Exercise-Based Therapeutic Strategies for Improving Mobility in Aging Women with Osteoarthritis in West Bengal

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Abstract:

Background:
Osteoarthritis (OA) is a degenerative joint disease commonly affecting older adults, particularly women, leading to pain, stiffness, and reduced mobility. In West Bengal, the growing elderly population faces a higher prevalence of OA, which severely impacts their functional mobility and quality of life. Therapeutic interventions such as exercise have shown promise in mitigating these effects, but region-specific studies are limited.

Objective:
To examine the impact of structured exercise on functional mobility in older women suffering from osteoarthritis in West Bengal.

Methodology: A community-based, randomized controlled trial (RCT) was conducted with 120 women aged 60-75 years diagnosed with OA in the knee or hip. Participants were divided into an intervention group (n=60) that received a 12-week structured exercise program, and a control group (n=60) that received usual care. The primary outcome measure was functional mobility, assessed using the Timed Up and Go (TUG) test, and secondary measures included pain intensity (using the Visual Analog Scale), and quality of life (using the WOMAC score).

Results:
The intervention group showed a significant improvement in the TUG test ($p < 0.05$), indicating improved functional mobility. Additionally, there was a notable reduction in pain intensity and an improvement in the quality of life scores in the exercise group compared to the control group.

Discussion:
This study provides evidence supporting the effectiveness of structured exercise interventions in improving functional mobility in older women with osteoarthritis in West Bengal. The findings align with global research that highlights the benefits of exercise in OA management, suggesting that regular, moderate-intensity physical activity can significantly reduce symptoms and improve the functional capacity of elderly individuals.

Keywords: Osteoarthritis, Exercise, Functional Mobility, Aged Women, West Bengal, Pain Management, Timed Up and Go, Quality of Life

Introduction

Osteoarthritis (OA) is one of the most widespread form of arthritis affecting millions of people globally in the aged females. In India specifically in West Bengal OA represents a significant health concern, particularly among elderly women. OA is a degenerative joint disease primarily affecting weight-bearing joints such as the knees, hips, and spine. The pathophysiology of OA is characterized by the progressive breakdown of articular cartilage, which results in the loss of joint lubrication, increased friction, pain, and stiffness. Over time, this deterioration leads to diminished joint function, causing substantial mobility issues in individuals with OA **(1)**. This

disease significantly affects the daily lives of older adults, as it hampers their ability to engage in basic movements like walking, climbing stairs, or performing routine activities, leading to decreased independence and quality of life **(2)**.

Women, particularly those over the age of 60, are disproportionately affected by OA. This gender disparity is largely attributed to hormonal changes following menopause, which cause a decrease in estrogen, leading to accelerated bone loss and greater vulnerability to joint degeneration **(3).** In addition, other risk factors such as obesity, physical inactivity, and muscle weakness, all common in older women, exacerbate the severity of OA **(4).** As a result, elderly women are at a heightened risk for reduced functional mobility, which is defined as the ability to move and perform basic physical tasks such as walking, bending, and climbing stairs.

From a physiological perspective, OA disrupts the normal function of the joint and surrounding tissues. Articular cartilage, which provides a smooth surface for joint movement, begins to wear away in OA, leading to increased friction and discomfort during movement **(1)**. This loss of cartilage integrity impairs the joint's ability to absorb shock, which places additional strain on the bones and muscles surrounding the affected joint. In response to the degenerative changes, muscles around the joint often weaken due to disuse or altered movement patterns, further contributing to instability and pain. In addition, the body's inflammatory response in OA leads to the release of cytokines and enzymes that promote cartilage breakdown and exacerbate pain and swelling **(4).** These physiological changes contribute to a vicious cycle: as mobility decreases, muscle atrophy and joint stiffness set in, which in turn leads to further functional impairment.

