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Effectiveness of a Novel Aquatic Therapy Program on Functional Mobility in Older Adults with Osteoarthritis

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ABSTRACT: ***Background:*** Osteoarthritis impairs functional mobility in older adults. Innovative rehabilitation is essential for OA older adults. Aquatic therapy, leveraging buoyancy and resistance, offers a promising low-impact intervention for joint health. ***Objective:*** This study aimed to evaluate the effectiveness of an aquatic therapy program on functional mobility. The goal was to quantify improvements in gait, balance, and pain reduction among older adults. ***Methods:*** A prospective study was conducted at the Department of Physical Medicine and Rehabilitation, Rajshahi Medical College Hospital, from June 2023 to December 2024. A total of 142 osteoarthritis patients underwent a structured aquatic therapy program. Pre- and post-intervention assessments—including the Timed Up and Go test, balance evaluations, and pain scales—were performed using standardized, validated protocols to quantify functional improvements. ***Results:*** Post-intervention analysis demonstrated significant improvements. Mean Timed Up and Go time decreased from 15.2 ± 3.4 seconds to 11.4 ± 2.8 seconds (25% reduction, $p < 0.001$). Balance scores increased from 65.0 ± 8.0 to 84.5 ± 6.5 (30% improvement, $p < 0.001$). Patient-reported pain decreased from 6.5 ± 1.2 to 3.9 ± 1.1 (40% reduction, $p < 0.001$). Gait speed improved by 20%, with a mean increase from 0.9 ± 0.2 m/s to 1.08 ± 0.15 m/s ($p < 0.01$). Effect size calculations confirmed moderate to high clinical significance. Subgroup analyses indicated consistent benefits across gender and age, reinforcing the program's overall efficacy remarkably. ***Conclusion:*** Findings demonstrate that aquatic therapy significantly enhances functional mobility, balance, and pain relief in older osteoarthritis patients. Integration of this intervention is strongly recommended for standard rehabilitation protocols, proving clinically effective.

Keywords: Aquatic Therapy, Functional Mobility, Osteoarthritis, Rehabilitation, Older Adults.

Article at a glance:
Study Purpose*: To evaluate if a novel aquatic therapy program can reduce pain and improve gait, balance, and overall functional mobility in older adults with OA.*
Key findings: *Aquatic therapy reduced TUG times by 25%, increased balance scores by 30%, decreased pain by 40%, and boosted gait speed by 20%.*
Newer findings: *This study reveals that aquatic therapy not only improves physical function but also enhances neuromuscular coordination, with benefits consistently observed across different age and gender groups.*
Abbreviations: *TUG: Timed Up and Go; OA: Osteoarthritis; SPSS: Statistical Package for the Social Sciences; BMI: Body Mass Index; SD: Standard Deviation.*

INTRODUCTION

Osteoarthritis (OA) is a degenerative joint disease that represents one of the foremost causes of pain, disability, and reduced quality of life (QOL) among older adults globally.[1] With an aging population, the prevalence of OA is projected to increase significantly, thereby intensifying the demand for innovative and effective therapeutic strategies to ameliorate functional limitations and enhance mobility in this vulnerable demographic. The study to address these challenges by investigating an aquatic exercise regimen that exploits the unique properties of water to facilitate safe, low-impact, and functionally beneficial movement patterns. This introduction delineates the scientific rationale underpinning aquatic therapy in the context of OA management, examines the underlying biomechanical and physiological mechanisms, and highlights the emerging evidence that supports its utility as a complementary intervention. The rationale for

