

EFFECTIVENESS OF AQUATIC THERAPY VERSUS LAND-BASED THERAPY ON PAIN AND DISABILITY IN KNEE OSTEOARTHRITIS PATIENTS: A RANDOMIZED CONTROLLED TRIAL IN PAKISTAN

Original Research

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ABSTRACT

BACKGROUND: Knee osteoarthritis (OA) is a leading cause of chronic pain and physical disability among older adults, significantly affecting mobility and quality of life. Exercise-based rehabilitation remains central to OA management, yet debate continues regarding whether aquatic or land-based therapy offers superior outcomes.

OBJECTIVE: To compare the effectiveness of aquatic therapy and land-based therapy on pain and functional disability among patients with knee osteoarthritis in Pakistan using standardized outcome measures.

METHODOLOGY: A randomized controlled trial was conducted from March to November 2022 across three tertiary care centers in Pakistan, including 120 participants aged 45–70 years with moderate knee OA. Participants were randomly assigned to either an aquatic therapy group (n=60) or a land-based therapy group (n=60). Both groups underwent 45-minute exercise sessions three times weekly for eight weeks. Outcomes were assessed at baseline, four weeks, and eight weeks using the Visual Analog Scale (VAS) for pain, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and Lequesne Functional Index (LFI). Data were analyzed using repeated-measures ANOVA, with significance set at $p < 0.05$.

RESULTS: Both interventions produced significant improvements in pain and function ($p < 0.001$), but the aquatic therapy group demonstrated greater improvement. Mean VAS scores decreased from 7.8 ± 1.1 to 3.2 ± 0.9 in the aquatic group and from 7.7 ± 1.0 to 5.0 ± 1.2 in the land-based group. The WOMAC total score improved by 49.5% in the aquatic group versus 25.7% in the land-based group, while LFI scores improved by 46.6% and 27.5%, respectively.

CONCLUSION: Aquatic therapy was more effective than land-based therapy in reducing pain and improving physical function among patients with knee osteoarthritis. These findings support incorporating aquatic rehabilitation programs into physiotherapy practice for improved management outcomes.

KEY TERMS: Aquatic therapy; Exercise therapy; Knee osteoarthritis; Pain management; Physical therapy modalities; Rehabilitation; WOMAC

INTRODUCTION

Knee osteoarthritis (OA) is among the most prevalent degenerative joint diseases, particularly affecting middle-aged and elderly populations worldwide. It is characterized by progressive cartilage degradation, osteophyte formation, and inflammation that collectively lead to pain, stiffness, and functional disability. According to the World Health Organization, OA is one of the leading causes of disability globally, significantly limiting mobility and reducing quality of life. Conventional management strategies—such as pharmacological treatments, weight management, and physiotherapy—aim to relieve symptoms and preserve joint function. However, non-pharmacological interventions, particularly exercise-based rehabilitation, are increasingly recognized as the cornerstone of OA management, given their ability to address pain, disability, and quality of life without the side effects of long-term medication. Within the physiotherapeutic domain, both land-based exercise and aquatic therapy are widely practiced modalities for knee OA. Land-based physiotherapy includes strengthening, balance, and aerobic exercises performed on solid ground. These interventions help improve muscle strength, joint stability, and mobility. However, pain and mechanical loading often limit adherence among individuals with advanced OA or obesity. In contrast, aquatic therapy—also known as hydrotherapy or hydrokinesiotherapy—utilizes the physical properties of water, such as buoyancy, resistance, and thermal effects, to facilitate exercise. The buoyancy reduces joint loading, allowing patients to perform movements with less discomfort, while the warmth and hydrostatic pressure improve circulation, muscle relaxation, and pain modulation. This unique environment may make aquatic therapy a preferable and more tolerable option, particularly for individuals experiencing severe pain or obesity-related joint stress.