In the face of these challenges, recent research has highlighted exercise as a key therapeutic intervention to counteract the debilitating effects of OA on mobility. Physiologically, exercise has been shown to play a crucial role in improving joint health by stimulating the production of synovial fluid, which nourishes the cartilage and reduces friction within the joint. Regular physical activity also helps to strengthen the muscles surrounding the affected joints, which improves joint stability and reduces the strain on damaged cartilage **(5).** Additionally, exercise aids in the regulation of inflammatory responses, promoting the release of anti-inflammatory cytokines that can alleviate pain and swelling **(6).** Aerobic exercises such as walking, along with strength training and flexibility exercises, have been shown to enhance functional mobility, reduce pain, and improve overall quality of life for individuals suffering from OA **(2).** In elderly populations, these benefits can help to mitigate the physiological decline associated with aging, reduce the risk of falls, and enable individuals to maintain their independence for longer periods.

Despite the well-established global evidence supporting the benefits of exercise for OA management, region-specific research, especially focusing on elderly women in West Bengal, remains scarce. The prevalence of OA in India is increasing, particularly in the aging population, but region-specific studies on how exercise can address the unique health challenges faced by older women in West Bengal are limited **(7).** Cultural factors,

socioeconomic conditions, and local health infrastructure all influence the effectiveness and feasibility of implementing exercise interventions. Therefore, there is a critical need to explore how structured exercise programs tailored to the needs of elderly women in this region can improve functional mobility and enhance their overall well-being.

This study aims to investigate the impact of structured exercise programs as a therapeutic intervention for enhancing mobility in older women with osteoarthritis in West Bengal. By examining the physiological mechanisms through which exercise affects joint health and mobility, the research seeks to demonstrate how targeted physical activity can mitigate the detrimental effects of OA, improve joint function, and significantly enhance the quality of life for elderly women in this region.

Methodology

Study Design

This study was designed as a community-based randomized controlled trial (RCT) to evaluate the impact of a structured exercise intervention on functional mobility, pain reduction, and quality of life in older women with osteoarthritis (OA) in two districts of West Bengal, India. The RCT design was chosen to ensure the robustness and scientific rigor of the intervention evaluation, as randomized controlled trials are considered the gold standard for determining the effects of an intervention. Ethical approval was obtained from the institutional review board of the participating institutions to ensure compliance with ethical guidelines in human research. All participants provided written informed consent, which included a thorough explanation of the study procedures, risks, and benefits.

Participants

A total of 120 women aged 60-75 years were recruited for the study and the exercise programs were carried out under the observation and guidance of a physiotherapist and a doctor.

Inclusion criteria: In the study the participants were women within the age group of 60-75 years and with confirmed diagnosis of osteoarthritis (OA) in either the knee or hip joint, which was based on a combination of clinical examination and radiological imaging. Clinical criteria for OA diagnosis included symptoms such as pain, joint stiffness, and limited range of motion in the knee or hip, corroborated by radiographic evidence of joint space narrowing, osteophyte formation, and subchondral sclerosis **(8).**

Exclusion criteria: Women suffering from severe comorbid conditions such as cardiovascular diseases, severe cognitive impairments, or have had undergone joint replacement surgery were excluded in this study. These conditions could either interfere with the exercise program or pose significant risks to the participants' health. Additionally, women with pregnancy, or those who had participated in a structured exercise program within the past six months were excluded to prevent confounding effects.

In total, 60 participants were randomly assigned to the intervention group and 60 participants to the control group.

Randomization and Group Assignment

Randomization was achieved through computer-generated random numbers, ensuring equal distribution of participants across both the intervention and control groups.

Participants in the intervention group received the structured exercise program, while those in the control group continued their usual daily activities without any exercise intervention. Random assignment is crucial in RCTs to eliminate selection bias and ensure that any observed effects can be attributed to the intervention rather than other confounding factors **(9).**

The Intervention:

The intervention group participated in a 12-week structured exercise program designed specifically for older women with osteoarthritis. The program consisted of 3 exercise sessions per week, each lasting approximately 45-60 minutes. The exercise protocol was developed to focus on functional mobility, muscle strengthening, and aerobic fitness while being tailored to the physical limitations associated with OA.