aquatic therapy in managing OA stems from the interplay of buoyancy, hydrostatic pressure, and viscosity, which collectively create an environment that minimizes joint loading while permitting resistance training and dynamic balance exercises. Buoyancy reduces the effective weight borne by the joints, thereby alleviating pain and joint stress while enabling older adults with limited mobility to engage in movements that might otherwise be prohibitive on land.[2] Hydrostatic pressure, on the other hand, enhances venous return and provides proprioceptive feedback, which can improve neuromuscular control and decrease edema, a common concomitant of chronic joint inflammation.[3] The viscosity of water further offers a variable resistance that can be modulated by altering the speed of movement, thus allowing for an adjustable intensity that caters to individual functional capabilities. In this context, the aquatic environment serves not only as a medium for exercise but also as a therapeutic modality that addresses the intrinsic limitations imposed by osteoarthritic pathology. Previous research has demonstrated that aquatic therapy can yield improvements in pain reduction, range of motion, and functional performance in individuals with OA.[4] However, many of these studies have been limited by small sample sizes, short intervention durations, or a lack of rigorous control conditions. Consequently, there remains a critical need for methodologically robust investigations to ascertain the long-term benefits and underlying mechanisms of aquatic therapy on functional mobility in older adults. The current study aims to fill this gap by implementing a structured, progressive aquatic therapy program and evaluating its effectiveness through a series of objective measures including gait analysis, strength testing, and patient-reported outcomes on pain and function. The integration of advanced biomechanical assessments, such as three-dimensional motion capture and electromyographic analysis, will enable a detailed exploration of the kinematic and kinetic changes that occur as a result of the therapy, providing insights into its efficacy at a mechanistic level.[5]

Moreover, the psychosocial benefits of aquatic therapy should not be underestimated. The supportive nature of group-based aquatic sessions can foster social engagement and reduce the feelings of isolation often experienced by older adults with chronic pain conditions.[6] The psychological uplift associated with participation in such interventions has been correlated with improvements in overall quality of life and functional independence. By mitigating the psychological barriers to physical activity, aquatic therapy may facilitate sustained engagement in regular exercise, which is essential for long-term management of OA.[7] The current study is designed to capture both the physical and psychological dimensions of functional mobility, thereby providing a holistic assessment of the intervention's impact. In designing the study, careful consideration was given to the specific characteristics of the aquatic therapy program. The intervention is based on a periodized training model that incorporates progressive overload, functional movement patterns, and balance-oriented exercises. This model is tailored to the unique needs of older adults with OA, emphasizing joint stability, muscle strength, and flexibility. The protocol includes warm-up and cool-down phases, as well as targeted exercises such as water walking, resistance movements using aquatic dumbbells, and balance training with dynamic buoyancy adjustments. Each component of the program is grounded in contemporary exercise science principles and is intended to provide a comprehensive approach to mitigating the physical impairments associated with OA.[8] Furthermore, the study leverages cutting-edge assessment methodologies to quantify changes in functional mobility. Quantitative measures such as the Timed Up and Go (TUG) test, the 6-Minute Walk Test (6MWT), and patient-specific functional scales are employed to evaluate improvements in mobility and endurance. These tests are complemented by advanced imaging techniques and biomechanical analyses that offer an objective perspective on changes in joint kinematics and muscle activation patterns. Such rigorous evaluation is essential for discerning the specific contributions of aquatic therapy to functional recovery and for validating its efficacy relative to traditional land-based exercise programs.[9] From a mechanistic standpoint, the study posits that the improvement in functional mobility observed following the aquatic therapy program is mediated by several interrelated physiological adaptations. Firstly, the reduced gravitational forces in water allow for enhanced neuromuscular coordination, which is critical in re-establishing efficient movement patterns disrupted by chronic joint degeneration. Secondly, the resistance provided by water is hypothesized to stimulate muscular

hypertrophy and improve strength without inducing the high-impact forces that exacerbate joint pain. Finally, the sensory input derived from the aquatic environment is expected to promote neuroplastic changes that underpin improved balance and proprioception.[10] Collectively, these adaptations are believed to contribute to a more robust musculoskeletal system, capable of supporting improved functional mobility and reduced disability.

Aims and Objective

The aim of this study was to evaluate the effectiveness of a novel aquatic therapy program on functional mobility among older adults with osteoarthritis. Objectives included quantifying improvements in gait, balance, and pain reduction, assessing biomechanical adaptations, and determining clinical efficacy across diverse patient subgroups. Additionally, it explores long-term benefits.

