GMR
The Original

EFFECT OF HALLIWICK AQUATIC TRAINING ON DYNAMIC BALANCE IN COMMUNITY-DWELLING OLDER ADULTS: A PRE–POST EXPERIMENTAL STUDY

[1] Tejal Pardeshi, [2] Shyam Ganvir, [3] Geeta Bhatt

[1.] PT, MPT, PhD Scholar *Department of Community Physiotherapy, K J Somaiya College of Physiotherapy, Somaiya Ayurvihar Complex, Eastern Express Highway, Sion, Mumbai – 400022, Maharashtra, India, Email: tejal.pardeshi@somaiya.edu
[2.] PT, PhD[1] Dr. Vithalrao Vikhe Patil Foundation College of Physiotherapy, Department of Community Physiotherapy, Ahmednagar, Maharashtra, India
[3.] PT, PhD[2] Professor and Head, Department of Neurophysiotherapy, K J Somaiya College of Physiotherapy, Sion, Mumbai, Maharashtra, India.

ABSTRACT

Background: Age-related reduction in balance contributes to an increased risk of falls and reduced functional independence in older adults. Aquatic therapy, particularly the Halliwick concept, provides a safe and supportive environment that may enhance postural control and dynamic balance. This study aimed to evaluate the effect of a Halliwick aquatic training program on dynamic balance in community-dwelling older adults with impaired dynamic balance (Mini-BESTest ≤20/28)

Methods: A single-group pre–post experimental study was conducted among 32 sedentary community-dwelling older adults aged 65–70 years. Participants completed a 4-week Halliwick aquatic training program comprising 12 supervised sessions (3 sessions/week, 45 minutes/session). Dynamic balance was assessed using the Mini-Balance Evaluation Systems Test (Mini-BESTest) before and after the intervention. Data were analyzed using a paired *t*-test. Statistical significance was set at $p < 0.05$.

Results: All **32** participants completed the intervention. Mean Mini-BESTest scores improved significantly from **16.28 ± 0.51** at baseline to **22.40 ± 0.69** following the intervention, with a mean difference of **6.13** points (95% CI: **6.05–6.20**). The improvement was statistically significant (**t**(31) = **159.66**, $p < 0.001$) and demonstrated a Cohen's *d* of **28.22**.

Conclusion: A four-week Halliwick aquatic training program was associated with significant improvements in dynamic balance among community-dwelling older adults with impaired dynamic balance. These findings suggest that Halliwick aquatic therapy may be a safe and effective intervention for improving postural control and supporting fall-prevention strategies in the older adult population. Further controlled trials are recommended to confirm these findings.

KEYWORDS: Aged; Postural Balance; Hydrotherapy; Halliwick Concept; Exercise Therapy; Fall Prevention.

INTRODUCTION

The global population is aging rapidly, resulting in an increasing prevalence of age-related impairments that compromise functional independence. Among these, balance impairment is one of the most significant contributors to falls in older adults. Age-related deterioration of the visual, vestibular, and somatosensory systems, together with reduced muscle strength, delayed neuromuscular responses, and impaired coordination, adversely affects postural control and dynamic balance. Consequently, approximately one-third of adults aged 65 years and older experience at least one fall annually, with the risk increasing progressively with advancing age. Falls are a leading cause of injury, disability, hospitalization, institutionalization, and mortality among older adults and are frequently associated with fear of falling, reduced mobility, activity restriction, loss of confidence, and diminished quality of life. Given the growing aging population and the substantial burden of falls, improving balance and reducing fall risk has become a major priority in geriatric rehabilitation and healthy aging initiatives. [6, 10, 12]

Exercise is one of the most effective non-pharmacological interventions for improving balance and reducing fall risk in older adults. Among the various exercise modalities, aquatic therapy has gained increasing attention because the unique physical properties of water provide a safe and supportive therapeutic environment. Buoyancy reduces the effects of gravity and decreases loading on weight-bearing joints, enabling individuals with impaired balance or reduced muscle strength to perform functional movements with greater confidence. Simultaneously, the viscosity and turbulence of water provide multidirectional resistance and continuous perturbations that challenge postural control, while hydrostatic pressure enhances proprioceptive input and sensory feedback. Collectively, these properties facilitate balance training while minimizing the fear of falling, making aquatic therapy particularly suitable for older adults. [4, 7, 9]

