

Evaluation of 3D Movement Method Effectiveness for Proprioceptive Enhancement Using Low-Tech Tools in a Midlife Woman: A Single-Case Study

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Abstract Background: Proprioceptive decline during the menopausal transition elevates fall risk and undermines functional mobility. Practical, low-tech approaches are needed to help midlife women train and monitor proprioception outside clinical settings. **Objective:** This study aimed to evaluate the effect of the 3D Movement Method intervention on proprioceptive function in a midlife woman and to examine the feasibility of paired, low-tech self-evaluation tools. **Methods:** A single-case design was employed with a 48-year-old woman familiar with the method. She completed a 7-day individualized intervention featuring four foundational exercises. Proprioceptive function was assessed before and after the intervention using two expert-scored functional test batteries. Supportive measures included somatic screening, daily body mapping, participant self-ratings, and independent expert ratings of video recordings. **Results:** The intervention was associated with improvements in postural control, coordination, and alignment, as measured by expert ratings and qualitative analysis. The participant's self-ratings increased but demonstrated a persistent optimistic bias relative to expert scores, particularly on proprioceptively demanding tasks. Somatic screening and body mapping indicated enhanced segmental awareness and greater whole-body coherence, with limited affective content. **Conclusion:** The 3D Movement Method shows promise for supporting short-term proprioceptive gains through home-based practice. However, the observed disconnect between self-evaluation and expert assessment highlights a need to integrate structured external feedback with low-tech self-monitoring tools. Future research should refine assessment rubrics, include broader interoceptive and affective prompts, and test efficacy in a larger, more diverse sample.

Keywords: menopausal transition, proprioception, balance, somatic awareness, home-based training, single-case study, self-evaluation, women's health

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1. Introduction

Proprioception is the sense of body position and movement in space. It underlies postural control, joint stability, and the coordination of complex actions, while operating largely outside conscious awareness [1,2,3]. Receptors in muscles, tendons, and joints send information about limb position and movement to the central nervous system, which adjusts movement continuously [4,5,6]. When this system is degraded, maintaining a stable stance and executing accurate movements become difficult—a pattern commonly observed in musculoskeletal conditions ranging from the cervical spine to the ankle [7].

Women in the menopausal transition are vulnerable to proprioceptive decline due to the combined effects of aging and menopause-specific physiology [8]. Age-

related reductions in muscle mass, bone density, and joint function contribute to decreased balance confidence, joint stiffness, and mobility limitations that affect daily life [9,10,11,12]. Reductions in estrogen further exacerbate these changes and are associated with shifts in body composition, including increased intra-abdominal fat, which can impair balance and functional mobility [13,14]. The risk of falls and fractures rises with age; because proprioception is central to postural control and balance, this risk is clinically important in midlife and beyond [15,16].

Targeted physical exercise can mitigate these risks. Programs that cultivate proprioception and balance (including Pilates, tai chi, qigong, and the 3D Movement Method) have been reported to improve postural stability and functional mobility in midlife women, including those in the menopausal transition and in postmenopause [11,13,25,26,27]. Many women, however, face time and resource constraints that limit participation in structured

classes; this has led to increased use of remote and blended formats that expanded during and after the COVID-19 pandemic [28,29,30,31,32].

A further challenge concerns measurement. Many validated proprioception assessments require laboratory or clinical infrastructure and were developed for neurological populations using specialized or robotic equipment [1] [17–24]. Although precise, these approaches are not easily implemented in everyday contexts by midlife women who lack access to devices and clinical staff. Practical evaluation, therefore, benefits from expert-scored functional tests that can be administered outside the laboratory, as well as from simple tools that document the participant's internal state.

The present approach is informed by body schema theory, which describes a dynamic, largely unconscious sensorimotor representation that supports posture and movement and is updated by proprioceptive, vestibular, and visual input [33,34,35]. The 3D Movement Method intervention was designed to refine the body schema through focused practice that emphasizes biomechanical alignment, sensorimotor coordination, and attentional engagement in everyday contexts.

This paper reports on Phase One of the broader study, which is structured as a single-case evaluation. The first aim was to assess short-term changes in proprioceptive function resulting from the 3D Movement Method intervention, using functional pretests and posttests scored by experts. The second aim was to examine how well two supportive low-tech tools (body mapping and somatic screening) reflect the participant's internal state when compared with independent expert ratings.

2. Materials and Methods

This study employed a single-case design, selected for its ecological validity and sensitivity to capturing meaningful individual change in applied movement contexts [36]. Widely used in sport and rehabilitation research, this approach enables in-depth tracking of personalized outcomes over time. In contrast to group-based designs that emphasize aggregate statistics, single-case studies allow for context-specific observation of functional change and lived bodily experience.

