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Verbal instructor feedback as a catalyst for proprioceptive change in the Zarina Del Mar 3D movement method: One-month follow-up single-case study

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Abstract
Background: Midlife learners often show fluctuating balance and mismatches between perceived and actual form. Brief remote sessions paired with concise, time-stamped instructor comments may refine proprioceptive control.
Objective: To describe one month of tailored the 3D Movement Method practice in a midlife participant and to test whether asynchronous knowledge-of-performance comments were associated with improvements beyond practice alone.
Design and setting: Single-case, remote follow-up over approximately seven weeks. Practice focused on four foundational movements (mermaid, side plank, push-up, shrimp squat). After an initial practice-only period, two cycles of brief, time-stamped comments were delivered on uploaded clips.
Data sources and analysis: Practice and test videos at anchor days 2, 11, 28, and 51; a three-time-point functional battery (days 0, 8, 48); expert comments; and participant reflections/interview. Videos were appraised with a structured qualitative rubric; verbal materials were analyzed reflexively.
Results: Relative to early practice, movement amplitude and continuity increased, compensations decreased, and balance and segmental control improved. Functional tests echoed these changes (e.g., deeper overhead squat with heel contact maintained; clearer roll down sequencing). Eyes-closed Romberg increased from approximately 30 seconds at baseline to approximately three minutes on sand at late follow-up with minimal sway. Improvements and reported mechanisms (slower tempo, deliberate amplitude monitoring, segment-by-segment control, growing autonomy without mirrors) converged temporally with the two comment cycles.
Conclusions: In this single case, a brief remote practice format paired with two rounds of concise asynchronous comments was feasible and associated with observable refinement of proprioceptive execution. Findings are preliminary and bounded by real-world capture conditions and inventor involvement, and they motivate multi-participant studies with standardized metrics and independent ratings.

Keywords: Proprioception, knowledge-of-performance, asynchronous feedback, single-case design, women's health, motor learning

Introduction

This paper reports Phase Two of a single-case study examining changes in proprioception associated with practice of the 3D Movement Method created by Zarina del Mar. Phase One (Manaenkova & Santanna, 2025a) [10] showed slight improvement in proprioceptive performance in a midlife participant who practiced a specific 3D Movement sequence for one week and highlighted the role of augmented feedback delivered by the inventor. Marked practice changes after that feedback motivated the present study to evaluate longer-term effects of the 3D Movement Method practice and to isolate the contribution of augmented feedback.

Proprioception is understood here as internal sensing that supports steady posture, segmental alignment, and smooth transitions between positions. It includes senses of limb position and movement and sense of effort and force, arising from multimodal afferent signals from skin, muscles, and joints integrated within central body maps (Proske & Gandevia, 2012) [11]. Training that targets proprioceptive function is pertinent for women in midlife, a period when

balance and mobility can fluctuate and fall risk may begin to rise. Cross-sectional evidence links higher menopausal symptom burden with poorer postural control in middle-aged postmenopausal women (Espírito Santo *et al*., 2021) [4]. Exercise appears to improve balance outcomes in perimenopausal and early postmenopausal women. A systematic review and network meta-analysis of randomized trials found that several exercise modes, including resistance training, balance training, mixed programs, and whole-body vibration,improved balance measures relative to non-exercise controls (Walsh *et al*., 2023) [20]. Proprioception is not limited to balance, however. Sensorimotor programs that explicitly target proprioceptive acuity can improve joint-position sense alongside balance, strength, and mobility in older adults, indicating effects on internal sensing as well as postural outcomes (Freire & Seixas, 2024) [5].

Many midlife women face time constraints arising from work and caregiving roles. Qualitative work identifies routine disruptions, competing demands, and self-sacrifice for others as common barriers to maintaining exercise in this life stage (McArthur *et al*., 2014) [8]. Remote and online formats can mitigate scheduling and access barriers by enabling home-based participation and flexible timing. Participants frequently cite convenience, including affordability and scheduling flexibility, as a benefit of online sessions (e.g., yoga) (Brinsley *et al*., 2021) [3]. Randomized and non-inferiority trials also indicate that telehealth-delivered exercise and rehabilitation can achieve outcomes comparable to in-person care for musculoskeletal conditions, supporting the feasibility of remote delivery when appropriately designed (Hinman *et al*., 2024) [6].