Recent systematic reviews and meta-analyses have consistently demonstrated that aquatic exercise significantly improves balance, gait performance, functional mobility, and fall-related outcomes in older adults compared with no intervention or conventional land-based exercise. [7–9] Despite these encouraging findings, most published studies have evaluated general aquatic exercise programs that primarily focus on strengthening, aerobic conditioning, flexibility, or functional exercises rather than structured aquatic rehabilitation approaches.

Among the various aquatic rehabilitation methods, the Halliwick concept is a structured, task-oriented approach specifically designed to promote independent movement and postural control in water. Based on the Halliwick Ten-Point Programme, the intervention progressively develops mental adjustment to water, breathing control, rotational control, balance recovery, and independent movement through carefully graded activities. [1–3] Unlike conventional aquatic exercise programs, Halliwick aquatic training specifically emphasizes trunk stability, multidirectional rotational control, anticipatory postural adjustments, equilibrium reactions, and dynamic balance through progressively challenging movement tasks. These characteristics suggest that Halliwick aquatic training may provide additional benefits for improving postural stability, functional balance, and movement confidence in older adults. [1–4]

Although Halliwick aquatic training has demonstrated beneficial rehabilitation outcomes in neurological and pediatric populations, including individuals with stroke, Parkinson's disease, multiple sclerosis, and cerebral palsy, [16–19] its application has been investigated predominantly in neurological rehabilitation rather than in healthy community-dwelling older adults. Previous studies have reported improvements in one or more outcomes, including balance, postural control, functional mobility, and movement confidence, following Halliwick-based interventions in these clinical populations. [16–19] However, evidence regarding the effectiveness of Halliwick aquatic training for improving dynamic balance in community-dwelling older adults remains limited. Furthermore, aquatic exercise studies have shown considerable heterogeneity in intervention protocols, treatment duration, and outcome measures, making it difficult to determine the specific contribution of Halliwick aquatic training to improvements in dynamic balance. [7–9] Therefore, well-designed clinical studies evaluating Halliwick aquatic training using standardized and clinically validated balance assessment tools in community-dwelling older adults are warranted.

The Mini-Balance Evaluation Systems Test (Mini-BESTest) is a reliable, valid, and clinically responsive instrument for assessing dynamic balance by evaluating anticipatory postural adjustments, reactive postural control, sensory orientation, and dynamic gait. [13–15] Therefore, the present study aimed to investigate the effect of a four-week Halliwick aquatic training program on dynamic balance in community-dwelling older adults using the Mini-BESTest.

METHODS

Study Design

A single-group pretest–posttest design was implemented over a four-week period. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki, and written informed consent was obtained from all participants before enrollment.

Sample Size Calculation

Sample size was calculated using the G*Power software (version 3.1) based on the primary outcome measure, the Mini-Balance Evaluation Systems Test (Mini-BESTest). A moderate anticipated effect size (d = 0.61) was derived from a previous study that used the Mini-BESTest as the primary measure of balance in older adults.

The required sample size was calculated using an alpha level of 0.05 and a statistical power of 80%. To compensate for potential attrition, the sample size was increased, resulting in the enrollment of 32 participants.

Participants

Thirty-two community-dwelling older adults aged 65–70 years with Mini-Balance Evaluation Systems Test (Mini-BESTest) scores ≤20/28, indicating impaired dynamic balance, were recruited from the local community through senior citizen associations and community advertisements. The inclusion criteria were Mini-BESTest scores of ≤20/28, independent ambulation, and a sedentary lifestyle. Exclusion criteria included severe musculoskeletal, neurological, or cardiopulmonary disorders that could interfere with participation in the aquatic training program. Participant recruitment and enrollment commenced on 31 May 2025, and the intervention was completed on 3 July 2025. All enrolled participants completed the intervention protocol.