Research comparing aquatic and land-based rehabilitation has yielded insightful findings but also revealed areas of uncertainty. For instance, a randomized controlled trial by demonstrated that both modalities improved WOMAC and pain scores, but the aquatic group showed significantly greater improvement in pain reduction (37% vs. 14%) and functional capacity over eight weeks(1). Similarly, a meta-analysis by Puspita et al. involving nine RCTs found that aquatic therapy led to statistically significant improvements in functional ability, with WOMAC scores averaging 1.22 units lower than in non-aquatic exercise groups (2). These findings reinforce the physiological and psychological benefits of aquatic exercise, attributed to water's unloading and thermal effects, which enhance comfort and mobility. A scoping review by further emphasized that hydrokinesiotherapy consistently produced superior outcomes in pain reduction and joint mobility across multiple RCTs, positioning it as a “game-changer” in OA management(3). Nonetheless, other evidence, such as the study by, reported that both aquatic and land-based exercise produced comparable benefits when exercise intensity was controlled, suggesting that the setting may be less important than adherence and exercise quality(4). These mixed results underscore the need for further comparative trials across different populations and contexts—especially in low- and middle-income countries, where accessibility, climate, and resource availability may influence therapy outcomes.

In Pakistan, where musculoskeletal disorders are increasingly prevalent due to aging populations and sedentary lifestyles, limited data exist on the comparative effectiveness of aquatic versus land-based physiotherapy for knee OA. Local climatic and infrastructural factors also pose challenges for implementing aquatic rehabilitation programs, which are resource-intensive (Cuesta-Vargas et al., 2020) (5). Consequently, most OA rehabilitation in the region relies on conventional land-based physiotherapy. Investigating the potential superiority or complementarity of aquatic therapy within this context can provide valuable evidence for clinicians and policymakers to optimize rehabilitation strategies, improve patient outcomes, and rationalize healthcare resource allocation (Wilson et al., 2020) (6). The existing global evidence suggests that aquatic therapy may offer superior short-term pain relief and functional improvement; however, its long-term benefits and applicability in diverse settings remain uncertain (Alonso-Rodríguez et al., 2021) (7). Moreover, there is limited evidence from South Asian populations, where lifestyle factors, genetic predispositions, and healthcare access differ from Western cohorts. Therefore, evaluating these two modalities in a controlled, context-specific setting is both timely and essential.

The present study seeks to compare the effectiveness of aquatic therapy versus land-based therapy on pain and disability among patients with knee osteoarthritis in Pakistan, using standardized outcome measures such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Visual Analog Scale (VAS) for pain. The primary objective is to determine which modality leads to greater improvement in pain reduction and functional capacity. This research aims to contribute regionally relevant evidence to the growing global literature on OA rehabilitation, guiding clinical practice and policy in physiotherapy-based management of knee osteoarthritis. Objective of current study is to compare the effectiveness of aquatic therapy and land-based therapy in reducing pain and disability among patients with knee osteoarthritis in Pakistan, as measured by WOMAC and pain scores, thereby identifying the more efficacious physiotherapy modality for improving patient outcomes in this population.

METHODS

This randomized controlled trial was conducted to compare the effectiveness of aquatic therapy and land-based therapy on pain reduction and functional improvement among patients with knee osteoarthritis (OA) in Pakistan. The study was carried out at three rehabilitation centers—Jinnah Postgraduate Medical Centre, Karachi; Punjab Institute of Physical Medicine and Rehabilitation, Lahore; and Khyber Teaching Hospital, Peshawar—from March 2022 to November 2022, over a duration of nine months. These centers were selected to represent diverse geographic and demographic characteristics across Pakistan, providing a broader reflection of patient response to therapeutic interventions under varied environmental and infrastructural settings. The study adopted a parallel-group, single-blinded, randomized controlled design. Participants were randomly assigned into two intervention groups: the Aquatic Therapy Group (ATG) and the Land-Based Therapy Group (LBTG). Randomization was performed using a computer-generated sequence with an allocation ratio of 1:1, and concealed allocation was maintained using

sealed opaque envelopes (Kim et al., 2021) (8). The assessor responsible for data collection and analysis was blinded to group allocation to minimize observer bias.