2.1. Participant

Table 1. Participant L. Detailed Profile.

Category	Details
Biometrics	Age: 48; Sex: F; BMI: 18.72; BP: 110/70 mmHg; HR: 68 bpm
Fitness level	Daily 3D exercises (5–15 min); pistol squats (minor difficulty), push-ups: 5-9 reps. Goals: mobility/core strength
Medical history	Past menstrual migraines (movement-managed); right ulna fracture (healed). No medications
Lifestyle	Non-smoker; alcohol abstinent (6 months); balanced diet; 6-8 hours of sleep
Background	Higher education; former engineer; middle-income
Exercise views	Advocates exercise for stress, cognition, joint/brain health, hormonal balance

Participant L was a 48-year-old woman with prior experience in the Zarina del Mar 3D Movement Method; she was the sole participant in this case study. Notably, she had no history of neurological or psychiatric diagnoses, did not use medications that affect the central nervous system, and did not have a professional athletic background. Familiarity with the method was required to ensure accurate engagement with the intervention. Prior to the study, she submitted a sample performance video to support the development of a tailored practice sequence. Detailed demographic and fitness characteristics are presented in Table 1.

2.2. 3D Movement Intervention

The intervention drew on the Zarina del Mar 3D Movement Method, a somatic training system that emphasizes biomechanical alignment, sensorimotor integration, and focused attention. The method has been applied across diverse groups of women and, in the present study, was adapted to the physical profile and capabilities of Participant L. Following the baseline assessment, a personalized sequence was designed that incorporated four foundational exercises: the side plank, shrimp squat, push-up, and mermaid stretch. These exercises were performed daily for seven days in everyday contexts, either as a continuous flow or as isolated segments according to the participant's comfort and ability. The 3D Movement Method intervention aimed to improve proprioceptive function through spatially varied, internally guided practice that emphasized movement amplitude, precision, and postural control.

2.3. Functional Test Batteries for Pretest and Posttest Assessment of Intervention

Change in proprioceptive function and sensorimotor coordination was assessed with two study-specific functional batteries administered in everyday contexts. These were the Proprioceptive and Postural Readiness Battery (PPRB) and the Sensorimotor Coordination and Balance Battery (SCBB). The batteries targeted alignment, segmental control, and balance as expressed in whole-body tasks, following established functional movement traditions in rehabilitation and sport science [12,37,38,39,41,42,43].

The PPRB comprised posture analysis, roll-down/roll-up, spinal twist, Z-sit (left and right), and an overhead squat. These tasks indexed craniocervical alignment, scapular symmetry, spinal articulation, hip mobility, pelvic control, and whole-body coordination.

The SCBB comprised a Romberg test, single-leg stance, shoulder rotation, elbow rotation, hip abduction, straight-leg hip rotation, stomping, and hand clapping. This set reflected common static and dynamic balance probes and rotational control measures used to examine joint position sense and neuromuscular integration [41,42,43].

Together, these two batteries provided a coherent, low-tech evaluation of postural strategy, balance control, symmetry, and body awareness that could be implemented outside clinical laboratories.

2.4. Participant Self-Evaluation and Expert Review Procedures

The efficacy of the 3D Movement Method intervention was assessed by combining participant self-ratings with independent expert scoring. All pretest and posttest tasks were scored by two physical education experts using a 10-point anchored scale, where a score of 1 indicated very poor or unstable execution and a score of 10 indicated technically precise, confident, and stable execution. Prior to formal scoring, the experts reviewed anchor examples and completed a brief calibration round to align their interpretation of the scale. The experts scored independently and were not present during participant practice. Inter-rater agreement was summarized as an exact match percentage and as a percentage of scores within one point across all tasks and time points. A calibration gap was computed as the participant's self-rating minus the experts' mean score for each task and time point.

2.5. Supportive Self-observation Tools: Somatic Screening and Body Mapping

Somatic screening was used to document internal bodily perception through guided introspection informed by somatic education practice. The procedure drew on principles associated with the Feldenkrais Method, in which subtle movement, spatial orientation, and asymmetry are observed as indicators of proprioceptive awareness [44,45,46]. Screening was conducted twice, once before and once after the 3D Movement Method intervention. Each session consisted of a slow, eyes-closed scan from head to feet with small exploratory movements, followed by real-time verbal reflections and a brief written account using open-ended prompts. Imagery or metaphor could be used when helpful to articulate the experience. The screening complemented the functional tests by recording perceived ease, restriction, and balance strategy in everyday contexts and, like body mapping, was analyzed descriptively and was not used as a primary outcome.