Reporting Guideline

The study was reported according to the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) reporting guideline.

Intervention

Participants underwent a Halliwick aquatic training program comprising **12 supervised sessions conducted three times per week over four weeks**. Each session lasted approximately **45 minutes** and was supervised by a physiotherapist trained in aquatic therapy. Training was conducted in a therapeutic swimming pool with the water temperature maintained at approximately **33°C** and the water depth at the level of the **xiphoid process (mid-chest)**, providing a safe environment for performing Halliwick exercises and dynamic balance activities.

Each training session consisted of:

- **Warm-up (10 min):** Water walking with ball throw-and-catch drills, followed by gentle upper- and lower-limb stretching exercises.
- **Main training (25 min): Activities** based on the Halliwick Ten-Point Programme [1, 2, 3, and 16,] including mental adjustment, rotational control in the transverse, sagittal, and combined planes, balance in stillness, balance under turbulent water conditions, and basic propulsion exercises designed to challenge postural control and dynamic balance.
- **Cool-down (10 min):** Relaxation, breathing exercises, and gentle stretching.

Exercise difficulty was progressively increased throughout the intervention according to each participant's tolerance and ability to maintain postural control during aquatic activities. Attendance was recorded throughout the intervention, and **all participants completed the 12-session training program.**

Safety monitoring
Participants were monitored throughout each session for signs of fatigue, dizziness, discomfort, or any adverse events. Rest periods were provided whenever required, and no adverse events occurred during the intervention period.

Outcome Measure
Dynamic balance was assessed using the Mini-Balance Evaluation Systems Test (Mini-BESTest) [13, 14, 15] at baseline and after completion of the four-week intervention. All assessments were performed by the same investigator to ensure consistency in outcome measurement.

Timing of assessment
The Mini-BESTest was administered within one week before the first intervention session and within one week after completion of the intervention program.

Ethics Approval
The study protocol was approved by the Institutional Ethics Committee of K J Somaiya College of Physiotherapy, Sion, Mumbai (Approval No. KJSCPT/272/24-25) and the Institutional Ethics Committee of Dr. Vithalrao Vikhe Patil Foundation's College of Physiotherapy, Ahmednagar (Approval No. DVVPF's/COPT/2023/2297-F). The study was prospectively registered with the Clinical Trials Registry–India (CTRI/2025/04/084535).

Statistical Analysis
Data were analyzed using Microsoft Excel. Descriptive statistics were expressed as mean ± standard deviation (SD). The distribution of the change scores was assessed using the Shapiro–Wilk test. Pre- and post-intervention Mini-BESTest scores were compared using a paired *t*-test. Statistical significance was set at $p < 0.05$. Cohen's *d* was calculated to estimate the effect size, and 95% confidence intervals (CI) were reported.

RESULTS
All **32** participants completed the 12-session Halliwick aquatic training program and were included in the final analysis. No participant withdrew from the study, and no adverse events were reported during the intervention period.
Dynamic balance, measured using the Mini-BESTest, improved significantly following the four-week Halliwick aquatic training program. The mean Mini-BESTest score increased from **16.28 ± 0.51** at baseline to **22.40 ± 0.69** after the intervention, representing a mean improvement of **6.13** points. Paired *t*-test analysis demonstrated a statistically significant improvement in dynamic balance (**t**(31) = **159.66**, $p < 0.001$). The effect size (Cohen's *d*) was **28.22**. The 95% confidence interval for the mean difference ranged from **6.05 to 6.20**.
Baseline participant characteristics are presented in Table 1. Changes in Mini-BESTest scores are presented in Table 2 and Figure 3.

Table 1. Baseline Demographic and Clinical Characteristics of Participants (n = 32)

Variable	Value
Number of participants	32
Age (Years)	66.84 ± 1.74
Male/Female	22/10
Sedentary lifestyle	32 (100%)
Baseline Mini-BESTest	16.28 ± 0.51
Independent ambulation	32 (100%)

Abbreviation: Mini-BESTest, Mini-Balance Evaluation Systems Test.