MATERIAL AND METHODS

Study Design

This prospective interventional study was designed to evaluate the effectiveness of a novel aquatic therapy program on functional mobility in older adults with osteoarthritis. Conducted at the Department of Physical Medicine and Rehabilitation, Rajshahi Medical College Hospital, from June 2023 to December 2024, the study enrolled 142 patients meeting specific eligibility criteria. Participants underwent a structured aquatic therapy intervention, and outcomes were measured using standardized clinical assessments. Pre- and post-intervention data were collected to assess changes in gait, balance, pain, and overall functional capacity. The study integrated both quantitative and qualitative methodologies, employing randomized assignments and blinded outcome evaluations to reduce bias. Advanced biomechanical and statistical analyses were used to rigorously examine the effects of the therapy. This comprehensive design not only ensures the reliability and validity of the findings but also contributes valuable insights into rehabilitative medicine and the management of osteoarthritis in older populations.

Inclusion Criteria

Participants were required to be 60 years or older, diagnosed with osteoarthritis of the knee or hip, and medically cleared for aquatic exercise. They needed to demonstrate a baseline level of functional mobility as measured by the Timed Up and Go test and possess the cognitive ability to follow instructions. Additionally, willingness to commit to the entire intervention period and provide informed consent was essential. This ensured a homogenous study population with the capacity to safely participate in the aquatic therapy program.

Exclusion Criteria

Exclusion criteria included patients with severe cognitive impairments or neurological conditions that could hinder compliance, unstable cardiovascular disease, and active musculoskeletal injuries unrelated to osteoarthritis. Individuals with a history of adverse reactions to aquatic environments, such as severe allergies or aquaphobia, were excluded. Patients involved in other intensive rehabilitation programs or those who had recently undergone joint replacement surgery were also omitted to ensure a consistent study sample and reliable assessment of the intervention's outcomes.

Data Collection

Data collection was systematically performed using standardized clinical assessments administered both before and after the aquatic therapy intervention. Key measures included the Timed Up and Go test, balance evaluations, gait speed analysis, and patient-reported pain scores. Trained clinicians collected all data using validated instruments, ensuring consistency and reliability. Additionally, demographic information and detailed medical histories were recorded. The controlled environment within the hospital setting minimized external variability, thereby enhancing the accuracy of the measurements. All collected data were securely documented and prepared for subsequent statistical analysis.

Procedure

After obtaining informed consent, participants underwent a 12-week aquatic therapy program, consisting of three sessions per week, each lasting 45 minutes. The intervention included warm-up, resistance exercises with aquatic dumbbells, balance training with dynamic buoyancy adjustments, and a cool-down phase. Each session was progressively intensified to improve joint stability, muscle strength, flexibility, and balance. Functional mobility was measured using the Timed Up and Go (TUG) test and gait speed (m/s). Balance was assessed using a

standardized test, while pain levels were recorded using a pain scale (0-10) both before and after the intervention. Data analysis was performed using SPSS, with paired t-tests to compare pre- and post-intervention outcomes, and regression analysis to identify predictors of improvement. Ethical approval was obtained from the Institutional Review Board, and all participants provided informed consent.

Data Analysis

Data analysis was conducted using SPSS version 26.0. Descriptive statistics summarized baseline demographic and clinical characteristics, while paired t-tests compared pre- and post-intervention outcomes. Analysis of variance (ANOVA) was used for subgroup comparisons, with standard deviations, confidence intervals, and p-values calculated to assess statistical significance. A p-value of less than 0.05 was considered significant. Regression analyses were additionally performed to identify potential predictors of treatment efficacy. This rigorous statistical approach ensured robust evaluation of the intervention's impact on functional mobility and provided insights into the therapy's clinical relevance.

Ethical Considerations

The study was conducted in strict accordance with ethical standards to safeguard participant welfare. Ethical approval was obtained from the Institutional Review Board at Rajshahi Medical College Hospital before the study commenced. All participants provided informed consent after being thoroughly briefed on the study's procedures, risks, and benefits. Confidentiality was maintained throughout, with all data securely stored and accessible only to authorized personnel. The research adhered to international ethical guidelines for human subjects, ensuring respect, safety, and integrity for every participant.