Body mapping was used to visualize changes in proprioceptive and interoceptive awareness during the seven-day intervention period. One map was requested per day, with additional maps invited when perceptible shifts occurred, including before, during, or after practice. Templates with anterior and posterior outlines were provided but could be modified or replaced by free drawing. A simple color key was suggested to represent tension, stiffness, pain, warmth, and relaxation; brief annotations were encouraged when drawings alone did not fully convey the somatic state. Sequences of maps were reviewed descriptively for visual completeness, anatomical consistency, and expressive detail to track perceived changes in alignment, movement amplitude, and whole-body coherence over time. This application followed embodied research traditions in which body maps externalize somatic states, support reflection on shifting bodily experience, and inform learning and regulation in applied settings [45,47,48]. Body mapping served as a supportive record of perceived state and was

not treated as a primary outcome.

2.6. Data Analysis

Analyses were descriptive and triangulated expert scores, participant self-ratings, somatic screening notes, and body maps. The primary outcomes were the expert-scored ratings from the two batteries at pretest and posttest. Inter-expert agreement and the self-to-expert calibration gap were summarized for each time point. Supportive materials were summarized to characterize perceived alignment, regional sensations, whole-body coherence, energy, and post-practice downregulation.

2.7. Ethical Considerations

This single-case study involved one healthy adult performing a self-directed, non-invasive movement program. No clinical procedures or sensitive health data were collected. In accordance with institutional and national guidance for minimal-risk research with healthy adults, formal ethics committee approval was not required. The study aims and procedures were explained verbally and in writing, and the participant provided written informed consent covering recorded practice sessions, tests, body mapping, somatic screening, and reflective materials, with explicit permission for anonymized publication. The participant had prior training in the 3D Movement Method, but there was no contact with the instructor during the study. All materials were standardized, and all data were submitted to the second author for independent expert evaluation. The procedures complied with the Declaration of Helsinki. Data were stored securely with access limited to the research team. Videos were de-identified by covering the face and blurring the background to preserve anonymity and confidentiality.

3. Results

3.1. Impact of 3D Movement Intervention on Proprioceptive Function: Functional Test Evaluation

The seven-day 3D Movement Method intervention was associated with improvements in coordination, balance, and proprioceptive function for Participant L. These gains were reflected in higher expert scores on functional tests and were observable in posttest recordings, which showed steadier segmental alignment, smoother movement sequencing, and more reliable balance holds in everyday contexts.

In the PPRB, the experts' overall mean score increased from 4.90 to 5.90. The lowest pretest scores (4.5 each) were observed for posture, spinal twist, and the overhead squat. At posttest, posture improved to 6.5, the overhead squat to 6.0, and spinal twist rose to 5.0. Roll-down/roll-up improved from 5.5 to 6.5, while the Z-sit score remained stable at 5.5. Participant self-ratings in this battery rose from a mean of 7.60 to 8.40.