Table 2. Changes in Mini-BESTest Scores After Halliwick Aquatic Training

Outcome Measure	Baseline (Mean ± SD)	Post-intervention (Mean ± SD)	Mean Difference	95% CI	*t* (df = 31)	Cohen's *d*	*p-value*
Mini-BETest	16.28 ± 0.51	22.40 ± 0.69	6.13	6.05–6.20	159.66	28.22	<0.001

Abbreviations: SD, standard deviation; CI, confidence interval; Mini-BESTest, Mini-Balance Evaluation Systems Test.
Note: Higher Mini-BESTest scores indicate better dynamic balance. Statistical comparisons were performed using a paired *t*-test.

Figure 1. Participant Flow Diagram. The flow diagram illustrates participant recruitment, enrolment, completion of the intervention, and inclusion in the final analysis.

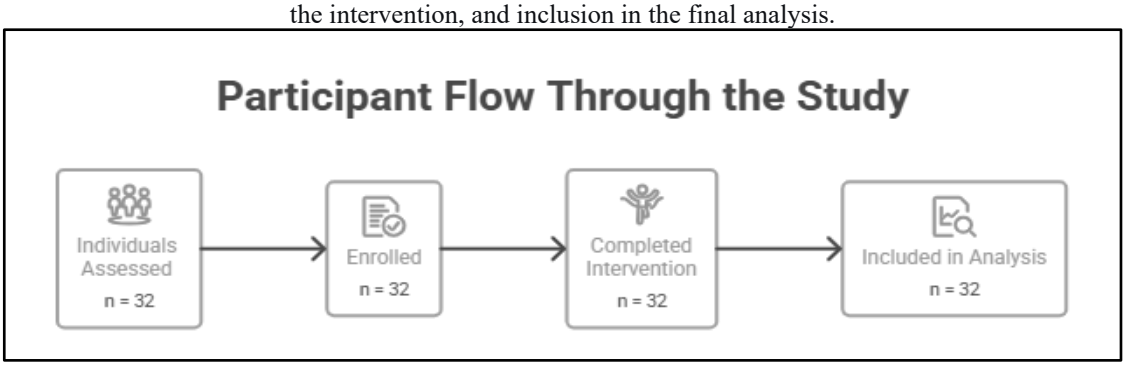


Figure 2. Halliwick aquatic training exercises - Images illustrate the warm-up activities, rotational control exercises, and balance training performed throughout the four-week intervention programme.

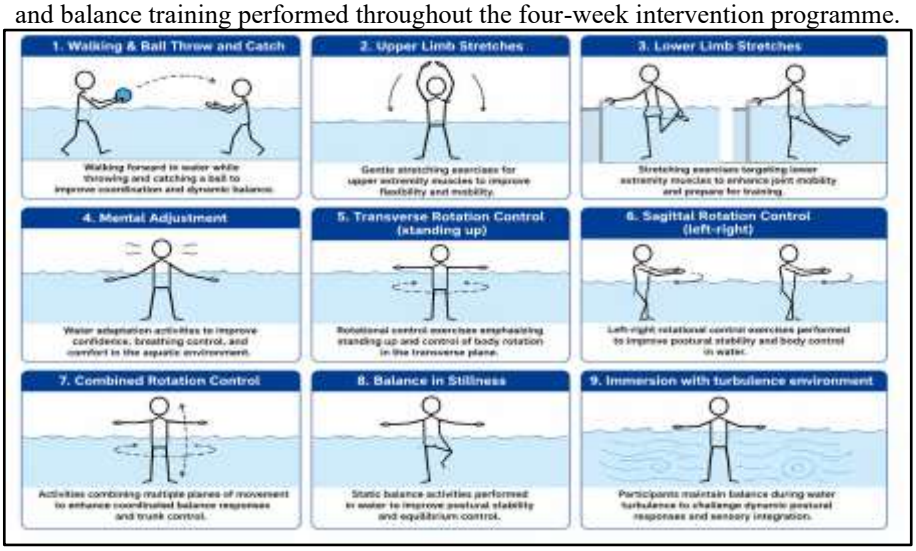
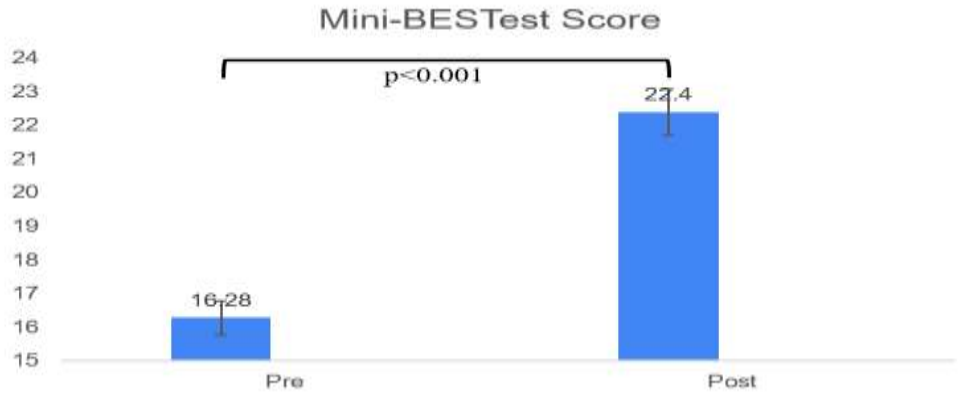