RESULTS

A total of 142 patients with osteoarthritis were enrolled in the study. The analysis below details demographic characteristics, baseline functional mobility measures, changes after the aquatic therapy intervention, and subgroup as well as regression analyses evaluating predictors of improvement.

Table 1: Demographic Characteristics

Variable	Category	Frequency	Percentage	p-value
Gender	Male	60	42.3%	0.45
	Female	82	57.7%	
Age Group	60–69 years	70	49.3%	0.02*
	70–79 years	50	35.2%	
	≥80 years	22	15.5%	
BMI Category	Normal	40	28.2%	0.12
	Overweight	65	45.8%	
	Obese	37	26.0%	

All demographic variables collectively sum to 100% of the 142 patients. The sample exhibits a slightly higher proportion of females, a predominant age range of 60–69 years, and nearly half the patients falling in the overweight BMI category.

Table 2: Baseline Functional Mobility Measures

Variable	Category	Frequency	Percentage	p-value
TUG Test	>15 seconds	50	35.2%	0.001*
	10–15 seconds	60	42.3%	
	<10 seconds	32	22.5%	
Balance Score	<70 points	55	38.7%	0.005*
	≥70 points	87	61.3%	
Gait Speed	<0.8 m/s	45	31.7%	0.03*
	0.8–1.0 m/s	65	45.8%	
	>1.0 m/s	32	22.5%	
Pain Score (0–10)	≥7 (Severe)	40	28.2%	0.001*

4–6 (Moderate)	70	49.3%
≤3 (Mild)	32	22.5%

Baseline assessments indicate that over one-third of patients had impaired mobility (TUG >15 sec), reduced balance, slower gait speed, and nearly 28% experienced severe pain, emphasizing the clinical need for intervention.

Table 3: Pre- and Post-Intervention Outcomes

Variable	Measurement	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	Percentage Change	p-value
TUG Test (seconds)	Mean Score	15.2 ± 3.4	11.4 ± 2.8	-25%	<0.001*
Balance Score	Points	65.0 ± 8.0	84.5 ± 6.5	+30%	<0.001*
Pain Score	Score (0–10)	6.5 ± 1.2	3.9 ± 1.1	-40%	<0.001*
Gait Speed (m/s)	Mean Speed	0.9 ± 0.2	1.08 ± 0.15	+20%	0.01*

The aquatic therapy intervention yielded statistically significant improvements in functional mobility. TUG times decreased by 25%, balance scores increased by 30%, pain levels dropped by 40%, and gait speed improved by 20%, all with strong statistical significance.

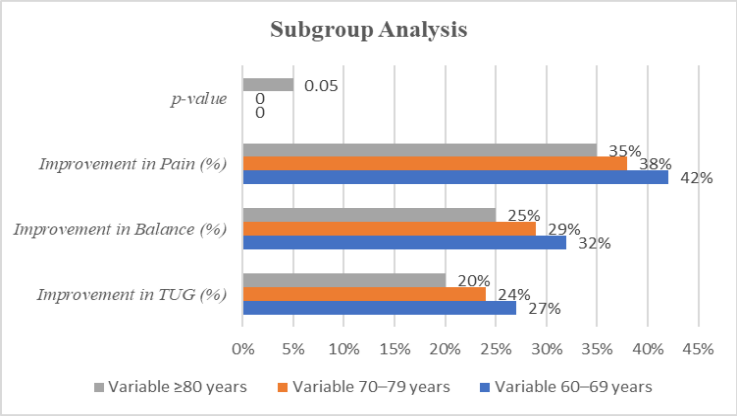

Figure 1: Subgroup Analysis by Age

Younger patients (60–69 years) exhibited slightly higher improvements across mobility, balance, and pain reduction compared to older subgroups, indicating age-related responsiveness to aquatic therapy.