Instruction quality and feedback design remain central in remote motor learning. Augmented feedback is externally provided information about movement that supplements intrinsic sensory information and typically takes the form of knowledge-of-performance (e.g., cues on alignment or timing) or knowledge-of-results (e.g., success metrics or error size) (Wälchli *et al*., 2016) [19]. Classic and contemporary studies indicate that augmented feedback can accelerate acquisition and that its schedule and form matter for retention: very frequent or continuous feedback can create a guidance effect that improves practice performance but weakens learning, whereas reduced frequency or delayed schedules often support better retention and transfer (Sigrist *et al*., 2013; Salmoni *et al*., 1984; Winstein & Schmidt, 1990) [17, 14, 21]. In educational movement contexts, video-based feedback has been shown to enhance learning relative to verbal instruction, which is pertinent to remote delivery (Mödinger *et al*., 2022) [12]. In the present study, augmented feedback consisted of brief, movement-focused comments time-stamped to practice recordings and delivered asynchronously, a mode that is feasible for remote skill training and common in health-professions education (Villagrán *et al*., 2023) [18].

Accordingly, this study evaluates longer-term effects of remotely delivered the 3D Movement Method practice and tests whether structured asynchronous augmented feedback provides incremental benefit over practice alone for proprioceptive control in a midlife learner.

1. Context of study

1.1. 3D Movement Method

The 3D Movement Method is an integrative body-mind system that links focused attention with precise movement control (Manaenkova & Santanna, 2025b) [11]. Sessions are short, require no equipment, and emphasize alignment, controlled loading, smooth transitions between positions, and clear perception of internal cues. The method aims to strengthen proprioceptive awareness so that position, movement, and effort are sensed and regulated during everyday tasks as well as during structured practice.

1.2 Verbal guidance

In remote delivery of the 3D Movement Method, verbal guidance is central. Detailed explanations name joint actions, describe intended weight distribution, and specify sensations that indicate correct execution. This helps adult learners translate abstract direction into accurate action and supports safety at home. It also addresses common constraints for midlife women whose schedules are shaped by work and caregiving responsibilities, since precise cues enable effective practice within limited time. In this study, guidance was provided in two forms: (1) long-form cueing accompanying the demonstration video to frame goals and technique, and (2) brief, time-stamped knowledge-of-performance comments returned after practice to direct attention to alignment, amplitude, and coordination on specific repetitions.

1.3 Instructor role

Zarina del Mar, developer of the 3D Movement Method, served as instructor for this case. She designed the practice sequence, recorded the demonstration, and provided the augmented feedback described above. Her expertise informed interpretation of movement quality. To preserve analytic transparency, collection of reflections and contextualization of findings were conducted independently by the co-author.

1.4 Participant L protocol

For Participant L, a personalized sequence drew on four foundational movements: side plank, shrimp squat, push-up, and mermaid stretch. The learner practiced either as a continuous flow or as isolated parts according to comfort and capacity. Practice was guided by a prerecorded demonstration without real-time contact. Coaching was added through an asynchronous review pathway in which the learner recorded sessions, the instructor reviewed them later, and concise comments were returned. The protocol targeted improvements in proprioceptive accuracy, movement amplitude, postural control, and segmental coordination.

Materials and Methods

This investigation used a single-case design, which provides an in-depth, idiographic examination of one participant's experience and change over time, allowing analysis of functional relations across repeated measures that can be obscured by group-level averaging in traditional designs (Barlow, Nock, & Hersen, 2009; Kazdin, 2011) [1, 7].

1. Participant

Participant L was a 48-year-old woman who practiced short 3D Movement sessions of approximately 5-15 minutes per day and reported a broad history of physical activity. She took no regular medication, had a resolved fracture of the right ulna, and reported menstrual migraine previously managed with movement. At baseline, she rated her posture

as good and flexibility as average, and she completed five to nine standard push-ups. Expanded sociodemographic information, health background, and the initial assessment battery are provided in the Phase One report (Manaenkova & Santanna, 2025a) [10].

2. Procedures and data collection

Two data sets were collected and integrated. The first comprised qualitative analyses of practice and test videos using a structured observational rubric that specified target execution domains and provided decision rules and anchors for consistent coding across days. The second comprised qualitative analyses of verbal materials, including the method inventor's feedback and the participant's reflections and interview. Although filming instructions were provided, Participant L recorded all practice and test sessions independently, without compensation or professional equipment; therefore, camera alignment and framing did not meet criteria for detailed quantitative kinematic analysis. Nevertheless, the recordings yielded rich qualitative information on alignment control, movement amplitude, continuity of transitions, tempo, balance control, and segmental coordination.

2.1. Video Materials

The visual analysis focused on four anchor days: day 2 (early practice reference), day 11 (first recording after asynchronous inventor feedback), day 28 (paired indoor home and outdoor beach recordings to examine context effects; the outdoor footage was used only for the shrimp squat), and day 51 (after second feedback). Days 5 and 8 were omitted because they resembled day 2; their early evolution is addressed in Phase One. Functional tests were filmed in a studio for the pretest on 28 June 2025, in a studio for posttest 1 on 7 July 2025, and on a beach for posttest 2 on 17 August 2025.

