



ASSESSING THE EFFECTIVENESS OF A TRADITIONAL INDIAN YOGA BASED EXERCISES PROGRAM IN IMPROVING BALANCE AND REDUCING FALLS AMONG ELDERLY PATIENTS WITH OSTEOARTHRITIS: A RANDOMIZED CONTROLLED TRIAL

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Abstract

Introduction: Osteoarthritis (OA) in elderly individuals significantly increases the risk of falls, leading to reduced mobility and quality of life. This study aimed to assess the effectiveness of a traditional Indian Yoga-based exercise program in improving balance and reducing falls among elderly patients with osteoarthritis.

Methods: A randomized controlled trial was conducted with 128 participants (aged ≥ 60 years) with knee or hip OA, randomly assigned to either a Yoga intervention group or a control group receiving standard care. The Yoga program consisted of 60-minute sessions held thrice weekly for 12 weeks. Outcomes were measured at baseline, 6 weeks, 12 weeks, and 24 weeks, including the Berg Balance Scale (BBS), Timed Up and Go (TUG) test, fall incidence, pain intensity, WOMAC score, and Falls Efficacy Scale-International (FES-I).

Results: The Yoga group showed significant improvements in BBS scores (between-group difference at 12 weeks: 5.9 points, $p < 0.001$) and TUG test times (between-group difference at 12 weeks: -2.3 seconds, $p < 0.001$) compared to the control group. Fall incidence in the Yoga group was significantly lower (incidence rate ratio: 0.56, $p < 0.001$). Pain intensity, WOMAC scores, and FES-I scores also improved significantly in the Yoga group. These improvements were largely maintained at the 24-week follow-up.

Conclusion: The traditional Indian Yoga-based exercise program demonstrated significant effectiveness in improving balance, reducing falls, and enhancing overall function in elderly patients with osteoarthritis. These findings suggest that Yoga could be a valuable addition to standard care protocols for fall prevention and OA management in this population.

Keywords: Yoga, Osteoarthritis, Elderly, Fall Prevention, Balance

Introduction:

The global population is aging rapidly, with the number of individuals aged 60 and above expected to double by 2050 (World Health Organization, 2021). This demographic shift has brought increased attention to age-related health issues, particularly those affecting mobility and quality of life. Among these, osteoarthritis (OA) stands out as a prevalent condition that significantly impacts the elderly population. Osteoarthritis, characterized by the degradation of joint cartilage and underlying bone, affects millions worldwide and is a leading cause of disability among older adults (Vos et al., 2017).

One of the most concerning consequences of OA in the elderly is the increased risk of falls. The pain, stiffness, and reduced joint mobility associated with OA can compromise balance and gait, making affected individuals more susceptible to falls (Alkan et al., 2014). Falls not only lead to immediate physical injuries but can also result in long-term psychological impacts, such as fear of falling, which further reduces mobility and independence (Delbaere et al., 2010).

In recent years, there has been a growing interest in exploring alternative and complementary approaches to managing OA symptoms and reducing fall risk in the elderly. Among these, traditional Indian Yoga has emerged as a promising intervention. Yoga, an ancient practice originating in India, encompasses physical postures (asanas), breathing exercises (pranayama), and meditation techniques. Its holistic approach to health and well-being aligns well with the complex, multifaceted nature of OA management and fall prevention in older adults (Ebnezar et al., 2012).

The potential benefits of Yoga for individuals with OA are multifaceted. The gentle, low-impact nature of Yoga asanas can help improve joint flexibility, muscle strength, and proprioception without exacerbating joint pain (Cheung et al., 2017). Additionally, the focus on body awareness and controlled movements in Yoga practice may enhance balance and postural control, crucial factors in fall prevention (Tiedemann et al., 2013). The meditative aspects of Yoga can also contribute to stress reduction and improved pain management, addressing the psychological components of OA and fall risk (Zhang et al., 2013).

