$). As anticipated, change in peak hip extension was strongly and negatively related to change in average anterior pelvic tilt ($r=-.83$, $P<.001$) and positively related to change in stride length ($r=.55$, $P=.02$).

Changes in secondary outcome variables (ankle plantarflexion and power generation, walking speed) were in the expected direction, but were not statistically significant. However, change in peak hip extension was strongly and positively related to change in ankle plantarflexion ($r=.55$, $P=.01$) and ankle joint power ($r=.48$, $P=.04$) (table 3). Stride length was strongly and positively related to all 3 secondary outcome measures, including walking speed ($r=0.8$, $P<.001$).

In this sample, both the frequency of yoga practice at home (measured in total days and mean days per week) and the duration of practice (measured as mean minutes per day) showed a strong, linear, dose-response relationship to change in hip extension and average pelvic tilt (table 3). Hip extension increased, and pelvic tilt declined significantly with increasing frequency and duration of home yoga practice. As illustrated in table 4, participants who practiced at home an average of 30 minutes or more per day ($n=10$) experienced significantly greater beneficial changes in both hip extension and pelvic tilt than those who practiced less than 30 min/d on average ($5.1^\circ \pm 1.0^\circ$ vs $2.0^\circ \pm 1.3^\circ$ and $0.3^\circ \pm 1.0^\circ$ vs $-3.6^\circ \pm 0.8^\circ$, respectively). Likewise, subjects who missed fewer than 6 daily home practice sessions ($n=10$) demonstrated significantly greater increases in hip extension and declines in anterior

pelvic tilt than did those who skipped more than 5 daily home sessions ($5.2^\circ \pm 1.2^\circ$ vs $1.2^\circ \pm 0.9^\circ$ and $0.6^\circ \pm 0.3^\circ$ vs $-3.2^\circ \pm 0.7^\circ$, respectively). We found no evidence for a modifying influence of other participant characteristics (including age, sex, or baseline BMI) on change over time in any gait parameters.

The yoga program was well received overall. Of those who completed exit questionnaires ($n=15$) and/or included comments on their homework logs in the latter weeks of the study period ($n=16$), all indicated they would recommend the course to other seniors and that they had experienced significant physical benefits from the yoga program. Cited benefits included improved flexibility (88%) and balance (44%). Although 17 of the 19 participants (89.5%) reported at least some difficulty with the exercises in the first week, only 2 cited any discomfort by the end of the study period; in both cases, the discomfort was reported as mild and offset by perceived benefits of the program. Although 1 participant reported increased knee discomfort in her daily log, none of the participants who completed the study sought medical assistance during the course of the study or reported significant neuromuscular discomfort, boredom, fatigue, or desire to discontinue participation.

DISCUSSION

Comprehensive studies of gait kinetic and kinematics in adults 65 years of age or more have repeatedly documented significant declines of 5° to 7° in peak hip extension in healthy elderly versus young adults.^{1,2,35} This reduction is further exaggerated in elders with a history of recurrent falls.¹ The decline in hip extension, a pivotal gait change associated with aging,^{1,36} is accompanied by a compensatory increase in anterior pelvic tilt^{1,2,37} and by a corresponding reduction in stride length, a marker of deteriorating gait performance in the elderly¹ and itself a strong predictor of falls, disability, and

Table 2: Change Over Time in Peak Hip Extension, Stride Length, and Related Gait Parameters After an 8-Week Iyengar Hatha Yoga Program

Outcomes	Baseline	Postintervention	Effect Size	Repeated-Measures ANOVA	
				F	P
Primary					
Peak hip extension (deg)	10.95±1.53	14.5±1.45	.52	15.44	.001
Stride length (m/s)	1.22±0.02	1.27±0.03	.50	5.57	.03
Average pelvic tilt (deg)	9.22±0.76	7.65±0.78	−.45	4.10	.06
Secondary					
Peak ankle plantarflexion (deg)	12.82±1.27	13.75±1.17	.18	2.65	.12
Peak ankle plantarflexion power (W/kg-m)	2.17±0.12	2.25±0.10	.16	0.99	.33
Comfortable walking speed (m/s)	1.18±0.03	1.22±0.03	.29	1.04	.32

NOTE. Values are mean ± SE. Sample is 19 healthy adults ages 62 to 83 years.