Later sessions on days 31 and 51 were recorded on a beach and were included in the analysis even though they were volunteer contributions beyond the initial plan. Their inclusion was justified for two reasons. Practicing on sand introduced an unstable surface that posed greater proprioceptive demands, especially for single-leg balance tasks such as the shrimp squat and side plank. Recordings in the public beach environment also showed the participant moving with greater spontaneity and freedom compared with earlier home recordings. These sessions therefore provided an ecologically relevant view of progression.

Additional proprioceptive assessments were analyzed from video without still images because their informative variables were temporal and dynamic. The Romberg task probed postural stability with and without vision and required observation of sway trajectories and recovery latency. Segmental rotations at the shoulders, elbows, and hips assessed joint organization and end-range control over time. Single-leg stance captured static balance and load symmetry with micro-corrections. Hand-clapping and stomping tasks examined rhythmic timing and bilateral coordination. Because these features were dynamic, the full recordings were evaluated rather than still images.

Table 1: Visual materials and time points used in analysis

Material	Label	Date	Setting	Included in figures	Notes
Practice	Day 2	1 July 2025	Home	Yes	Early reference before any inventor feedback; days 5 and 8 are very similar and are not illustrated here.
Practice	Day 5	4 July 2025	Home	No	Very similar to day 2; detailed discussion appears in the Phase One report.
Practice	Day 8	7 July 2025	Home	No	Very similar to day 2; detailed discussion appears in the Phase One report.
Practice	Day 11	10 July 2025	Home	Yes	First recording after the initial round of asynchronous inventor feedback.
Practice	Day 28 (indoor)	27 July 2025	Home	Yes	Paired with day 28 outdoor to examine context effects after sustained practice.
Practice	Day 28 (outdoor)	27 July 2025	Beach	Yes, limited	Used only for the shrimp squat comparison to illustrate environmental influence.
Practice	Day 51	21 August 2025	Beach	Yes	First practice recording after the second round of inventor feedback.
Functional test	Pretest	28 June 2025	Studio	Yes	Baseline prior to the one-month practice period.
Functional test	Posttest 1	7 July 2025	Studio	Yes	After one week of practice; procedures are detailed in the Phase One report.
Functional test	Posttest 2	17 August 2025	Beach	Yes	Late outcome in a naturalistic setting recorded during vacation.

2.2. Verbal materials

Verbal materials included the inventor's feedback, short written reflections from the participant, a mid-period Zoom interview, and a final reflection. Zarina del Mar, the method's inventor, provided augmented verbal feedback at two distinct time points. Feedback 1 followed review of practice videos up to day 8 and addressed stiffness, limited amplitude, and restricted movement freedom. Feedback 2 followed review of practice videos up to day 28 and addressed further progression and refinement. From the participant side, qualitative reflections were collected through written self-evaluations submitted with videos, an in-depth Zoom interview on 14 July 2025 regarding perceptions of progress and difficulty, and a final written reflection on 17 August 2025 after the second round of expert feedback.

3. Data analysis

Triangulation across methods, researchers, and data sources was planned in advance to enhance trustworthiness and convergence (Schlunegger *et al*., 2024) [15]. Video materials were appraised with a structured qualitative rubric aligned to proprioceptive targets. The rubric assessed stability and control (sway amplitude; smoothness of entries and holds), accuracy after correction (joint organization relative to a defined reference; responsiveness to prior cues), error detection and correction (fault recognition; speed and quality of balance recovery), spatial sense without vision

(stability and accuracy when visual monitoring was removed), and progression (greater amplitude, longer holds, and improved balance relative to baseline). Because camera angles and environments varied, judgments emphasized relative relationships between segments. This qualitative stance is suited to remote settings where precise kinematics are not available and is consistent with recent reports on video appraisal of movement quality (Seuren *et al*., 2024; Lange & Danielsson, 2024) [16, 9]. Screenshots for figures were produced in Kinovea.

All verbal materials were transcribed and analyzed with reflexive thematic analysis in MAXQDA. Coding proceeded from familiarization to initial codes, then to candidate themes, review, and definition. Reporting followed current guidance for reflexive practice and transparent description of analytic decisions (Braun & Clarke, 2024). Triangulation across methods and researchers was used to compare the visual and textual streams and to audit key judgments. This approach aligns with recent guidance on rigor in qualitative casework and supports cautious interpretation without claims of experimental control (Schlunegger *et al*., 2024) [15].

4. Ethical considerations

This project involved one healthy adult who undertook a self-directed, non-invasive movement program; no clinical procedures, biomedical interventions, or sensitive health information were collected. Under institutional and national policies for minimal-risk research with adults, a formal ethics review was not required. After written and verbal explanation of aims and procedures, Participant L provided written informed consent that covered practice and test recordings, body maps, somatic screening, and written reflections, including permission for de-identified use in publications.