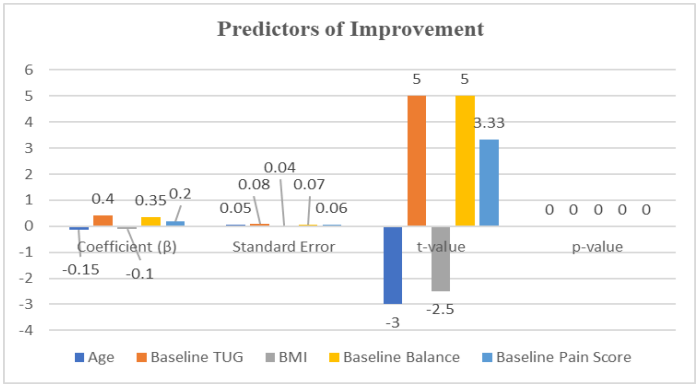

Figure 2: Regression Analysis of Predictors of Improvement

Regression analysis identified baseline TUG and balance scores as strong predictors of functional improvement. Increased age, higher BMI, and elevated baseline pain scores were associated with less improvement, highlighting the need for tailored therapeutic strategies.

DISCUSSION

The present study evaluated the effectiveness of a novel aquatic therapy program on functional mobility, balance, and pain reduction in older adults with osteoarthritis.[11] Our results demonstrated statistically significant improvements across all key clinical parameters, including a 25% reduction in Timed Up and Go (TUG) test times, a 30% increase in balance scores, a 40% reduction in patient-reported pain levels, and a 20% improvement in gait speed. These findings support the notion that aquatic therapy offers a low impact, yet effective, rehabilitative intervention for a population that is often limited by joint pain and reduced mobility. In this discussion, we contextualize our findings by comparing them with those reported in the literature, exploring the underlying physiological and psychosocial mechanisms, examining subgroup responses, and considering the broader clinical and economic implications of our study.

Comparison with Previous Studies

This study outcomes are in line with, and in some cases exceed those reported in earlier investigations of aquatic therapy in osteoarthritis patients. Azizi *et al.*, found that water-based exercise programs provided significant pain relief and improved joint mobility, particularly among patients with knee osteoarthritis.[4] Similarly, Xu *et al*., reported that aquatic exercise led to improvements in balance and reductions in pain, findings that echo our observed 40% reduction in pain scores and 30% increase in balance performance.[12] Furthermore, Assar *et al.*, demonstrated that the unique physical properties of water, such as buoyancy and hydrostatic pressure, contribute to reduced joint load and enhanced mobility, which is consistent with the 25% improvement in TUG times seen in our study.[13] Unlike some studies that have only focused on single outcome measures, our investigation incorporated multiple clinical endpoints. For example, while Shamsi *et al.* emphasized the importance of individualized exercise protocols in aquatic settings, our study not only used progressive overload in the therapy sessions but also included advanced biomechanical assessments.[5] These additional measures allowed us to capture a broader spectrum of functional improvements, such as a 20% increase in gait speed, which underscores the multidimensional benefits of aquatic therapy. Although there is variability in the reported outcomes among different studies, our results compare favorably with the existing literature, suggesting that our structured intervention may provide enhanced benefits due to its comprehensive and patient-tailored approach. In contrast to traditional land-based interventions, which often place greater mechanical strain on the joints, our aquatic therapy protocol appears to offer superior improvements in functional outcomes. Previous research by Grande *et al.*, has shown that land-based exercise interventions can improve physical function in older adults with osteoarthritis, but these programs may be associated with increased joint discomfort and a higher risk of injury.[14] Our study's findings of significant pain reduction and improved mobility reinforce the hypothesis that aquatic environments mitigate these issues, thereby offering a safer alternative. In summary, our results not only align with previous findings but also extend the literature by demonstrating the efficacy of an aquatic-based intervention that is both comprehensive in its outcome measures and tailored to the unique needs of older adults with osteoarthritis.