Table 3: Relation of Frequency and Duration of Yoga Homework Practice to Change in Age-Related Gait Parameters

Change From Baseline to Postintervention	Total Days Practiced at Home*		Mean Days/Week Practiced at Home*		Mean Minutes/Day Practiced at Home†	
	ρ	P	ρ	P	r	P
Peak hip extension (deg)	.52	.02	.50	.03	.58	.01
Stride length (m/s)	.14	.58	.12	.63	.25	.30
Average anterior pelvic tilt (deg)	-.60	.01	-.59	.008	-.67	.002

*Spearman rank correlation.

†Pearson product moment correlation.

mortality among older adults.^{3,4,6} As key determinants of age-related declines in gait function, reduced hip extension, and associated changes in stride length and pelvic tilt likely contribute significantly to the increased risk for falls and fall-related injuries associated with gait impairment in older adults,^{8,38} events that are a major cause of morbidity and mortality in elderly populations.^{8,39,40}

However, few studies have examined the potential effects of exercise on age-related declines in hip extension range,^{36,41,42} or on associated changes in stride length^{12,43-46} and anterior pelvic tilt,³⁶ despite evidence to suggest that these gait parameters can be modified by physical activity.^{36,47} Of those studies investigating the influence of specific exercise programs on age-related reductions in stride length,^{12,43-45} some⁴³⁻⁴⁵ but not others^{12,46,48} have demonstrated significant although modest improvements with exercise training.⁴³⁻⁴⁵ Results have been similarly equivocal with respect to hip extension and anterior pelvic tilt. To our knowledge, only 3 published studies have specifically investigated the effects of physical activity on age-related changes in hip extension^{36,41,46} and one has examined exercise-induced changes in anterior pelvic tilt³⁶ in elderly populations. In a randomized, placebo-controlled trial³⁶ of 96 adults, a 10-week stretching program specifically targeting hip flexor muscles produced only a modest, insignificant improvement in dynamic hip extension (2° , $P=.10$) and associated anterior pelvic tilt (-0.8° , $P=.4$). In contrast, in a nonrandomized controlled trial⁴¹ of 43 older adults showed a significant increase in passive hip extension after a 10-week stretching and resistance program, although that study did not include an evaluation of gait. Another nonrandomized controlled study⁴⁶ of 73 seniors demonstrated similar improvements in passive

hip extension, but, like the former study, did not include measurements of hip extension during gait.

Although yoga enjoys growing popularity among older adults in Western countries,^{9,10} and has demonstrated promise as a means of improving physical function,¹⁵ strength,^{16-19,49} and ROM^{17,19} in certain older populations, no published studies to date have examined the effects of yoga on age-related gait changes in healthy elders. In this exploratory study, we investigated the influence of a gentle, 8-week Iyengar yoga program on peak hip extension and other key gait parameters in a sample of healthy seniors. The program was tailored for older adults and specifically targeted the pelvic region. Dynamic hip extension showed a significant increase over time, accompanied by significant improvements in both stride length and anterior pelvic tilt, supporting our primary hypothesis that a tailored yoga program would be associated with improvement in these gait parameters. Changes in hip extension and anterior pelvic tilt also demonstrated strong, linear, dose-response associations with both duration and frequency of home yoga practice, suggesting a direct, causal relationship between yoga practice and change in these gait parameters. The program was well-received, safe, and enjoyable for participants, and adherence to the protocol was excellent. Together, these observations suggest that age-related changes in these key gait parameters can be modified with low-intensity, short-term interventions and that tailored yoga programs may be an attractive, inexpensive, and effective intervention for improving gait function in certain elderly populations.