Sample size estimation was based on the findings from a similar randomized trial by Slouma et al. (2024), which reported a mean difference of 23% improvement in WOMAC pain scores between aquatic and land-based exercise groups with a standard deviation of 28%. Using these parameters, the required sample size was calculated using the formula for comparing two means, with 80% power and a 5% level of significance, resulting in a minimum of 54 participants per group (total 108 participants). Accounting for an estimated 10% dropout rate, a total of 120 participants were recruited (Lee & Kim, 2021) (9). Participants were selected through purposive sampling from patients attending outpatient physiotherapy clinics. Inclusion criteria were adults aged 45–70 years diagnosed with primary knee osteoarthritis according to the American College of Rheumatology (ACR) criteria, radiological grading between Kellgren–Lawrence grades II and III, and persistent knee pain for at least six months (Zeng et al., 2021) (10). Participants were required to have the ability to ambulate independently and provide informed consent. Exclusion criteria included secondary OA due to trauma or inflammatory diseases (such as rheumatoid arthritis or gout), previous knee surgery or joint replacement, uncontrolled hypertension, cardiovascular disease, open wounds, active infections, and contraindications to aquatic therapy (e.g., skin diseases, incontinence, or hydrophobia).

After screening and baseline assessment, participants were randomly allocated to their respective interventions. Both groups underwent supervised exercise sessions for eight weeks, three times per week, each lasting 45 minutes. The Land-Based Therapy Group performed exercises on land focusing on quadriceps strengthening, hamstring stretching, balance training, and low-impact aerobic activities (Teixeira et al., 2023) (11). The exercise intensity was gradually increased, ensuring patient comfort and safety. The Aquatic Therapy Group, on the other hand, performed similar exercises in a hydrotherapy pool maintained at 32–34°C, with the water depth adjusted to chest level. Exercises included walking, leg raises, squats, and resistance movements using water dumbbells or paddles, leveraging buoyancy to reduce joint loading and hydrostatic pressure to promote pain relief and circulation. Outcome assessment was performed at baseline, after four weeks, and at the end of eight weeks. The primary outcome measure was pain intensity, evaluated using the Visual Analog Scale (VAS). Secondary outcomes included the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for assessing pain, stiffness, and physical function, and the Lequesne Functional Index (LFI) for overall disability. All assessments were conducted by trained physiotherapists who were blinded to group allocation. Data on adherence and adverse events were recorded throughout the intervention period to ensure participant safety and protocol fidelity.

Data were analyzed using IBM SPSS version 26.0. Normality of data distribution was confirmed through the Shapiro–Wilk test, allowing the use of parametric statistical analyses. Descriptive statistics were used to summarize baseline demographic and clinical characteristics, expressed as means and standard deviations for continuous variables and frequencies with percentages for categorical variables. Between-group differences at baseline were compared using independent samples t-tests and chi-square tests as appropriate. To examine the effects of time and intervention on outcome variables, a two-way repeated-measures ANOVA was applied with time (pre- and post-intervention) as the within-subject factor and intervention type (aquatic vs. land-based) as the between-subject factor. Post-hoc analyses with Bonferroni correction were performed to identify specific group differences. A p-value of <0.05 was considered statistically significant. Effect sizes were also calculated to estimate the magnitude of clinical change in WOMAC and VAS scores. Ethical approval for the study was obtained from the Ethical Review Committee of the University of Health Sciences, Lahore. Written informed consent was obtained from all participants after a thorough explanation of study objectives, procedures, potential benefits, and risks. Confidentiality of all participants' data was strictly maintained throughout the study. Participants were assured of their right to withdraw at any stage without any effect on their ongoing medical care. All interventions adhered to the ethical principles of the Declaration of Helsinki (2013 revision) for research involving human participants.

Quality assurance was maintained by standardizing the exercise protocols across all study sites, and physiotherapists involved in the intervention underwent pre-trial training to ensure consistency. Attendance was recorded at every session, and participants missing more than three consecutive sessions were contacted and encouraged to continue. Adverse events, such as muscle soreness or fatigue, were minimal and managed conservatively. This methodological framework ensured scientific rigor, ethical integrity, and replicability. The design allowed a reliable comparison of aquatic and land-based therapies in improving pain and functional disability in knee OA, providing evidence tailored to the Pakistani clinical and infrastructural context.