Several studies have investigated the effects of Yoga on various aspects of health in older adults, including those with OA. A systematic review by Patel et al. (2012) found evidence supporting the use of Yoga for improving pain and functional outcomes in individuals with knee OA. Another study by Schmid et al. (2010) demonstrated improvements in balance and fear of falling among older adults following a 12-week Yoga intervention. However, despite these promising findings, there remains a need for more robust, well-designed randomized controlled trials to establish the effectiveness of Yoga-based interventions specifically for balance improvement and fall reduction in elderly OA patients.

The cultural context of this study is particularly significant. In India, where Yoga originated, there is a rich tradition of using these practices for health and well-being. However, the integration of traditional practices into modern healthcare systems requires scientific validation. This study aims to bridge the gap between ancient wisdom and contemporary medical practice by rigorously evaluating the effectiveness of a traditional Indian Yoga-based exercise program in a clinical setting.

The choice of focusing on balance and fall prevention is crucial, given the significant impact of falls on the health and independence of older adults with OA. Falls can lead to fractures, hospitalization, and a cascade of health complications that can severely diminish quality of life (Gillespie et al., 2012). By targeting balance improvement and fall reduction, this study addresses a critical aspect of OA management that has the potential to significantly enhance the overall well-being of affected individuals.

Moreover, the emphasis on a traditional Indian Yoga-based program is noteworthy. While various exercise interventions have been studied for fall prevention, the unique combination of physical postures, breathing exercises, and meditative practices in Yoga offers a comprehensive approach that may be particularly beneficial for this population. The gentle, adaptable nature of Yoga makes it

suitable for older adults with varying levels of physical capacity, and its emphasis on mindfulness may contribute to improved body awareness and fall prevention strategies (Gonçalves et al., 2011). This study also addresses an important gap in the literature regarding culturally appropriate interventions for diverse populations. As healthcare becomes increasingly globalized, it is essential to evaluate the effectiveness of traditional practices within their cultural context. The findings from this study could have implications not only for the Indian healthcare system but also for the integration of culturally diverse practices in geriatric care worldwide.

The aim of this study is to assess the effectiveness of a traditional Indian Yoga-based exercise program in improving balance and reducing falls among elderly patients with osteoarthritis through a randomized controlled trial.

Methodology:

Study Design:

A randomized controlled trial (RCT) was conducted to evaluate the effectiveness of a traditional Indian Yoga-based exercise program in improving balance and reducing falls among elderly patients with osteoarthritis. The study employed a parallel-group design with two arms: an intervention group receiving the Yoga-based program in addition to standard care, and a control group receiving standard care alone.

Study Site:

The study was conducted at the Department of Geriatrics and Rheumatology of a tertiary care hospital in New Delhi, India. This site was chosen due to its expertise in managing elderly patients with osteoarthritis and its facilities suitable for conducting Yoga sessions.

Study Duration:

The study was conducted over a period of 6 months, from January to June 2023. This duration allowed for a 12-week intervention period followed by a 3-month follow-up to assess the sustained effects of the program.

Sampling and Sample Size:

A convenience sampling technique was used to recruit participants from the outpatient department of the hospital. The sample size was calculated using G*Power software, assuming a medium effect size ($f = 0.25$), an alpha level of 0.05, and a power of 0.80. Accounting for an estimated dropout rate of 20%, a total of 128 participants (64 per group) were recruited for the study.

Inclusion and Exclusion Criteria:

The study included participants aged 60 years and above with a clinical diagnosis of osteoarthritis of the knee or hip, confirmed by radiographic evidence (Kellgren-Lawrence grade ≥ 2). Participants were required to be able to walk independently or with minimal assistance (cane or walker) and to communicate effectively in Hindi or English. Exclusion criteria encompassed severe cognitive impairment (Mini-Mental State Examination score < 24), uncontrolled hypertension or diabetes, recent joint replacement surgery (within the past 6 months), other severe musculoskeletal conditions, and regular participation in Yoga or similar mind-body practices in the past 3 months.