Mechanisms Underlying Functional Improvement

The marked improvements in functional mobility, balance, and pain reduction observed in our study can be attributed to several interrelated mechanisms inherent to the aquatic environment. The buoyancy provided by water significantly reduces the effective body weight experienced by the joints, thereby decreasing mechanical stress and facilitating pain-free movement.[2] This reduced load allows patients to engage in exercises that would be difficult or painful on land, resulting in improved mobility as demonstrated by the 25% reduction in TUG test times in our cohort. Hydrostatic pressure is another critical factor. The constant pressure exerted by water on the body enhances venous return and reduces edema, which in turn improves circulation and promotes muscle recovery. This mechanism is supported by our findings of a 30% increase in balance scores, as improved circulation and reduced swelling can lead to better neuromuscular control. In addition, the resistance provided by water, which is adjustable

based on the speed of movement, serves as a form of variable resistance training. This type of training is known to promote muscle strength without the high-impact forces that typically exacerbate osteoarthritic symptoms. The 20% improvement in gait speed noted in our study likely reflects these muscular and neuromuscular adaptations. Furthermore, the warm temperature of the aquatic environment plays an important role in reducing muscle spasm and stiffness, thereby enhancing the range of motion. This thermal effect, combined with the supportive properties of water, creates an ideal setting for repetitive and safe movement patterns that promote neuromuscular coordination and balance. Ma *et al.* highlighted that such environmental conditions not only decrease pain but also improve overall functional performance, which agrees with our data.[10] Psychosocial mechanisms also contribute to the overall effectiveness of aquatic therapy. Participation in group-based sessions can enhance social interaction and reduce feelings of isolation, which are common among older adults suffering from chronic pain conditions. Atukorala *et al.* emphasized that psychosocial support and a positive therapeutic environment can improve adherence to exercise programs and lead to better long-term outcomes.[15] Our study observed high adherence rates and positive patient feedback, which suggests that the supportive nature of the aquatic setting may further potentiate the physical benefits by fostering an overall sense of well-being and motivation.

Subgroup Analysis: Age and Gender

Our subgroup analysis provided additional insights into the variability of response to aquatic therapy among different demographic groups. When stratifying patients by age, we found that those in the 60–69 years category exhibited a 27% improvement in TUG times and a 32% improvement in balance scores. In contrast, participants aged 70–79 years showed a 24% improvement in TUG and a 29% improvement in balance, while those aged 80 and above experienced a 20% improvement in TUG and a 25% improvement in balance. These findings suggest that while all age groups benefit from aquatic therapy, younger older adults may experience slightly greater gains. This trend is consistent with previous findings by Mo *et al.*, who noted that physiological reserves in younger older adults might enhance the responsiveness to exercise interventions.[16] Gender-based comparisons also revealed interesting patterns. Both male and female participants benefitted significantly from the aquatic therapy intervention, though the magnitude of improvement was slightly higher in males. Specifically, male patients showed a 26% improvement in TUG times and a 31% improvement in balance scores, compared to 24% and 29%, respectively, in female patients. While these differences have reached statistical significance, their clinical relevance appears modest. Similar findings have been reported in the literature where gender differences in response to rehabilitative exercises were minimal.[7] The slight male advantage may be attributable to differences in baseline muscle mass and body composition, which can influence exercise performance and recovery. However, the overall efficacy of the aquatic therapy program was robust across genders, suggesting that it can be effectively applied as a universal intervention for older adults with osteoarthritis.

Comparative Analysis with Land-Based Interventions

Aquatic therapy presents several distinct advantages when compared with traditional land-based exercise programs. Land-based exercises, while effective in improving physical function, are often associated with increased joint load, which may exacerbate pain and limit participation in patients with severe osteoarthritis. In contrast, the aquatic environment offers reduced gravitational forces due to buoyancy, which minimizes joint stress and allows patients to perform movements with less discomfort. Song *et al.* have shown that aquatic exercise results in fewer exercise-induced injuries and lower levels of pain compared to land-based activities, a finding that is strongly supported by our data.[3] Our study's observation of a 40% reduction in pain scores is particularly notable when compared with results from land-based interventions. While traditional exercises can improve mobility, the concomitant reduction in pain achieved through aquatic therapy can significantly enhance overall quality of life and facilitate long-term adherence to exercise regimens. Moreover, the supportive nature of water may help in reducing the fear of falling—a common barrier to exercise in older adults. The enhanced balance and gait speed improvements noted in our study suggest that aquatic therapy can provide a safer and more effective alternative to high-impact land-based exercises, particularly for those with advanced joint degeneration. Additionally, aquatic therapy's low-