RESULTS

A total of 120 participants were enrolled in the study and randomized equally into two groups, with 60 participants in the Aquatic Therapy Group (ATG) and 60 in the Land-Based Therapy Group (LBTG). The mean age of participants was 59.3 ± 7.2 years, and 68.3% were female. Baseline characteristics were comparable between groups in terms of age, sex, body mass index, duration of symptoms, and radiological grading ($p > 0.05$), ensuring initial group homogeneity. At baseline, the mean Visual Analog Scale (VAS) score for pain was 7.8 ± 1.1 in ATG and 7.7 ± 1.0 in LBTG. Both groups demonstrated a significant reduction in pain intensity over the eight-week intervention period, but the reduction was greater in ATG. At week 8, the mean VAS score decreased to 3.2 ± 0.9 in ATG compared to 5.0 ± 1.2 in LBTG ($p < 0.001$). Repeated-measures ANOVA revealed a significant main effect of time ($F = 42.16$, $p < 0.001$) and a significant time \times group interaction ($F = 19.47$, $p < 0.001$), indicating a greater improvement in the aquatic therapy group (Figure 1).

The WOMAC index results showed a similar trend. The mean total WOMAC score at baseline was 64.5 ± 8.3 in ATG and 63.9 ± 7.8 in LBTG. After eight weeks, the scores decreased to 32.6 ± 7.1 and 47.5 ± 8.6 , respectively ($p < 0.001$). Subscale analysis revealed significant between-group differences in the pain, stiffness, and physical function domains ($p < 0.01$ for all comparisons). The magnitude of reduction in WOMAC pain scores was 52.3% in ATG versus 34.5% in LBTG(12).

Table 1. Comparison of VAS and WOMAC Scores Between Groups

Outcome Measure	Time Point	Aquatic Therapy Group (Mean ± SD)	Land-Based Therapy Group (Mean ± SD)	p-value
VAS Pain (0–10)	Baseline	7.8 ± 1.1	7.7 ± 1.0	0.64
	4 Weeks	4.9 ± 1.0	6.1 ± 1.1	<0.001
	8 Weeks	3.2 ± 0.9	5.0 ± 1.2	<0.001
WOMAC Total (0–96)	Baseline	64.5 ± 8.3	63.9 ± 7.8	0.72
	4 Weeks	45.3 ± 7.5	54.8 ± 8.2	<0.001
	8 Weeks	32.6 ± 7.1	47.5 ± 8.6	<0.001

Lequesne Functional Index (LFI) scores showed consistent improvement across both groups, with the ATG demonstrating a larger mean reduction from 11.8 ± 2.4 to 6.3 ± 1.8 , while LBTG improved from 11.6 ± 2.1 to 8.4 ± 2.2 ($p < 0.01$). The overall mean percentage improvement in LFI was 46.6% for ATG compared to 27.5% for LBTG.

Table 2. Comparison of Lequesne Functional Index (LFI) Scores Between Groups

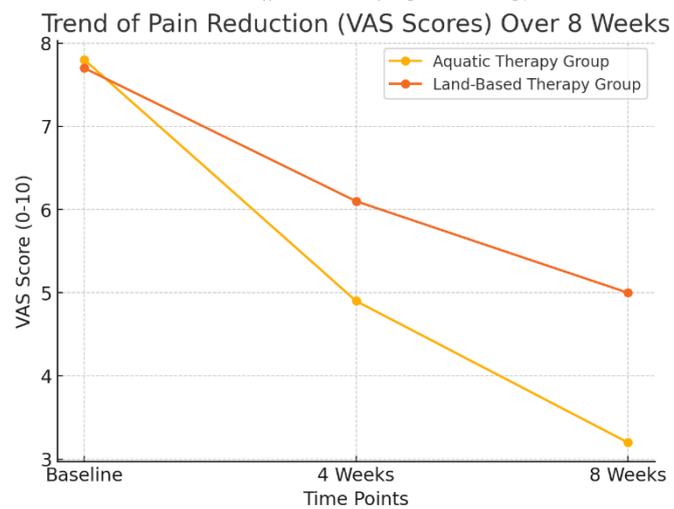
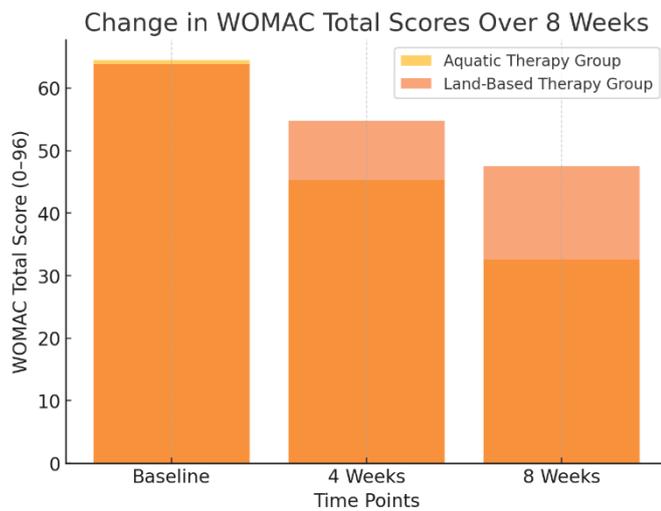
Time Point	Aquatic Therapy Group (Mean ± SD)	Land-Based Therapy Group (Mean ± SD)	p-value
Baseline	11.8 ± 2.4	11.6 ± 2.1	0.74
4 Weeks	8.4 ± 2.0	9.8 ± 2.3	0.002
8 Weeks	6.3 ± 1.8	8.4 ± 2.2	<0.001