Figure 3. Pre- and Post-intervention Mini-BESTest Scores Following Halliwick Aquatic Training



Abbreviation: Mini-BESTest, Mini-Balance Evaluation Systems Test.

DISCUSSION

The present study investigated the effect of a four-week Halliwick aquatic training program on dynamic balance in community-dwelling older adults. The findings demonstrated a statistically significant improvement in Mini-BESTest scores following the intervention, with the mean score increasing from **16.28 ± 0.51** at baseline to **22.40 ± 0.69** after training. These findings suggest that Halliwick aquatic training appears to be a promising intervention for improving dynamic balance and postural control among older adults and may contribute to reducing modifiable risk factors associated with falls.

The improvement in dynamic balance observed in the present study can be explained by both the therapeutic properties of the aquatic environment and the task-oriented principles of the Halliwick concept. Water buoyancy decreases

gravitational loading and provides a safe environment for practicing balance activities with a reduced fear of falling, while viscosity, turbulence, and hydrostatic pressure continuously challenge postural control through multidirectional perturbations and enhanced proprioceptive feedback. These characteristics encourage repeated activation of postural muscles, improve sensory integration, and facilitate motor learning. Furthermore, the Halliwick Ten-Point Programme progressively develops mental adjustment, trunk control, rotational control, equilibrium reactions, and coordinated movement, thereby promoting improvements in dynamic balance and functional postural stability. [1–4]

The findings of the present study are consistent with those of Resende et al., who reported significant improvements in balance and a reduction in fall risk among older women following a structured hydrotherapy program. [5] Likewise, recent systematic reviews and meta-analyses have consistently demonstrated that aquatic exercise significantly improves balance, gait performance, and functional mobility in older adults. [7–9] Kim et al. reported that aquatic exercise produced meaningful improvements in balance and gait compared with control interventions, while Shariat et al. concluded that aquatic exercise effectively enhances dynamic balance and postural stability in older adults.[7,8] More recently, Deng et al. confirmed that aquatic exercise significantly improves balance and functional mobility and recommended its incorporation into rehabilitation programmes for older adults.[9] The improvements observed in the present study are therefore in agreement with the growing body of evidence supporting aquatic exercise as an effective intervention for age-related balance impairment.

An important aspect of the present study is that it evaluated a Halliwick aquatic training program, rather than a conventional aquatic exercise program. While most previous studies have focused on general aquatic strengthening, aerobic, or balance exercises, the Halliwick concept specifically emphasizes trunk stability, multidirectional rotational control, anticipatory postural adjustments, and equilibrium reactions through progressively challenging movement tasks. [1–3] These principles are fundamental to dynamic balance and are reflected in the domains assessed by the Mini-BESTest. The structured progression from mental adjustment to independent movement in water may therefore explain the substantial improvement observed following only four weeks of intervention.