Identity protection was maintained through a pseudonym and video de-identification: faces were blurred, long sleeves and leggings were required, and video backgrounds were removed. Data were stored on secure drives with access restricted to the research team. Although the participant had prior experience with the 3D Movement Method, the study itself included no real-time instructor contact; materials were standardized for consistency, and all submissions were sent directly to the second author. All procedures were conducted in accordance with the Declaration of Helsinki.

Results

Results are presented in four parts: (1) video analysis of practice by exercise using anchor day 2, day 11, day 28, and day 51, interpreted relative to instructor feedback after day 8 and by day 28; (2) outcomes from the functional test battery recorded on 28 June, 7 July, and 17 August 2025; (3) dynamic proprioceptive tasks reviewed from full videos (Romberg, segmental rotations, single-leg stance, hand-clapping, and stomping); and (4) qualitative analysis of the instructor's verbal feedback across two review points together with the participant's interview and written reflections. Sensitivity notes were added where relevant, including a preexisting right-leg issue and the use of beach footage as an unstable-surface context.

1. Practice results

1.1. Mermaid

The Mermaid sequence showed progressive gains in movement freedom and improvisation—smoother coordination across planes, larger ranges, and more continuous transitions. Figure 1 shows a time series (top to bottom: day 2, day 11, day 28, day 51).

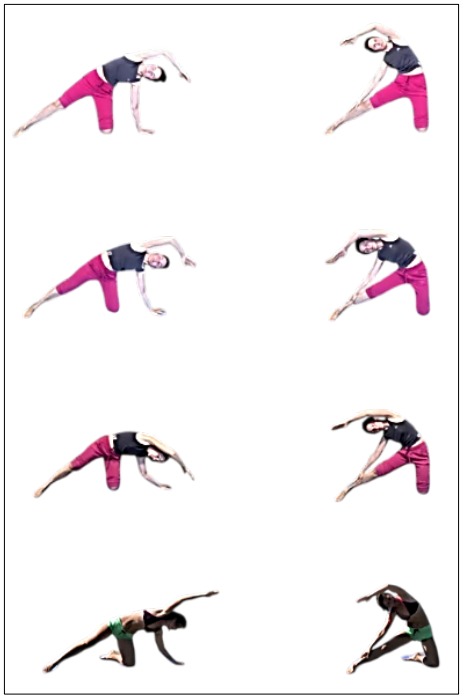


Fig 1: Time series of mermaid modification (from top to bottom: day 2, day 11, day 28, day 51).

Early recordings on day 2 showed discrete side-to-side repetitions with pauses, movement largely confined to the frontal plane, limited amplitude, and discontinuous transitions. Following feedback after day 8 (addressing stiffness, limited amplitude, and restricted freedom), day 11 showed smoother coordination, steadier balance, and larger ranges. By day 28 the sequence was fluid and continuous, with deeper lateral flexion and visible trunk elongation; the

arms were used dynamically to reach forward and mobilize the thoracolumbar region. By day 51 these refinements were consolidated; amplitude and continuity were sustained, and small three-dimensional path changes were explored (sagittal and oblique shifts). Expert noted greater movement freedom and smoother transitions at two months than at one month, supporting the interpretation that well-timed verbal feedback accelerated proprioceptive refinement.

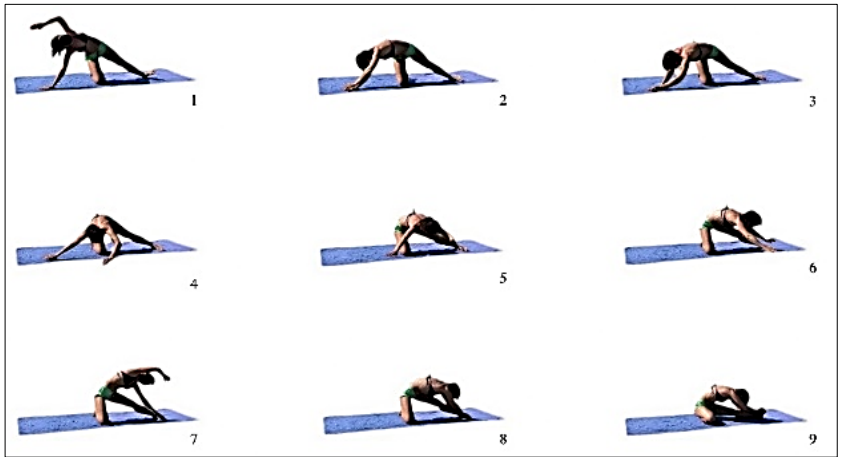


Fig 2: Mermaid performed as a continuous sequence (day 51).

1.2. Side plank

Figure 3 shows a time series of the side plank modification performed on both sides on day 2, day 11, day 28, and day 51. The task required stabilization on one supporting arm and leg while the free leg moved perpendicular to the body, with progression toward a forward-plane lowering close to the ground. Day 2 showed limited amplitude, frequent instability, brief holds, and difficulty grasping the free leg. Day 11, day 28, and day 51 demonstrated deeper amplitude, steadier trunk and pelvic alignment, more controlled lowering toward the floor, improved balance, and greater ease in grasping the leg and sustaining the posture.