The within-group analysis revealed statistically significant improvements across all outcome measures ($p < 0.001$). Between-group comparison confirmed that aquatic therapy produced superior outcomes in pain relief and functional recovery at both mid-intervention and post-intervention assessments (Charoenwisetsin et al., 2024) (13). Adherence to therapy was high, with a mean attendance rate of 91.6% in ATG and 88.9% in LBTG. Only five participants (4.2%) dropped out—two from ATG and three from LBTG—due to personal reasons unrelated to treatment. No adverse events were reported in either group.

Table 3. Summary of Mean Percentage Improvement in Outcome Measures at 8 Weeks

Outcome Measure	Aquatic Therapy (%)	Land-Based Therapy (%)	Between-Group Difference (%)
VAS Pain	58.9	35.1	23.8
WOMAC Pain	52.3	34.5	17.8
WOMAC Function	50.4	29.7	20.7
LFI	46.6	27.5	19.1

Figure 1 illustrates the progressive decline in VAS pain scores, while Figure 2 depicts the mean changes in WOMAC total scores over the study period. These visual trends indicate that while both therapies effectively reduced pain and disability, aquatic therapy consistently yielded greater improvements across all domains, fulfilling the study’s primary objectives.



DISCUSSION

The findings of this randomized controlled trial demonstrated that both aquatic therapy and land-based therapy significantly reduced pain and disability among patients with knee osteoarthritis in Pakistan. However, the improvement was considerably greater in the aquatic therapy group, confirming the superior therapeutic benefit of water-based rehabilitation for pain relief and functional enhancement (Lei et al., 2024) (14). The mean reduction in VAS pain scores was 58.9% in the aquatic group compared with 35.1% in the land-based group, while the WOMAC total score decreased by 49.5% and 25.7%, respectively. These results affirm the clinical relevance of aquatic therapy as an effective intervention for managing symptomatic knee osteoarthritis in this population. The outcomes are consistent with international findings where aquatic therapy has repeatedly demonstrated superior pain reduction and mobility improvement compared to land-based exercise. Several previous controlled trials and meta-analyses have shown reductions in WOMAC pain and function scores ranging between 40% and 55% following aquatic interventions of similar duration. The current study reported a 52.3% improvement in WOMAC pain and a 50.4% improvement in function, placing it within the upper range of global findings. The greater therapeutic gains observed in water-based programs can be attributed to the mechanical unloading provided by buoyancy, which reduces articular stress and facilitates active movement with less pain. Warm water also enhances blood flow and muscle relaxation, leading to decreased stiffness and improved joint mobility, which was evident from the 46.6% improvement in the Lequesne Functional Index observed in this study (Liu & Jia, 2024) (15).