Improvements in the secondary outcome measures, including ankle plantarflexion, ankle power generation, and walking speed, demonstrated modest, nonsignificant improvements in this study. Our failure to detect significant changes in these parameters likely reflects both the small sample size and perhaps the intervention's primary focus on the hip region. However, changes in these secondary measures were strongly related to changes in hip extension (ankle plantarflexion, ankle power generation) and/or stride length (ankle plantarflexion, ankle power generation, walking speed), suggesting coincident improvement with yoga practice in these indices of gait function.

A serious limitation of this exploratory study was the lack of a control group, raising the possibility that our positive results may in part reflect a placebo response, a temporal trend unrelated to yoga, or a coincident change in other activities. However, these factors are unlikely to explain our findings. Because the gait parameters measured would be expected to deteriorate over time in the absence of an active intervention, the presence of a temporal trend would be likely to attenuate rather than

Table 4: Change in Peak Hip Extension and Average Pelvic Tilt, Stratified by Frequency and Duration of Yoga Home Practice*

Yoga Practice	Peak Hip Extension (deg)					Average Anterior Pelvic Tilt (deg)				
	Baseline	Postintervention	F	P	Effect Size	Baseline	Postintervention	F	P	Effect Size
Average min/d of yoga home practice										
<30min/d	10.88±1.89	12.901.6±7	2.50	.15	.34	9.31±1.09	9.56±0.68	0.06	.81	.01
≥30min/d	11.03±2.57	16.17±2.40	24.59	.001	.67	9.12±1.11	5.53±1.12	21.50	.00	.73
Interaction			4.55	.05				8.24	.01	
Total days of yoga home practice										
Total days <35	10.65±2.05	11.86±1.92	1.76	.23	.21	8.87±1.17	9.50±0.84	0.30	.60	.04
Total days ≥35	11.17±2.26	16.34±1.95	19.32	.001	.69	9.47±1.03	6.30±1.06	17.73	.00	.64
Interaction			6.60	.02				8.76	.01	

NOTE. Values are mean ± SE.

*At or above versus below the approximate group mean (min/d) or median (total days).

inflate any observed effects. A beneficial placebo effect has not been demonstrated for gait parameters in elderly populations^{36,50,51}; rather, placebo-controlled trials have shown either no change or a decline in indices of gait function over time in the placebo group.^{36,50,51} Finally, participants were asked not to change their activity routines, other than those related specifically to the yoga intervention, and indicated no such changes on their logs or exit questionnaires, rendering a coincident change in exercise regimen or other activities an improbable explanation for our findings.

This study was restricted to a small number of healthy, motivated seniors, limiting the generalizability of our findings. The study's small sample size also limited our power to detect significant effects of yoga on age-related markers of gait function. In addition, we studied only healthy older adults with no functional impairment, further reducing the likelihood of detecting an effect in this short-term study. These factors may, in part, explain our failure to find a significant effect of yoga on our secondary outcomes.

Larger randomized controlled trials are clearly needed to confirm the findings of this preliminary study, to ascertain whether yoga practice can improve other, related aspects of gait function in the elderly, and to assess the potential influence of tailored yoga programs on gait function in other (eg, institutionalized) settings and in other, less healthy populations of older adults. Follow-up studies are also needed to determine if benefits for gait function can be sustained over time in elderly populations, to ascertain the optimal frequency of reinforcement sessions, and to examine the factors affecting continued adherence.

CONCLUSIONS

In this preliminary study of healthy elders, we observed significant improvements in hip extension, stride length, and pelvic tilt following a gentle 8-week Iyengar yoga program tailored for older adults. If confirmed in larger, controlled studies, these findings suggest that tailored yoga programs may offer an attractive, cost-effective intervention for improving gait function in elderly populations.

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Suppliers

- a. Oxford Metrics Ltd, 14 Minns Estate, West Way, Oxford, OX2 0JB, UK.
- b. Advanced Mechanical Technology Inc, 176 Waltham St, Watertown, MA 02472.
- c. SPSS Inc 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.