Data Collection Tools and Techniques:

Data were collected using a combination of validated assessment tools and standardized questionnaires. Balance was assessed using the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test. Fall incidence was recorded through monthly fall diaries and follow-up phone calls. Secondary outcomes included pain intensity (measured using the Visual Analog Scale), functional capacity (assessed with the Western Ontario and McMaster Universities Osteoarthritis Index -

WOMAC), and quality of life (evaluated using the Short Form-36 Health Survey - SF-36). Additionally, fear of falling was assessed using the Falls Efficacy Scale-International (FES-I).

Baseline assessments were conducted prior to randomization. Follow-up assessments were performed at 6 weeks (mid-intervention), 12 weeks (end of intervention), and 24 weeks (3-month post-intervention follow-up). All assessments were conducted by trained research assistants blinded to group allocation.

The Yoga-based intervention was delivered by certified Yoga instructors with experience in working with older adults. The program consisted of 60-minute sessions held three times per week for 12 weeks. Each session included a combination of gentle warm-up exercises, specific Yoga asanas adapted for individuals with OA, pranayama breathing techniques, and guided relaxation. The control group received standard care, which included general advice on OA management and fall prevention.

Data Management and Statistical Analysis:

Data were entered into a secure, password-protected database using REDCap electronic data capture tools. Double data entry was performed to ensure accuracy. Statistical analysis was conducted using SPSS version 26.0. Descriptive statistics were used to summarize demographic and clinical characteristics of the participants. The normality of data distribution was assessed using the Shapiro-Wilk test.

For primary outcomes (BBS and TUG scores), a mixed-model repeated measures ANOVA was used to analyze changes over time between the two groups. Post-hoc analyses with Bonferroni correction were performed for significant interactions. The incidence of falls was compared between groups using Poisson regression. For secondary outcomes, appropriate parametric or non-parametric tests were applied based on data distribution. Intention-to-treat analysis was employed to handle missing data, using multiple imputation techniques. A p-value < 0.05 was considered statistically significant for all analyses.

Ethical Considerations:

The study protocol was approved by the Institutional Ethics Committee of the tertiary care hospital (Approval No. IEC/2022/1234). All participants provided written informed consent before enrollment. The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. Participants were informed of their right to withdraw from the study at any time without affecting their standard care. Data confidentiality was maintained throughout the study, with all personal identifiers removed from the dataset used for analysis.

Results:

Table 1: Baseline Characteristics of Participants

Characteristic	Yoga Group (n=64)	Control Group (n=64)	p-value
Age (years), mean ± SD	68.5 ± 5.2	69.1 ± 4.8	0.512
Female, n (%)	41 (64.1%)	39 (60.9%)	0.714
BMI (kg/m ²), mean ± SD	27.3 ± 3.8	26.9 ± 4.1	0.638
OA Duration (years), mean ± SD	7.2 ± 4.5	7.5 ± 4.3	0.703
Kellgren-Lawrence Grade, n (%)			
Grade 2	28 (43.8%)	30 (46.9%)	0.855
Grade 3	26 (40.6%)	24 (37.5%)	
Grade 4	10 (15.6%)	10 (15.6%)	

Table 2: Changes in Berg Balance Scale Scores

Time Point	Yoga Group (n=64)	Control Group (n=64)	Between-Group Difference (95% CI)	p-value
Baseline	45.2 ± 5.8	44.9 ± 6.1	0.3 (-1.8 to 2.4)	0.778
6 weeks	48.7 ± 5.3	45.6 ± 5.9	3.1 (1.0 to 5.2)	0.004
12 weeks	52.1 ± 4.7	46.2 ± 5.7	5.9 (3.8 to 8.0)	<0.001
24 weeks	51.5 ± 4.9	45.8 ± 5.8	5.7 (3.6 to 7.8)	<0.001

Table 3: Changes in Timed Up and Go Test (seconds)

Time Point	Yoga Group (n=64)	Control Group (n=64)	Between-Group Difference (95% CI)	p-value
Baseline	12.8 ± 2.5	12.6 ± 2.3	0.2 (-0.6 to 1.0)	0.624
6 weeks	11.2 ± 2.1	12.3 ± 2.2	-1.1 (-1.8 to -0.4)	0.003
12 weeks	9.8 ± 1.8	12.1 ± 2.1	-2.3 (-3.0 to -1.6)	<0.001
24 weeks	10.1 ± 1.9	12.2 ± 2.2	-2.1 (-2.8 to -1.4)	<0.001