Fig 3: Time series of side plank modification (top to bottom: day 2, day 11, day 28, day 51).

1.3. Push-up: Figure 4 presents a time series of push-up practice and its modification on day 2, day 11, day 28, and day 51. Early sessions on day 2, day 5, and day 8 showed attempts at standard push-ups with limited elbow flexion, the chest far from the floor, variable trunk alignment, and weak shoulder-girdle control. After feedback advising a temporary shift to push-ups on the knees with greater depth and a slower tempo, performance changed quickly. By day 11 the participant lowered with more controlled elbow flexion, brought the chest closer to the floor, and returned to support with coordinated scapular motion; wrist placement and pressure became more consistent, the trunk line remained neutral, and repetitions were completed without abrupt pauses. By day 28 sequences were sustained for longer, depth was preserved across repetitions, and elbow/shoulder paths were more consistent, indicating better proprioceptive sensing of joint position and load distribution. By day 51 these gains were consolidated; range and form were maintained across repetitions with controlled bottom transitions and steadier breathing and pacing. Taken together, the series suggests that an early knee-supported modification enabled full-amplitude practice without compensations, building the coordination and capacity needed for stronger upper-body work.

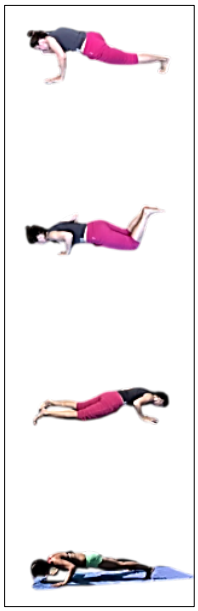


Fig 4: Time series of push-up and modifications (top to bottom: day 2, day 11, day 28, day 51).

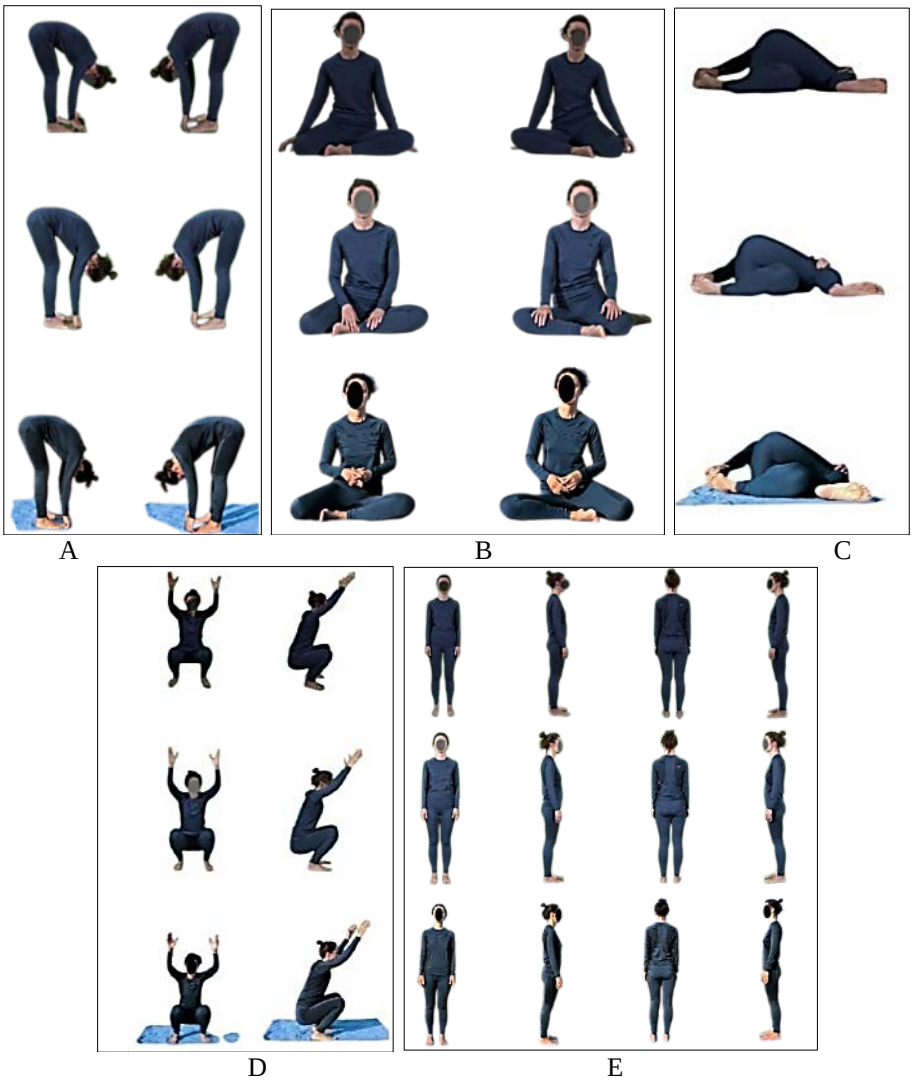
1.4. Shrimp squat: Figure 5 shows a time series of the shrimp squat and its modification on day 2, day 11, day 28, and day 51. In the early phase on day 2, day 5, and day 8, the participant could descend to the floor with the rear knee and return to standing, but balance was unstable: several attempts ended in lateral collapse, and foot placement and trunk alignment varied across repetitions. After feedback advising light chair support, practice shifted toward a slower tempo, clearer alignment over the stance foot, and controlled transitions through the bottom position. By day 11 repetitions showed fewer balance losses and more consistent hip and ankle control. The day 28 outdoor recording on sand (for environmental comparison) showed deeper range with brief, well-timed contacts on the chair and improved recovery from small perturbations. By day 51 on the beach the squat was completed without falls, with steadier trunk position, smoother descent and rise, and longer holds near the bottom when needed.