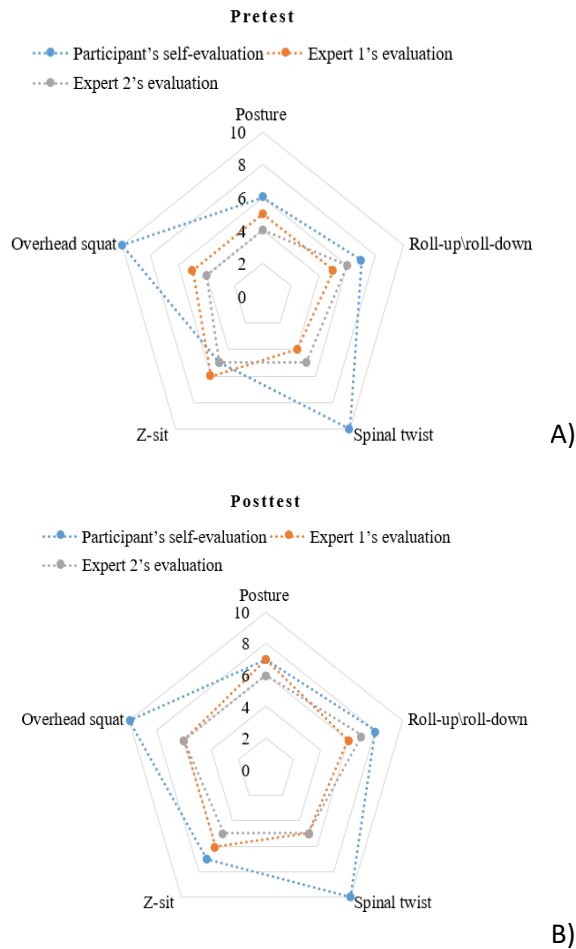


Figure 1. PPRB evaluations: (A) pretest and (B) posttest performance

In the SCBB, the experts' overall mean score increased from 4.81 to 5.25. The lowest pretest scores were for single-leg stance (4.0) and the Romberg test, hip abduction, and straight-leg hip rotation (4.5 each). These scores improved at posttest: Romberg test to 5.5, single-leg stance to 5.0, hip abduction to 5.5, and straight-leg hip rotation to 5.0. Expert scores for shoulder rotation, elbow rotation, stomping, and hand clapping were unchanged. Participant self-ratings rose from a mean of 7.75 to 8.13, though small declines were noted in single-leg stance and the upper-limb rotations.

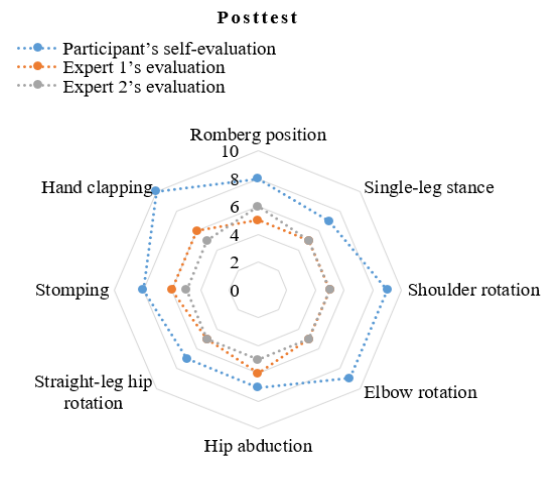
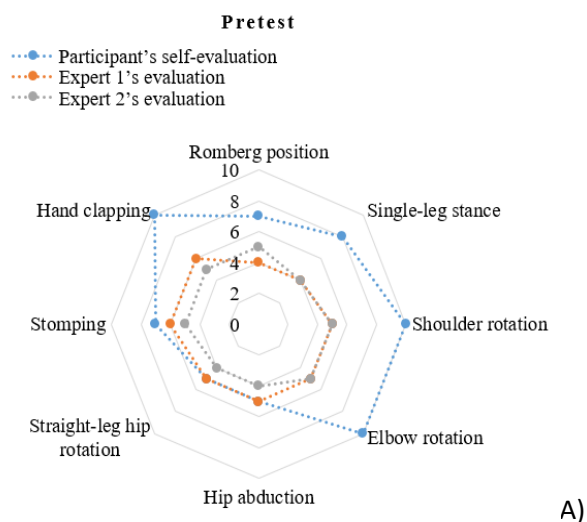


Figure 2. SCBB performance evaluations with (A) pretest and (B) posttest results

Inter-expert agreement was high at both time points, with scores within one point on every task. Exact matches increased from 0 to 2 of 5 tasks in the PPRB and from 3 to 4 of 8 in the SCBB. The mean calibration gap between the participant's self-ratings and the experts' mean narrowed slightly but persisted, moving from +2.70 to +2.50 points in the PPRB and from +2.94 to +2.88 points in the SCBB.

3.2. Supportive Results: Body Mapping and Somatic Screening

Somatic screening was conducted twice, following somatic education practices [44,45,46]. During both sessions, Participant L provided concise observations focused on alignment and symmetry, with limited affective or interoceptive content.

In the pretest, which was performed supine with eyes closed, she perceived the left side of her body as elevated relative to the right—a perception not corroborated by external observation, as her daughter noted level shoulders. She also reported cervical tension and tingling in her middle and ring fingers, without attributing emotional meaning to these sensations.

Posttest reflections, collected immediately after the seven-day intervention, indicated perceptual shifts consistent with improved proprioceptive organization. She reported equal shoulder contact with the surface, an absence of neck tension, and smooth, coordinated movement in the pelvis and lower limbs. These subjective reports aligned with expert evaluations of improved postural stability and coordination on the functional tests.

Body mapping was used to visualize changes in proprioceptive and interoceptive awareness across the seven-day intervention, following embodied research traditions [45,47,48]. Despite the option to use a wide palette of symbols, Participant L consistently marked three areas throughout the week (a schematic overview of day-by-day mappings is presented in Figure 3): vibration or numbness in the leg attributed to prior overexertion, a sensation in the abdominal region that emerged during practice, and persistent discomfort under the right shoulder blade. According to her notes (and consistent with expert observation) the latter reflected ongoing upper body weakness. This repeated focus indicated increased

segmental awareness in regions under habitual tension and mechanical load. A representative correspondence between a practice frame and a same-day map is shown in Figure 4, where the mapped right scapular focus aligns with visible compensations on video.