Table 4: Fall Incidence Rate (falls per person-year)

Time Period	Yoga Group (n=64)	Control Group (n=64)	Incidence Rate Ratio (95% CI)	P-value
0-12 weeks	0.75	1.25	0.60 (0.42 to 0.86)	0.005
13-24 weeks	0.62	1.18	0.53 (0.36 to 0.77)	0.001
Overall (0-24 weeks)	0.68	1.22	0.56 (0.43 to 0.73)	<0.001

Table 5: Changes in Visual Analog Scale for Pain (0-10 cm)

Time Point	Yoga Group (n=64)	Control Group (n=64)	Between-Group Difference (95% CI)	p-value
Baseline	6.2 ± 1.8	6.1 ± 1.7	0.1 (-0.5 to 0.7)	0.745
6 weeks	4.8 ± 1.6	5.7 ± 1.8	-0.9 (-1.5 to -0.3)	0.004
12 weeks	3.5 ± 1.4	5.4 ± 1.7	-1.9 (-2.5 to -1.3)	<0.001
24 weeks	3.8 ± 1.5	5.5 ± 1.8	-1.7 (-2.3 to -1.1)	<0.001

Table 6: Changes in WOMAC Total Score

Time Point	Yoga Group (n=64)	Control Group (n=64)	Between-Group Difference (95% CI)	p-value
Baseline	48.3 ± 12.5	47.9 ± 11.8	0.4 (-3.8 to 4.6)	0.851
6 weeks	40.1 ± 10.7	45.6 ± 11.5	-5.5 (-9.3 to -1.7)	0.005
12 weeks	32.6 ± 9.4	43.8 ± 11.2	-11.2 (-14.8 to -7.6)	<0.001
24 weeks	34.2 ± 9.8	44.5 ± 11.4	-10.3 (-13.9 to -6.7)	<0.001

Table 7: Changes in Falls Efficacy Scale-International (FES-I) Score

Time Point	Yoga Group (n=64)	Control Group (n=64)	Between-Group Difference (95% CI)	p-value
Baseline	31.5 ± 8.2	30.9 ± 7.8	0.6 (-2.1 to 3.3)	0.661
6 weeks	27.3 ± 7.1	29.8 ± 7.6	-2.5 (-5.0 to 0.0)	0.050
12 weeks	23.6 ± 6.4	28.9 ± 7.4	-5.3 (-7.7 to -2.9)	<0.001
24 weeks	24.2 ± 6.6	29.1 ± 7.5	-4.9 (-7.3 to -2.5)	<0.001

Discussion:

The results of this randomized controlled trial provide compelling evidence for the effectiveness of a traditional Indian Yoga-based exercise program in improving balance and reducing falls among elderly patients with osteoarthritis (OA). The study findings demonstrate significant improvements in balance, functional mobility, pain reduction, and fall prevention in the Yoga group compared to the control group receiving standard care alone.

The Berg Balance Scale (BBS) scores (Table 2) showed a progressive improvement in the Yoga group throughout the intervention period, with a significant between-group difference emerging at 6 weeks and further increasing at 12 weeks. This improvement was largely maintained at the 24-week follow-up, suggesting a sustained effect of the Yoga intervention on balance. These findings are consistent with those reported by Tiedemann et al. (2013), who found significant improvements in balance following a 12-week Iyengar yoga program in older adults. The magnitude of improvement in our study (5.9 points at 12 weeks) exceeds the minimal clinically important difference of 4 points for the BBS in older adults (Donoghue & Stokes, 2009), indicating a meaningful clinical impact.

The Timed Up and Go (TUG) test results (Table 3) corroborate the BBS findings, showing significant improvements in functional mobility in the Yoga group. The reduction in TUG time from baseline to 12 weeks in the Yoga group (3 seconds) surpasses the minimal clinically important difference of 1.14 seconds established for individuals with knee OA (Wright et al., 2011). This improvement in functional mobility aligns with the findings of Cheung et al. (2017), who reported significant reductions in TUG time following an 8-week Hatha yoga intervention in older women with knee OA.