Although evidence regarding Halliwick aquatic training in healthy older adults remains limited, studies conducted in neurological rehabilitation provide additional support for its therapeutic potential. Halliwick-based interventions have demonstrated improvements in balance, functional mobility, postural control, and movement confidence in individuals with stroke, Parkinson's disease, multiple sclerosis, and cerebral palsy. [16–19] While these populations differ from community-dwelling older adults, the common emphasis on postural control, trunk stability, and balance recovery supports the potential transferability of Halliwick principles to older individuals experiencing age-related balance decline.

The improvement in Mini-BESTest scores observed in the present study is clinically meaningful because the Mini-BESTest evaluates multiple components of dynamic balance, including anticipatory postural adjustments, reactive postural control, sensory orientation, and dynamic gait. [13–15] Improvements across these domains may translate into better functional mobility, greater confidence during activities of daily living, and a reduced risk of falls. These findings are particularly relevant considering that international guidelines identify exercise-based balance training as a cornerstone of fall prevention in older adults. [10] Halliwick aquatic training may therefore represent a valuable rehabilitation option for older adults who are reluctant or unable to participate safely in land-based balance training because of pain, weakness, joint degeneration, or fear of falling. [4,10]

The present study has several strengths. It employed a standardized Halliwick aquatic training program delivered by trained physiotherapists, achieved complete participant adherence without dropouts or adverse events, and utilized the Mini-BESTest, a reliable and clinically validated measure of dynamic balance. [13–15] Furthermore, the study was prospectively registered with the Clinical Trials Registry–India and conducted following institutional ethical approval, thereby enhancing methodological transparency and reproducibility.

Nevertheless, several limitations should be acknowledged. The study employed a single-group pre–post experimental design without a control group, limiting the ability to attribute the observed improvements exclusively to the Halliwick intervention. The relatively small sample size and recruitment from a single geographical region may also limit the generalizability of the findings. Additionally, outcome assessments were performed immediately after the intervention, and no long-term follow-up was undertaken to determine whether the improvements in balance were sustained over time. Future research should include randomized controlled trials with larger and more diverse samples, blinded outcome assessment, long-term follow-up, and direct comparisons between Halliwick aquatic training, conventional aquatic exercise, and land-based balance programs to establish comparative effectiveness.

In conclusion, a four-week Halliwick aquatic training program significantly improved dynamic balance in community-dwelling older adults. The findings support Halliwick aquatic training as a safe, feasible, and clinically effective intervention for enhancing postural control and dynamic balance. Incorporating Halliwick-based aquatic rehabilitation into community and clinical fall-prevention programs may provide an effective strategy for maintaining functional independence and promoting healthy aging. [10]

CONCLUSION

A four-week Halliwick aquatic training program was associated with a significant improvement in dynamic balance among community-dwelling older adults, as demonstrated by increased Mini-BESTest scores following the intervention. These findings suggest that Halliwick aquatic therapy appears to be a safe, feasible, and effective rehabilitation approach for enhancing postural control in older adults. Incorporating Halliwick-based aquatic exercises into rehabilitation programs may help improve balance and support fall-prevention strategies in the aging population. Further randomized controlled studies with larger samples and long-term follow-up are warranted to confirm these findings and establish their long-term clinical benefits.

Acknowledgments
The authors would like to thank all the participants for their valuable time, commitment, and enthusiastic participation in this study. We also sincerely thank the staff who assisted with the aquatic therapy sessions and supported the successful conduct of the study.
Funding : None
The authors declare no conflict of interest.