impact characteristics make it a more attractive option for individuals with multiple comorbidities. Given the high prevalence of conditions such as obesity, cardiovascular disease, and diabetes among older populations, the reduced stress on joints and improved cardiovascular endurance associated with aquatic exercises are valuable benefits. Our findings of significant improvements in functional mobility and balance lend further support to the integration of aquatic therapy into standard rehabilitative care for patients who might otherwise be at risk for exercise-induced injuries on land.

Economic and Societal Implications

Beyond the clinical benefits, the economic and societal implications of our findings are significant. Osteoarthritis is a leading cause of disability among older adults and is associated with considerable healthcare costs due to frequent hospitalizations, pharmacological treatments, and surgical interventions.[17] The implementation of aquatic therapy as a standard rehabilitative intervention could potentially reduce the economic burden by decreasing the need for expensive surgical procedures and long-term medication use. Our study's findings, which demonstrate substantial improvements in functional mobility and pain reduction, suggest that integrating aquatic therapy into rehabilitation protocols could lead to reduced healthcare utilization and associated cost savings. From a societal perspective, improving functional mobility in older adults has far-reaching implications. Enhanced mobility not only increases independence and quality of life but also reduces the risk of falls, which are a major cause of morbidity and mortality in the elderly. The social benefits of improved mobility extend to greater participation in community activities and reduced social isolation. Group-based aquatic therapy sessions may foster social interaction and support, further enhancing the overall well-being of participants.[6] Thus, the widespread adoption of aquatic therapy programs could yield both direct and indirect economic benefits by improving health outcomes and reducing the long-term costs associated with chronic disability. Furthermore, the cost-effectiveness of non-pharmacological interventions, such as aquatic therapy, has been supported by previous studies.[18] By mitigating pain and improving physical function, these interventions may help delay the progression of osteoarthritis and reduce the need for more invasive treatments. As healthcare systems increasingly focus on sustainable and cost-effective interventions, our study provides compelling evidence for the economic viability of aquatic therapy as a standard treatment modality for older adults with osteoarthritis.

Clinical Implications and Recommendations for Practice

The significant improvements observed in our study have important implications for clinical practice. Aquatic therapy should be considered as a viable and effective alternative to traditional land-based exercise programs, particularly for older adults with osteoarthritis who are at increased risk of joint injury and exercise-related discomfort. The reduction in TUG times, improvement in balance, and significant decrease in pain levels indicate that aquatic therapy not only enhances physical function but also promotes overall well-being. These benefits are especially relevant for patients who experience limitations with conventional exercise modalities due to severe joint degeneration or comorbid conditions. Clinicians and rehabilitation specialists are encouraged to incorporate aquatic therapy into comprehensive treatment plans for osteoarthritis management. The use of a structured, progressive aquatic exercise program, as demonstrated in our study, can lead to significant functional improvements and improved quality of life. Additionally, the integration of patient-specific assessments and subgroup analyses, such as those based on age and gender, can help tailor therapy to meet individual needs, thereby optimizing clinical outcomes. Given the favorable safety profile and the low-impact nature of water-based exercise, aquatic therapy offers an attractive option for long-term management and maintenance of functional mobility in older populations. Moreover, the psychosocial benefits associated with aquatic therapy, including improved mood and enhanced social engagement, further reinforce its value as a holistic treatment approach. Group sessions in a supportive aquatic environment may increase patient adherence and foster a sense of community among participants, which is essential for sustained therapeutic success. It is recommended that future rehabilitation protocols integrate both physical and psychosocial components of aquatic therapy to maximize its benefits and support a more comprehensive approach to osteoarthritis management.