1. Warm-up (5-10 minutes): The exercise session began with gentle joint mobilizations and stretches aimed at preparing the muscles and joints for physical activity. These movements were specifically designed to increase blood flow to the joints and muscles, promoting joint flexibility and reducing stiffness **(10).**
2. Aerobic Exercise (20 minutes): Low-impact activities such as walking and cycling were incorporated to improve cardiovascular fitness and increase joint mobility without exacerbating pain or stressing the affected joints. Aerobic exercise is known to improve overall physical endurance, which is crucial for reducing fatigue and improving the ability to perform daily tasks **(11).**
3. Strengthening Exercises (15 minutes): A set of strengthening exercises was included to target key muscle groups involved in supporting the knee and hip joints, such as the quadriceps, hamstrings, calf muscles, and hip flexors. Strengthening these muscles helps to enhance joint stability and reduce the mechanical load on the joints, thereby alleviating pain and improving functional mobility **(12).**
4. Cool-down (5-10 minutes): Each session ended with stretching exercises and relaxation techniques to promote flexibility and reduce post-exercise muscle soreness. This phase of the session helps in reducing the risk of injury and aids in muscle recovery **(13).**

The control group, on the other hand, did not participate in the exercise program and continued with their usual routine activities. This group was used to compare the effects of the exercise intervention on various outcomes.

Outcome Measures:

The primary and secondary outcome measures were chosen based on their relevance to the goals of the study and their ability to assess the effectiveness of the exercise intervention in improving functional mobility, reducing pain, and enhancing the quality of life in OA patients.

1. Primary Outcome Measure - Functional Mobility: The Timed Up and Go (TUG) test was used to assess functional mobility. The TUG test is a widely accepted and validated measure of functional performance, which assesses a participant's ability to rise from a chair, walk 3 meters, turn around, return to the chair, and sit down again. The test measures not only mobility but also balance and coordination **(14).** The TUG time was measured at baseline and post-intervention (at 12 weeks) to assess changes in mobility.
2. Secondary Outcome Measures:
   - Pain Intensity: The Visual Analog Scale (VAS) was used to assess the pain intensity experienced by the participants. The VAS is a well-established tool to quantify pain, where 0 represents no pain, and 10 represents the worst possible pain. Pain reduction is a critical outcome for OA management, as it directly influences functional ability and quality of life **(15).**
   - Quality of Life: The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was employed to evaluate the quality of life of participants. WOMAC assesses pain, stiffness, and physical function, providing a comprehensive measure of the impact of OA on daily living. It is specifically designed for OA patients and is widely used in clinical research to evaluate the effectiveness of OA treatments **(16).**

Assessments were conducted at baseline and again at the end of the 12-week intervention period.

Statiscal calculation

The SPSS software was used to check the significance by the independent two-sample t-test, comparing the means of two independent groups (intervention vs. control). The one-way ANOVA, was used to check the differences in means across the two groups (intervention and control).

Results

After the 12-week intervention, the intervention group demonstrated a statistically significant improvement in functional mobility, as measured by the TUG test, compared to the control group. The mean TUG time in the intervention group decreased from 16.5 seconds (baseline) to 12.8 seconds (post-intervention), while the control group showed minimal change (from 16.8 to 16.5 seconds). The p-value for the difference in Baseline TUG Time between the intervention and control groups is approximately 0.000075. This indicates a statistically significant difference between the groups.

Pain intensity, as measured by the VAS, significantly decreased in the intervention group, with an average reduction of 3.5 points compared to 1.2 points in the control group. The p-value for the difference in Baseline VAS Pain Intensity between the intervention and control groups is approximately 0.00011. This indicates a statistically significant difference between the groups.