Data Availability Statement
The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

REFERENCES
1. Garcia MK, Joares EC, Silva MA, Bissolotti RR, Oliveira S, Battistella LR. The Halliwick concept, inclusion, and participation through aquatic functional activities. *Acta Fisiatr.* 2012;19(3):142-150. doi:10.5935/0104-7795.20120022
2. Kokaridas D, Lambeck J. The Halliwick concept: a collaborative aquatic method. *Inq Sport Phys Educ.* 2015;13(2):65-76.
3. Lambeck J, Gamper U. The concept of the Halliwick. In: Cole AJ, Becker BE, editors. *Comprehensive Aquatic Therapy.* 3rd ed. Pullman (WA): Washington State University Publishing; 2011. p. 1106-1116.
4. Becker BE. Aquatic therapy: scientific foundations and clinical rehabilitation applications. *PM R.* 2009;1(9):859-872. doi:10.1016/j.pmrj.2009.05.017
5. Resende SM, Rassi CM, Viana FP. Effects of hydrotherapy on balance and prevention of falls among older women. *Rev Bras Fisioter.* 2008;12(1):57-63.
6. Lord SR, Sherrington C, Menz HB, Close JCT. *Falls in Older People: Risk Factors and Prevention Strategies.* 2nd ed. Cambridge: Cambridge University Press; 2007.
7. Kim Y, Kim J, Son J, et al. The effect of aquatic exercise on balance and gait in older adults: a systematic review and meta-analysis. *BMC Geriatr.* 2020;20:302. doi:10.1186/s12877-020-01723-3
8. Shariat A, Cleland JA, Danaee M, et al. Aquatic exercise and dynamic balance in older adults: a systematic review and meta-analysis. *J Exerc Rehabil.* 2018;14(5):753-760. doi:10.12965/jer. 1836344.172
9. Deng Y, Zhang X, Liu Y, et al. Effects of aquatic exercise on balance and functional mobility in older adults: a systematic review and meta-analysis. *Front Public Health.* 2024;12:136285 6. doi:10.3389/fpubh.2024.1362856
10. Montero-Odasso M, van der Velde N, Martin FC, et al. World guidelines for falls prevention and management for older adults: a global initiative. *Ageing.* 2022;51(9):afac205. doi:10.1093/ageing/afac205
11. World Health Organization. *WHO Guidelines on Physical Activity and Sedentary Behavior.* Geneva: World Health Organization; 2020.
12. World Health Organization. *Decade of Healthy Ageing: 2021–2030.* Geneva: World Health Organization; 2021.
13. Horak FB, Wrisley DM, Frank J. The Balance Evaluation Systems Test (BESTest) to differentiate balance deficits. *Phys Ther.* 2009;89(5):484-498. doi:10.2522/ptj.20080071
14. Franchignoni F, Horak F, Godi M, Nardone A, Giordano A. Using psychometric techniques to improve the Balance Evaluation Systems Test: the Mini-BESTest. *J Rehabil Med.* 2010;42(4):323-331. doi:10.2340/16501977-0537
15. Löfgren N, Lenholm E, Conradsson D, et al. The Mini-BESTest: a clinically reproducible tool for balance evaluations in mild to moderate Parkinson's disease? *BMC Neurol.* 2014;14:235. doi:10.1186/s12883-014-0235-7
16. Tapia C, Constanzo J, González V, Barría RM. Effectiveness of aquatic therapy based on the Halliwick concept in children with cerebral palsy: a systematic review. *Neurorehabilitation.* 2023;53(3):371-376. doi:10.3233/NRE-230184
17. Tripp F, Krakow K. Effects of an aquatic therapy approach (Halliwick-Therapy) on functional mobility in subacute stroke patients: a randomized controlled trial. *Clin Rehabil.* 2014;28(5):432-439. doi:10.1177/0269215513504942.
18. Terrens AF, Soh SE, Morgan P. The safety and feasibility of a Halliwick style of aquatic physiotherapy for falls and balance dysfunction in people with Parkinson's disease: A single blind pilot trial. *PLoS One.* 2020;15(7):e0236391. doi:10.1371/journal.pone.0236391.
19. Gürpınar B, Kara B, Idiman E. Effects of aquatic exercises on postural control and hand function in multiple sclerosis: Halliwick versus aquatic plyometric exercises: a randomized trial. *J Musculoskelet Neuronal Interact.* 2020;20(3):386-394.