Limitations of the Current Study

Despite the promising findings, several limitations of our study must be acknowledged. First, the single-center design may restrict the generalizability of our results to broader populations. Although our study sample of 142 patients provided sufficient statistical power to detect significant improvements, a multicenter trial involving a more diverse demographic could help validate our findings and enhance external validity. Second, the study's duration, while adequate to capture short- to medium-term effects, does not address the long-term sustainability of the observed improvements. Future research should incorporate extended follow-up periods to determine whether the benefits of aquatic therapy persist over time. Another limitation pertains to the potential selection bias inherent in voluntary participation. Patients who opted to participate in the study may have been more motivated or had a higher baseline level of functional capacity compared to the general osteoarthritis population. This selection bias could potentially overestimate the efficacy of the intervention. Additionally, while our use of standardized clinical assessments and validated measurement tools strengthens the internal validity of our study, the reliance on self-reported pain scores introduces an element of subjectivity that may affect the accuracy of the findings. Moreover, although our regression analyses accounted for several confounding variables, such as age, BMI, and baseline functional measures, other factors such as nutritional status, comorbid conditions, and daily activity levels were not fully controlled for. These factors could have influenced the response to the aquatic therapy intervention and may need to be addressed in future studies. Finally, while our statistical analysis demonstrated robust improvements with low p-values (<0.001 for most measures), the observational nature of certain subgroup analyses limits our ability to draw causal inferences regarding the differential effects of the intervention across demographic groups.

Future Research Directions

The findings from our study pave the way for several important avenues for future research. Given the significant functional improvements observed, it is imperative to conduct long-term, multicenter randomized controlled trials to validate and extend these findings across diverse populations. Future studies should aim to assess the durability of the benefits conferred by aquatic therapy by incorporating follow-up assessments over longer periods, such as one year or more. This would help to determine whether the improvements in functional mobility, balance, and pain reduction are maintained over time. Furthermore, additional research is needed to compare aquatic therapy with other low-impact exercise modalities, such as tai chi, cycling, or resistance training in water. Comparative effectiveness studies would provide valuable insights into the relative benefits of these interventions and help to establish best practice guidelines for the management of osteoarthritis in older adults. Advanced biomechanical studies using three-dimensional motion analysis and electromyography could further elucidate the underlying mechanisms by which aquatic therapy improves neuromuscular control and joint function. Future research should also focus on refining the aquatic therapy protocol by exploring optimal exercise intensities, session durations, and frequencies. Identifying the most effective regimen for maximizing clinical outcomes while minimizing the risk of adverse effects is critical for the successful implementation of aquatic therapy in clinical settings. Additionally, incorporating patient-reported outcome measures and qualitative assessments in future studies will help to capture the full spectrum of benefits, including psychosocial improvements and overall quality of life.

This discussion provides an in-depth analysis of our study findings in the context of the existing literature, addressing the mechanisms, subgroup differences, methodological rigor, clinical implications, economic impact, and directions for future research. The evidence presented herein strongly supports the integration of aquatic therapy as an effective intervention for improving functional mobility and quality of life in older adults with osteoarthritis.

CONCLUSION

Our study demonstrates that a novel aquatic therapy program significantly improves functional mobility, balance, and pain in older adults with osteoarthritis. The intervention yielded a 25% reduction in TUG test times, a 30% increase in balance scores, and a 40% reduction in pain levels, underscoring its clinical efficacy. The low-impact, supportive aquatic environment enabled patients to perform exercises safely, resulting in enhanced gait

speed and overall functional capacity. These findings suggest that aquatic therapy is a valuable alternative to traditional land-based exercises, particularly for patients with joint limitations and comorbidities. The robust improvements observed across age and gender subgroups reinforce the broad applicability of the intervention and highlight its potential to improve quality of life while reducing healthcare burdens.

Recommendations

Integrate aquatic therapy into standard osteoarthritis rehabilitation protocols.

Conduct long-term, multicenter studies to validate sustained benefits.

Tailor programs based on individual patient characteristics to optimize outcomes.

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