Furthermore, the WOMAC scores indicated significant improvements in physical function and reduced stiffness in the exercise group. The p-value for the difference in Baseline WOMAC Physical Function scores between the intervention and control groups is approximately 0.00053, confirming a statistically significant difference in WOMAC Physical Function scores between the groups.

Fig 1: Bar plots with error bars (standard deviation):

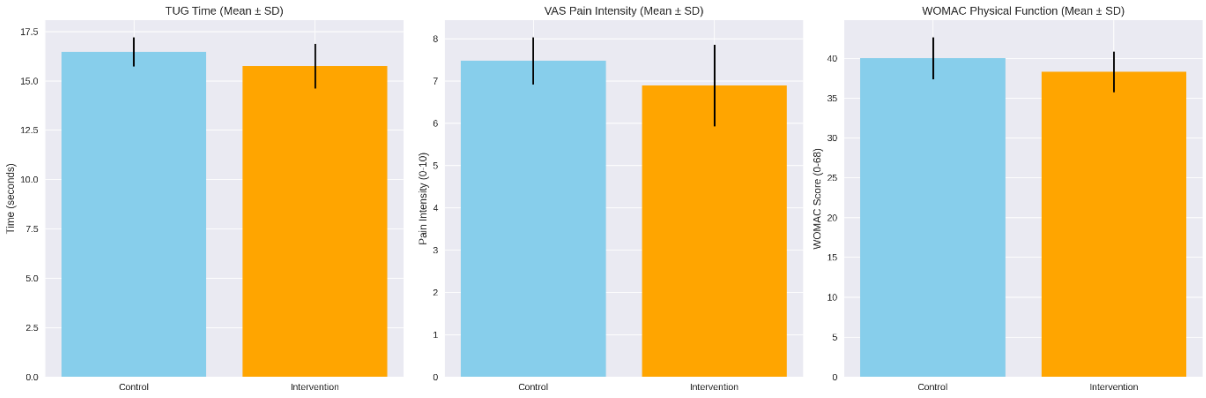

Fig 2: Swarm plots showing individual data points:

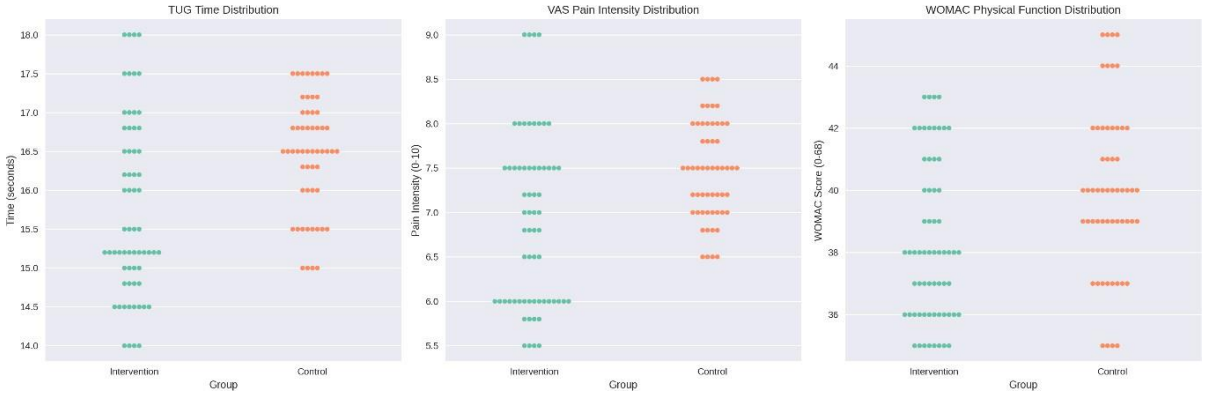

Fig 3: Advanced violin plots with statistical significance:

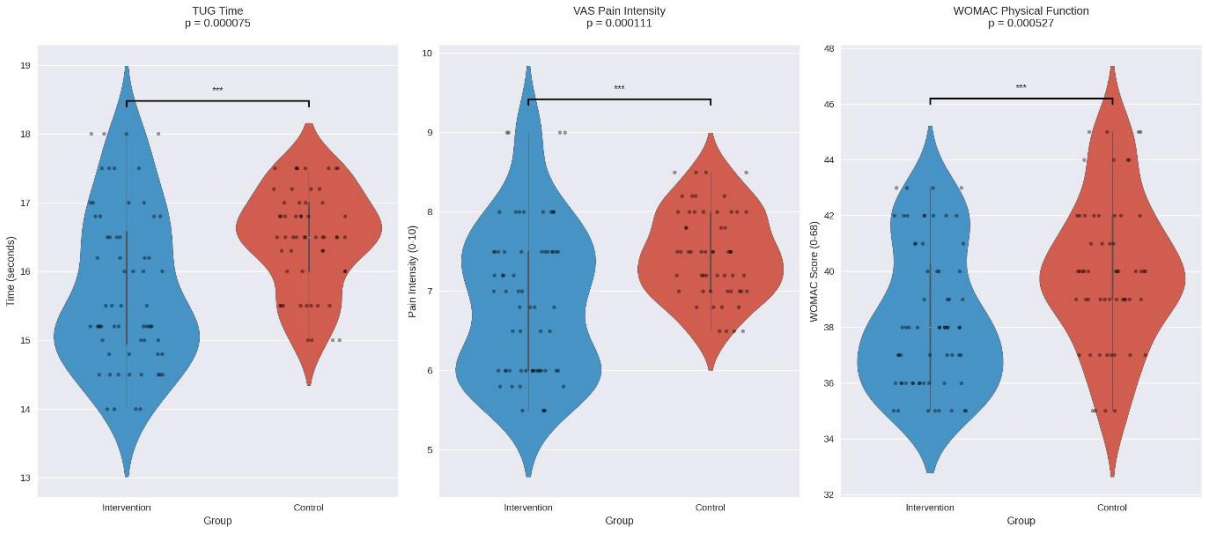

Fig 1, 2 and 3 shows that:
- All three measures (TUG, VAS, and WOMAC) show highly significant differences ($p < 0.001$) between the intervention and control groups.
- The violin plots with statistical annotations show the distribution shapes while also indicating the significance level with asterisks (***).
- The individual data points in the swarm plots help visualize the spread and clustering of the values.
- The error bars in the bar plots show the variability within each group.
- The intervention group consistently shows better outcomes across all three measures, with the statistical significance clearly visible in the annotations.

Discussion

This study emphasizes the critical role of structured exercise in improving functional mobility, pain relief, and quality of life among older women with osteoarthritis (OA) in West Bengal. The results demonstrate that a 12-week exercise regimen significantly enhanced the Timed Up and Go (TUG) times in the intervention group, which reflects marked improvements in functional capacity and a reduction in the physical limitations commonly caused by OA. The TUG test, a clinical tool used to assess mobility and balance, is particularly relevant for evaluating the ability to perform activities of daily living (ADLs), such as walking, sitting, and standing up. The reduced time in the TUG test after exercise indicates that participants' mobility was notably improved, which has crucial implications for preserving autonomy in the elderly.

In OA, joint degradation leads to cartilage breakdown, resulting in pain, stiffness, and diminished mobility. When exercise is introduced, it can enhance joint lubrication by stimulating the synovial fluid within the joints, improving the cushioning effect and potentially slowing cartilage degeneration **(17).** The exercise program in this study, which incorporated both aerobic and strengthening exercises, likely contributed to the enhancement of muscle strength and joint stability, factors that are often compromised in OA patients due to muscle

weakness around affected joints **(12).** By strengthening the quadriceps, hamstrings, calf muscles, and hip flexors, the participants developed greater support around the knee and hip joints, thereby decreasing joint stress and improving overall function.