One of the most striking findings of this study is the significant reduction in fall incidence in the Yoga group compared to the control group (Table 4). The incidence rate ratio of 0.56 over the 24-

week period indicates that participants in the Yoga group experienced nearly half the number of falls compared to those in the control group. This result is particularly noteworthy given the high risk of falls in elderly individuals with OA. Our findings align with those of Schmid et al. (2010), who reported improvements in balance and fear of falling following a 12-week yoga intervention in older adults, although their study did not directly measure fall incidence. The reduction in falls observed in our study may be attributed to several factors. The improved balance and functional mobility, as evidenced by the BBS and TUG results, likely contribute significantly to fall prevention. Additionally, the mindfulness and body awareness cultivated through Yoga practice may enhance proprioception and postural control, further reducing fall risk. These findings underscore the potential of Yoga as a comprehensive intervention for fall prevention in elderly OA patients.

The Yoga intervention demonstrated a substantial effect on pain reduction, as measured by the Visual Analog Scale (VAS) (Table 5). The between-group difference of 1.9 cm at 12 weeks exceeds the minimal clinically important difference of 1.1 cm for VAS in knee OA patients (Tubach et al., 2005). This pain reduction is comparable to, and in some cases surpasses, the effects reported for other non-pharmacological interventions for OA, such as tai chi and aerobic exercise (Wang et al., 2009; Fransen et al., 2015). The mechanism underlying pain reduction in Yoga practice may involve multiple factors. The gentle, low-impact nature of Yoga asanas can improve joint mobility and muscle strength without exacerbating joint stress. Furthermore, the meditative and breathing components of Yoga may contribute to pain management through stress reduction and improved coping strategies. These findings are consistent with those of Ebnezar et al. (2012), who reported significant pain reduction following an integrated Hatha yoga therapy program in patients with knee OA.

The improvements in WOMAC scores (Table 6) indicate a significant enhancement in overall functional capacity in the Yoga group. The between-group difference of 11.2 points at 12 weeks is well above the minimal clinically important improvement of 9.1 points for total WOMAC score in knee OA patients (Tubach et al., 2005). This improvement in functional capacity is likely a result of the combined effects of pain reduction, increased joint mobility, and enhanced muscle strength achieved through the Yoga practice. While not presented in a separate table, the study also found significant improvements in quality of life measures (SF-36) in the Yoga group compared to the control group. These findings are in line with those of Patel et al. (2012), whose systematic review and meta-analysis reported significant improvements in health-related quality of life following Yoga interventions in older adults.

The reduction in Falls Efficacy Scale-International (FES-I) scores (Table 7) indicates a significant decrease in fear of falling in the Yoga group. This improvement is particularly important as fear of falling can lead to activity restriction, further deconditioning, and increased fall risk, creating a vicious cycle (Delbaere et al., 2010). The reduction in fear of falling observed in our study may be attributed to the improved balance, functional mobility, and overall confidence gained through the Yoga practice. An important aspect of our findings is the sustained effect of the Yoga intervention, as evidenced by the 24-week follow-up results. While there was a slight regression in some outcomes between the 12-week and 24-week time points, the improvements remained significant compared to the control group. This suggests that the benefits of the Yoga program extend beyond the intervention period, potentially due to continued practice by participants or lasting physiological and psychological changes. The effectiveness of our Yoga-based program compares favorably with other exercise interventions for fall prevention in older adults. A Cochrane review by Gillespie et al. (2012) found that exercise programs reduced the rate of falls in community-dwelling older adults by approximately 30%. Our study demonstrated a 44% reduction in fall rate, suggesting that Yoga may be particularly effective in this population.

Furthermore, the multifaceted nature of Yoga, addressing physical, mental, and emotional aspects of health, may provide advantages over traditional exercise programs. The combination of physical postures, breathing exercises, and meditation in Yoga offers a comprehensive approach to improving balance, strength, flexibility, and body awareness, all of which contribute to fall prevention.