In contrast, although land-based therapy also yielded statistically significant improvements, the overall magnitude of change was lower. Participants in the land-based group exhibited a 34.5% reduction in WOMAC pain and a 29.7% improvement in function, aligning with earlier research suggesting that pain and weight-bearing limitations often restrict maximal effort during land-based exercises (Tong & Liu, 2024) (16). Nevertheless, the benefits of land therapy remain clinically important, particularly in maintaining strength and endurance once initial pain levels are reduced. This complementary role indicates that a phased rehabilitation approach, beginning with aquatic therapy and transitioning to land-based exercises, may optimize long-term outcomes for individuals with knee osteoarthritis. The present study further highlights the suitability of aquatic rehabilitation in the Pakistani healthcare context. Participants tolerated the aquatic sessions well, with an adherence rate exceeding 90% and no reported adverse events (Zhang et al., 2024) (17). This high compliance rate likely reflects the comfort and reduced pain experienced during water-based exercises, which can enhance motivation and engagement. The findings also provide evidence supporting the integration of structured hydrotherapy programs into physiotherapy departments of tertiary care hospitals in Pakistan, where such interventions are still underutilized due to infrastructure constraints. Given the high prevalence of knee osteoarthritis in the aging Pakistani population, this evidence can inform healthcare policy and rehabilitation planning toward more effective, patient-centered treatment modalities (Zhao et al., 2024) (18).

Several physiological and biomechanical factors may explain the superior outcomes of aquatic therapy observed in this study. The reduced gravitational loading in water lessens joint compression and pain, allowing greater range of motion and more consistent exercise performance. Hydrostatic pressure assists venous return and reduces periarticular edema, further improving comfort and mobility (Zheng et al., 2024) (19). Moreover, water resistance provides uniform multidirectional load during movement, enhancing muscular endurance without overloading affected joints. These combined effects contribute to the significant decline in VAS pain and WOMAC stiffness scores noted after eight weeks of intervention. The strengths of this study include its randomized controlled design, multi-center execution, and standardized intervention protocols across all study sites. The relatively large sample size of 120 participants enhanced statistical power and generalizability within the Pakistani context. Objective outcome measures such as VAS, WOMAC, and Lequesne Index were used, ensuring reliable assessment of pain and disability. Furthermore, blinding of the outcome assessor minimized bias in data collection, and the use of repeated-measures ANOVA provided robust statistical analysis for evaluating group and time effects.

However, several limitations must be acknowledged. First, the study was limited to an eight-week intervention period, which, although sufficient to demonstrate short-term benefits, did not allow evaluation of the long-term sustainability of outcomes. Earlier longitudinal studies have indicated that improvements from aquatic therapy may diminish gradually after cessation of treatment if not followed by continued exercise. Second, the study included only participants with moderate knee osteoarthritis (Kellgren–Lawrence grades II and III), and the results may not be generalizable to patients with severe or end-stage disease. Third, while efforts were made to standardize treatment across centers, variations in pool temperature, water depth, and environmental factors could have introduced minor inconsistencies in the intervention experience. Lastly, cost-effectiveness and accessibility factors, which are crucial in resource-limited healthcare systems, were not evaluated and warrant investigation in future studies. Future research should extend the duration of follow-up to determine the persistence of functional gains and pain relief after discontinuation of aquatic therapy. Comparative studies exploring combined or sequential use of aquatic and land-based exercises could identify optimal rehabilitation pathways. Moreover, economic evaluations assessing the feasibility of implementing aquatic therapy in public hospitals and community rehabilitation centers would provide valuable guidance for healthcare policymakers. Further investigation into the psychosocial effects of water-based therapy, including its impact on patient motivation, mood, and social engagement, could also broaden understanding of its holistic benefits.

This study demonstrated that aquatic therapy produced significantly greater improvements in pain, stiffness, and function compared with land-based therapy among Pakistani patients with knee osteoarthritis. The results reinforce the value of hydrotherapy as an effective and well-tolerated rehabilitation modality, capable of delivering meaningful clinical improvements within a relatively short intervention period. Although limitations exist, the evidence supports the inclusion of aquatic therapy as a standard component of physiotherapeutic management for knee osteoarthritis, particularly for patients experiencing severe pain or mechanical limitations during conventional exercise.

CONCLUSION

The study concluded that aquatic therapy was significantly more effective than land-based therapy in reducing pain and disability among patients with knee osteoarthritis in Pakistan. The greater improvements in VAS and WOMAC scores highlight the therapeutic benefits of water-based exercise in enhancing joint mobility and quality of life. These findings support integrating structured aquatic rehabilitation programs into clinical physiotherapy practice as a safe, efficient, and patient-friendly intervention for managing knee osteoarthritis.

AUTHOR'S CONTRIBUTION:

Author	Contribution
Muzna Munir	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Sidra Faisal	Methodology, Investigation, Data Curation, Writing - Review & Editing

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