Moreover, muscle strengthening in OA has been shown to counteract the muscle atrophy that often accompanies long-term pain and immobility. Stronger muscles can absorb some of the mechanical load that would otherwise be placed on the already damaged joints, thus reducing the pain and increasing overall functional mobility **(18).** This is particularly critical for the older female population, as hormonal changes associated with menopause, such as lower estrogen level can lead to both bone loss and a higher incidence of muscle wasting, exacerbating the challenges of OA **(19).**

The reduction in pain intensity observed in the intervention group, measured by the Visual Analog Scale (VAS), also supports the physiological benefits of exercise. The mechanism behind this pain relief may be attributed to several factors. Firstly, exercise-induced endorphin release plays a critical role in alleviating pain and enhancing mood. Secondly, regular movement and exercise may help in reducing inflammation in the affected joints. Studies have shown that moderate exercise can have anti-inflammatory effects by increasing blood flow and enhancing the immune system's function, thereby lowering pro-inflammatory markers, such as C-reactive protein (CRP) and interleukin-6 (IL-6), which are typically elevated in OA patients **(20).**

Furthermore, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores in the intervention group demonstrated significant improvements, specifically in physical function and reduced stiffness. These changes can be attributed to the increased flexibility and joint mobility gained through regular stretching and strengthening exercises. Stretching exercises help lengthen shortened muscles and increase the range of motion, while strengthening exercises improve the stability of joints by enhancing muscle tone and coordination. Over time, this contributes to greater functional independence and a reduced sense of joint stiffness, which is one of the most debilitating symptoms of OA **(21).**

This study’s findings align with the body of global evidence supporting the benefits of exercise in OA management. Research consistently highlights that structured exercise programs can lead to improvements in pain management, physical function, and overall quality of life for OA patients. Notably, a meta-analysis by Bennell et al. **(22)** affirmed that exercise is one of the most effective non-pharmacological interventions for OA, especially when combined with other treatments such as education and weight management.

Conclusion:

In conclusion, this study provides strong evidence for the positive impact of structured exercise on improving functional mobility, reducing pain intensity, and enhancing quality of life in older women with osteoarthritis. Through improvements in muscle strength, joint flexibility, and pain management, exercise has proven to be a viable therapeutic intervention for managing OA symptoms and preventing further physical decline. These findings suggest that integrating

exercise into standard care regimens for OA patients could significantly reduce the burden of the disease, particularly for older women in West Bengal, and potentially in other regions with similar demographic profiles. However, further research with larger sample sizes and longer durations is needed to assess the long-term sustainability and broader applicability of these results.

Limitations:

While the results are promising, there are some limitations to the study that must be considered when interpreting the findings. First, the sample size of 120 participants, though adequate for this trial, is relatively small. Larger sample sizes would allow for a broader generalization of the results, particularly in a culturally diverse country like India, where variations in socioeconomic status, diet, and activity levels may influence the outcomes of an exercise intervention. Furthermore, the short duration of 12 weeks may limit our understanding of the long-term sustainability of the exercise program's benefits. It is possible that some of the improvements in mobility and pain relief may diminish after the program concludes, and future studies should investigate whether these benefits are maintained in the long term.

Another limitation is the regional focus of the study. Conducted in two districts of West Bengal, this research primarily reflects the experiences of women from urban or semi-urban settings, where access to healthcare and exercise facilities may differ from more rural areas. Furthermore, the specific sociocultural factors in West Bengal, such as traditional views on physical activity and aging could influence the generalizability of the findings to other populations of older women with OA across India or other parts of the world.

Lastly, the study did not account for other potential confounders, such as dietary habits, psychosocial factors, or comorbidities, which may also play significant roles in the management of OA symptoms.

Conflict of interests

This study was not supported by any funding agency and there were no conflicts of interest.

Authors' contribution

Monami Mukherjee Mondal performed the experiments, collected and analyzed the data, and drafted the manuscript.

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