Fig 5: Time series of shrimp squat and modifications (top to bottom: day 2, day 11, day 28, day 51).

2. Test results: The functional test battery was reviewed at three time points and is shown as a composite figure. Figures 6A-6E present the pretest on day 0, posttest 1 on day 8, and posttest 2 on day 48. The independent expert and

the second author reached similar judgments, indicating gradual improvement in mobility, posture, and control across the period. In roll up and roll down (Figure 6A), sequencing became clearer from pelvis to thoracic spine, with fewer pauses and a longer reach; by posttest 1 and posttest 2 the participant initiated movement with less momentum and returned to start with smoother control, consistent with increased hamstring and upper-back length and better eccentric control. In Z-sit (Figure 6B), amplitude increased with a more upright trunk and reduced stiffness; side-to-side symmetry improved relative to pretest, with a steadier base and less hand support, although a mild right-side limitation remained visible. In spinal twist (Figure 6C), range increased with a more stable pelvis and less shoulder elevation; the head and thorax rotated more in concert, end-range control improved, and the return to neutral was smoother with less rebound. In overhead squat (Figure 6D), squat depth improved while heel contact was maintained; thoracic extension and shoulder flexion increased; rib cage alignment over the pelvis was more vertical; and knees tracked more consistently over the feet, with reduced lumbar rounding near the bottom and a more continuous ascent. Posture in four positions (Figure 6E) showed small but consistent gains: head-neck alignment was more centered over the torso, scapular resting position appeared less elevated, rib flare decreased, and pelvic tilt was closer to neutral; these adjustments were present at posttest 1 and held at posttest 2 (recorded on a beach).

Dynamic proprioceptive tasks assessed from full videos supported these observations. In the Romberg task, eyes-closed time increased from approximately 30 seconds at day 0 to approximately 3 minutes at posttest 2 on sand with minimal sway, indicating improved stability without visual input under a more challenging surface. Segmental rotations at the shoulders, elbows, and hips did not slow but showed more controlled joint positioning and less accessory motion compared with pretest and posttest 1, indicating better dissociation and end-range control. Single-leg stance showed increased balance, reflected in a deeper forward hinge on day 51 with steadier pelvic and trunk alignment despite the unstable sand surface. Hand-clapping and stomping displayed a more regular rhythm, fewer timing slips, improved left-right coordination, and more symmetrical force application, with sequences sustained longer without loss of pattern. Taken together, the expert and the second author agreed that balance and control improved across tests and dynamic tasks, consistent with a stronger linkage between attention and movement and with the progression documented in the practice sequences.



Note. Panels: (A) roll up and roll down; (B) Z-sit; (C) spinal twist; (D) overhead squat; (E) posture in four positions. Rows display day 0 (pretest, 28 June 2025), day 8 (posttest 1, 7 July 2025), and day 48 (posttest 2, 17 August 2025). Faces are blurred and backgrounds removed to preserve anonymity. Posttest 2 was recorded on a beach.

Fig 6: Composite time series of functional tests at three time points.

3. Instructor feedback

The baseline review, conducted after viewing practice up to day 8, emphasized exploratory variability and greater depth of amplitude and noted relative shoulder-girdle weakness. A temporary regression for pushing tasks was recommended, and a free-flow recording without camera constraints was invited to encourage autonomy.

The follow-up review, after viewing practice through day 28, described clear improvements in movement autonomy, range control, and upper-body performance during push-up and side-plank variations, with consistently strong execution of the shrimp squat. The instructor reframed the initial belief about upper-body weakness, arguing that capacity appeared to unlock once amplitude monitoring, slower tempo, and segmental control became consistent habits. Gains were summarized across strength, coordination, flexibility, control of mobility, and proprioception. The instructor attributed change to slower execution, attention to amplitude, and explicit segment-by-segment control, indicating a shift from reproducing external shapes toward internally guided regulation of range, sequencing, and weight transfer.