Limitations and Future Directions:

Despite the promising results, several limitations should be noted. The study was conducted at a single center, which may limit its generalizability. Future multi-center trials could address this limitation. Additionally, while the 6-month duration provided insights into short-term effects, longer follow-up periods would be valuable to assess the long-term impact of Yoga practice on fall prevention and OA management. The study design did not allow for blinding of participants, which is a common limitation in exercise intervention studies. Future research could consider comparing Yoga to other active interventions to control for attention and expectation effects. Furthermore, investigating the optimal frequency and duration of Yoga practice for maximum benefit in this population would be valuable.

Conclusion:

In conclusion, this randomized controlled trial provides strong evidence for the effectiveness of a traditional Indian Yoga-based exercise program in improving balance, reducing falls, and enhancing overall function in elderly patients with osteoarthritis. The significant improvements observed across multiple outcome measures, including balance, functional mobility, pain, and fear of falling, highlight the potential of Yoga as a comprehensive, non-pharmacological intervention for this population. The findings of this study have important clinical implications, suggesting that Yoga could be integrated into standard care protocols for elderly OA patients to enhance fall prevention strategies and improve quality of life. Future research should focus on implementation strategies to incorporate Yoga programs into various healthcare settings and investigate the long-term effects of sustained Yoga practice in this population.

References:

1. Alkan, B. M., Fidan, F., Tosun, A., & Ardiçoğlu, O. (2014). Quality of life and self-reported in patients with knee osteoarthritis. *Modern Rheumatology*, 24(1), 166-171.
2. Bastille, J. V., & Gill-Body, K. M. (2004). A yoga-based exercise program for people with chronic poststroke hemiparesis. *Physical Therapy*, 84(1), 33-48.
3. Büssing, A., Ostermann, T., Lüdtke, R., & Michalsen, A. (2012). Effects of yoga interventions on pain and pain-associated disability: a meta-analysis. *The Journal of Pain*, 13(1), 1-9.
4. Crews, R. T., Yalla, S. V., disability Fleischer, A. E., & Wu, S. C. (2013). A growing troubling triad: diabetes, aging, and falls. *Journal of Aging Research*, 2013, 342650.
5. Cheung, C., Wyman, J. F., Resnick, B., & Savik, K. (2017). Yoga for managing knee osteoarthritis in older women: a pilot randomized controlled trial. *BMC Complementary and Alternative Medicine*, 17(1), 131.
6. Delbaere, K., Close, J. C., Heim, J., Sachdev, P. S., Brodaty, H., Slavin, M. J., ... & Lord, S. R. (2010). A multifactorial approach to understanding fall risk in older people. *Journal of the American Geriatrics Society*, 58(9), 1679-1685.
7. Donoghue, D., & Stokes, E. K. (2009). How much change is true change? The minimum detectable change of the Berg Balance Scale in elderly people. *Journal of Rehabilitation Medicine*, 41(5), 343-346.
8. Ebnezar, J., Nagarathna, R., Yogitha, B., & Nagendra, H. R. (2012). 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. *The Journal of Alternative and Complementary Medicine*, 18(5), 463-472.

9. Fransen, M., McConnell, S., Harmer, A. R., Van der Esch, M., Simic, M., & Bennell, K. L. (2015). Exercise for osteoarthritis of the knee. *Cochrane Database of Systematic Reviews*, (1).
10. Gillespie, L. D., Robertson, M. C., Gillespie, W. J., Sherrington, C., Gates, S., Clemson, L. M., & Lamb, S. E. (2012). Interventions for preventing falls in older people living in the community. *Cochrane Database of Systematic Reviews*, (9).
11. Gonçalves, L. C., Vale, R. G. D., Barata, N. J. F., Varejão, R. V., & Dantas, E. H. M. (2011). Flexibility, functional autonomy and quality of life (QoL) in elderly yoga practitioners. *Archives of Gerontology and Geriatrics*, 53(2), 158-162.
12. Hagins, M., Moore, W., & Rundle, A. (2007). Does practicing hatha yoga satisfy recommendations for intensity of physical activity which improves and maintains health and cardiovascular fitness? *BMC Complementary and Alternative Medicine*, 7(1), 40.
13. Jeter, P. E., Nkodo, A. F., Moonaz, S. H., & Dagnelie, G. (2014). A systematic review of yoga for balance in a healthy population. *The Journal of Alternative and Complementary Medicine*, 20(4), 221-232.
14. Kraemer, J. M., & Marquez, D. X. (2009). Psychosocial correlates and outcomes of yoga or walking among older adults. *The Journal of Psychology*, 143(4), 390-404.
15. Ni, M., Mooney, K., Richards, L., Balachandran, A., Sun, M., Harriell, K., ... & Signorile, J. F. (2014). Comparative impacts of Tai Chi, balance training, and a specially-designed yoga program on balance in older fallers. *Archives of Physical Medicine and Rehabilitation*, 95(9), 1620-1628.
16. Park, J., McCaffrey, R., Newman, D., Cheung, C., & Hagen, D. (2014). The effect of Sit 'N' Fit Chair Yoga among community-dwelling older adults with osteoarthritis. *Holistic Nursing Practice*, 28(4), 247-257.
17. Patel, N. K., Newstead, A. H., & Ferrer, R. L. (2012). The effects of yoga on physical functioning and health related quality of life in older adults: A systematic review and meta-analysis. *The Journal of Alternative and Complementary Medicine*, 18(10), 902-917.
18. Sharma, M. (2014). Yoga as an alternative and complementary approach for arthritis: a systematic review. *Journal of Evidence-Based Complementary & Alternative Medicine*, 19(1), 51-58.
19. Schmid, A. A., Van Puymbroeck, M., & Kocaja, D. M. (2010). Effect of a 12-week yoga intervention on fear of falling and balance in older adults: A pilot study. *Archives of Physical Medicine and Rehabilitation*, 91(4), 576-583.
20. Tiedemann, A., O'Rourke, S., Sesto, R., & Sherrington, C. (2013). A 12-week Iyengar yoga program improved balance and mobility in older community-dwelling people: A pilot randomized controlled trial. *The Journals of Gerontology: Series A*, 68(9), 1068-1075.
21. Tubach, F., Ravaud, P., Baron, G., Falissard, B., Logeart, I., Bellamy, N., ... & Dougados, M. (2005). Evaluation of clinically relevant changes in patient reported outcomes in knee and hip osteoarthritis: the minimal clinically important improvement. *Annals of the Rheumatic Diseases*, 64(1), 29-33.
22. Vos, T., Abajobir, A. A., Abate, K. H., Abbafati, C., Abbas, K. M., Abd-Allah, F., ... & Murray, C. J. L. (2017). Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: A systematic analysis for the Global Burden of Disease Study 2016. *The Lancet*, 390(10100), 1211-1259.
23. Wang, C., Schmid, C. H., Hibberd, P. L., Kalish, R., Roubenoff, R., Rones, R., & McAlindon, T. (2009). Tai Chi is effective in treating knee osteoarthritis: a randomized controlled trial. *Arthritis & Rheumatism*, 61(11), 1545-1553.
24. World Health Organization. (2021). Ageing and health. <https://www.who.int/news-room/fact-sheets/detail/ageing-and-health>
25. Wright, A. A., Cook, C. E., Baxter, G. D., Dockerty, J. D., & Abbott, J. H. (2011). A comparison of 3 methodological approaches to defining major clinically important

- improvement of 4 performance measures in patients with hip osteoarthritis. *Journal of Orthopaedic & Sports Physical Therapy*, 41(5), 319-327.
26. Youkhana, S., Dean, C. M., Wolff, M., Sherrington, C., & Tiedemann, A. (2016). Yoga-based exercise improves balance and mobility in people aged 60 and over: a systematic review and meta-analysis. *Age and Ageing*, 45(1), 21-29.
 27. Zhang, J. X., Leung, P. C., Xu, X. M., & Lau, H. Y. (2013). Effect of yoga on chronic non-specific neck pain: An unconditional growth model. *Complementary Therapies in Medicine*, 21(6), 529-538.