4. Participant reflection

Participant L provided a Zoom interview and a brief written reflection after one month of practice. Her account centered on three processes: calibration of felt sensations with video evidence; adoption of slower tempo with deeper amplitude as primary control parameters; and growing capacity for self-correction without mirrors. On material sufficiency she noted, “Everything you sent was enough. I did not look for anything else. It was all clear.” She described calibration with recordings: “My sensations misled me until I saw myself on video,” and “I thought I did worse after practice; then I watched the recordings and saw it was better.” Targeted cues were experienced as immediately actionable: “Fewer reps but deeper amplitude - I applied it and it worked right away,” and “Feedback from Zarina gave a big push to my progress.” Vision-independent control was emphasized: “I did all the tests with my eyes closed; I will continue that,” and “I do not need a mirror - I feel where my limbs are in space and can correct them.” She reported load redistribution across chains and transfer to daily life and sport: “It is not the lower back doing all the work; all the muscles engage,” and “On skis I feel what is tense, and I change how I move so it relaxes.” Progress markers reinforced adherence: “I began to do real push-ups from the knees,” and “Comments after a month show I am moving in the right direction - it inspires and motivates me more.” (Participant L, Zoom interview and written reflection).

Discussion

This single-case study examined how brief, remote practice with the 3D Movement Method, paired with structured asynchronous feedback, related to changes in proprioceptive control over approximately 7 weeks. Across practice on day 2, day 11, day 28, and day 51, movement amplitude, continuity, balance, and segmental coordination improved, and the timing of these shifts aligned with feedback after day 8 and by day 28. Functional tests at day 0, day 8, and day 48 corroborated gains in mobility and postural control, and dynamic tasks assessed from full videos supported better vision-independent stability and joint-specific organization. Qualitative analyses of instructor feedback and participant reflections converged on plausible mechanisms - slower tempo, deliberate amplitude monitoring, and explicit segment-by-segment control - indicating that time-efficient remote practice can be paired with concise, asynchronous feedback to refine proprioception in a midlife learner. These patterns are consistent with motor-learning evidence that targeted, less-frequent feedback supports durable change while avoiding guidance dependence. Feasibility also matters: all sessions occurred in real-world settings (home and beach), illustrating practical advantages when materials are clear and follow-up is structured. Triangulation across methods and analysts strengthened interpretation while avoiding claims of experimental control.

1. Limitations

Generalizability is limited by the single-case design and the participant’s prior familiarity with the method. Feedback was designed and delivered by the method’s inventor; although data flow was separated and an independent expert reviewed the test battery, allegiance effects cannot be excluded. Consumer-grade video with variable angles, horizons, and outdoor settings constrained precise kinematic analysis, so judgments emphasized relative segment relationships rather than absolute joint metrics. Several assessments at posttest 2 were performed on sand, increasing ecological validity but introducing surface-related variability. Follow-up was short; retention beyond two months and transfer to diverse daily or sport demands were not tested.

2. Future studies

Further research should include several participants with varied profiles, including those without prior experience, to examine reproducibility and contextual limits. Different feedback formats and frequencie - such as asynchronous comments, live guidance, standardized tutorials, or automated cues - should be compared to identify the most effective approach. Objective outcome measures, including joint-position-sense tests, inertial sensors, or computer-vision analysis, can complement qualitative evaluation by independent reviewers. Recording procedures should be standardized for camera height, distance, and horizon, with additional trials under eyes-closed and unstable-surface conditions to assess vision-independent balance.

Conclusion

A brief, remote program of the 3D Movement Method combined with two cycles of asynchronous augmented feedback was associated with meaningful improvement in proprioceptive control in one midlife participant. Practice shifted from segmented, frontal-plane repetitions toward fluid, three-dimensional exploration, and functional and dynamic assessments showed parallel gains in mobility, balance, and organization. The qualitative record indicates that slower tempo, amplitude targets, and explicit control cues helped shift performance from external imitation to internal regulation. While preliminary and bounded by single-case scope and real-world video constraints, these findings support the feasibility of remote proprioceptive training enhanced by concise, well-timed feedback and motivate systematic multi-participant studies addressing mechanism, dose, and retention.

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Author contributions
Zarina Manaenkova: methodology; writing - review and editing. Ekaterina Santanna: formal analysis; writing - original draft.

Conflict of interest
Zarina Manaenkova is the originator of the 3D Movement Method and provided asynchronous instructional comments to the participant. To reduce role conflict, she had no role in primary data coding or analysis; her comments were analyzed solely by the second author. Data handling and analysis were led by the co-author, with independent checking where applicable.

Data availability statement
De-identified supporting materials are available from the corresponding author on reasonable request. Raw practice videos are not publicly shared to protect participant privacy.

Ethical considerations
Under institutional and national policies for minimal-risk research with adults, formal ethics review was not required. The participant received written and verbal information about the study and provided written informed consent.

References
1. Barlow DH, Nock MK, Hersen M. *Single-case experimental designs: Strategies for studying behavior change*. 3rd ed. Boston: Pearson; 2009.
2. Braun V, Clarke V. Supporting best practice in reflexive thematic analysis reporting in Palliative Medicine: A review of published research and introduction to the Reflexive Thematic Analysis Reporting Guidelines (RTARG). Palliative Medicine. 2024;38(6):608-16.
3. Brinsley J, Smout M, Davison K. Satisfaction with online versus in-person yoga during COVID-19. J Altern Complement Med. 2021;27(10):893-6.
4. Espírito Santo J, Aibar-Almazán A, Martínez-Amat A, Loureiro NEM, Brandão-Loureiro V, Lavilla-Lerma ML, *et al*. Menopausal symptoms, postural balance, and functional mobility in middle-aged postmenopausal women. Diagnostics. 2021;11(12):2178.
5. Freire I, Seixas A. Effectiveness of a sensorimotor exercise program on proprioception, balance, muscle strength, functional mobility and risk of falls in older people. Front Physiol. 2024;15:1309161.
6. Hinman RS, Campbell PK, Kimp AJ, Russell T, Foster NE, Kasza J, *et al*. Telerehabilitation consultations with a physiotherapist for chronic knee pain versus in-person consultations in Australia: The PEAK non-inferiority randomized controlled trial. Lancet. 2024;403(10433):1267-78.
7. Kazdin AE. *Single-case research designs: Methods for clinical and applied settings*. 2nd ed. New York: Oxford University Press; 2011.
8. McArthur D, Dumas A, Woodend K, Beach S, Stacey D. Factors influencing adherence to regular exercise in middle-aged women: A qualitative study to inform clinical practice. BMC Womens Health. 2014;14:49.
9. Lange E, Danielsson L. Reaching for connection: A qualitative study of communication and interaction in video-based physiotherapy. Physiother Theory Pract. 2024;40(12):2865-76.
10. Manaenkova Z, Santanna E. Evaluation of 3D Movement Method effectiveness for proprioceptive enhancement using low-tech tools in a midlife woman: A single-case study. Am J Med Case Rep. 2025;13(9):52-8.
11. Manaenkova Z, Santanna E. Cognitive, emotional, and self-perception outcomes of the 3D Movement Method: A qualitative study of adult women's experiences. J Behav Brain Sci. 2025;15:183-99.
12. Mödinger M, Woll A, Wagner I. Video-based visual feedback to enhance motor learning in physical education—A systematic review. Ger J Exerc Sport Res. 2022;52(3):447-60.
13. Proske U, Gandevia SC. The proprioceptive senses: Their roles in signaling body shape, body position and movement, and muscle force. Physiol Rev. 2012;92(4):1651-97.
14. Salmoni AW, Schmidt RA, Walter CB. Knowledge of results and motor learning: A review and critical reappraisal. Psychol Bull. 1984;95(3):355-86.
15. Schlunegger MC, Zumstein-Shaha M, Palm R. Methodologic and data-analysis triangulation in case studies: A scoping review. West J Nurs Res. 2024;46(8):611-22.
16. Seuren LM, Gilbert A, Ramdharry G, Walumbe J, Shaw SE. Video analysis of communication by physiotherapists and patients in video consultations: A qualitative study using conversation analysis. Physiotherapy. 2024;123:30-7.
17. Sigrist R, Rauter G, Riener R, Wolf P. Augmented visual, auditory, haptic, and multimodal feedback in motor learning: A review. Psychon Bull Rev. 2013;20(1):21-53.
18. Villagrán I, Rammsy F, Del Valle J, Gregorio de las Heras S, Pozo L, García P, *et al*. Remote, asynchronous training and feedback enables development of neurodynamic skills in physiotherapy students. BMC Med Educ. 2023;23:267.
19. Wälchli M, Ruffieux J, Bourquin Y, Keller M, Taube W. Maximizing performance: Augmented feedback, focus of attention, and/or reward? Med Sci Sports Exerc. 2016;48(4):714-9.
20. Walsh GS, Delextrat A, Bibbey A. The comparative effect of exercise interventions on balance in perimenopausal and early postmenopausal women: A systematic review and network meta-analysis of randomized controlled trials. Maturitas. 2023;175:107790.
21. Winstein CJ, Schmidt RA. Reduced frequency of knowledge of results enhances motor skill learning. J Exp Psychol Learn Mem Cogn. 1990;16(4):677-91.