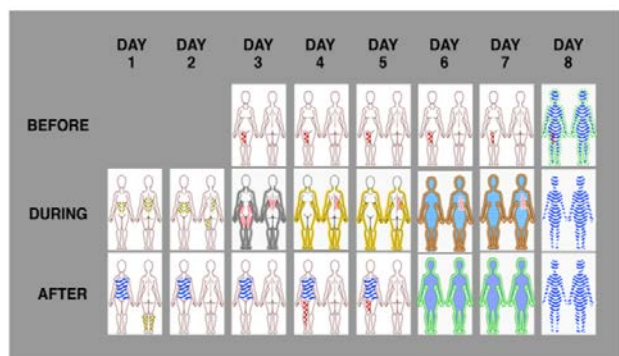


Figure 3. Schematic representation of body maps across practice days. "Before" indicates sensations prior to 3D movement practice, "During" refers to sensations experienced during practice, and "After" reflects sensations following 3D movement practice

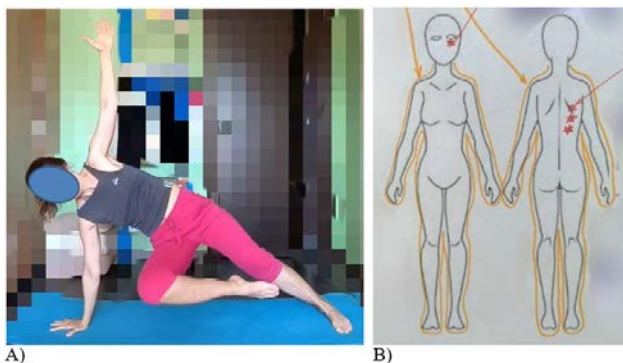


Figure 4. A) Screenshot of movement 2 (Day 5 of practice) and B) Body map from Day 5 highlighting the painful right scapular area

Across the intervention period, the maps progressed from local markings to full-body outlines. From the start, the participant noted post-practice energy and vitality. These sensations were initially localized in the core but were described as extending to the whole body by day 6; correspondingly, the maps began to display broader, integrated contours. Written reflections (e.g., "Movements 1 and 2 were easy, but movements 3 and 4 felt challenging, likely due to late practice" and "Movement 1 felt easier with better coordination and smoother flow") corresponded to these visual changes.

On day 3, a general full-body sensation was first recorded and colored gray, which was interpreted as fatigue after intense practice. On day 4, the same region was colored brown, and by day 5 it was colored yellow—a shift the participant associated with lower perceived difficulty and greater ease. By day 7, all maps presented a complete outline, including the head, and were accompanied by reports of sudden sleep onset and deep relaxation, consistent with post-practice downregulation and a temporary sense of internal balance.

On day 8, relaxation was no longer marked. Instead, the participant reported whole-body energy and alertness present before the session, a sense of harmony during the session, and psychological tension related to anticipated testing.

This sequence, illustrated in Figure 3, suggested growing coherence of whole-body proprioception and an emerging capacity to register interoceptive shifts in bodily terms. These observations complemented the functional test findings and documented subjective changes in energy, localization, and whole-body coherence following the intervention.

4. Discussion

This single-case evaluation found that the 3D Movement Method intervention was associated with modest, measurable improvements in proprioceptive function, as judged by independent experts. Gains were evident in alignment, sequencing, and balance on the functional batteries, with clearer segmental control and steadier holds visible on posttest recordings. These findings met the first aim and were consistent with short-term neuromotor and attentional recalibration [11,13,25,26,27]. As shown in Figure 1 and Figure 2, persistent upper-body weakness remained.

A key finding was a persistent optimism bias in self-evaluation; self-ratings were consistently two to three points higher than expert scores, and this gap did not narrow. High inter-expert agreement supported the reliability of the scoring rubric, indicating this discrepancy was a feature of self-perception rather than measurement error.

The interpretive frame of body schema theory helped explain the results [33,34,35]. A seven-day intervention window plausibly produced cleaner timing and more stable configurations, aligning with experts' observations of within-anchor improvement. However, the participant's own judgments did not recalibrate toward the external expert anchors.

This highlights a central challenge for remote formats: self-ratings alone proved insufficient for calibration despite plain-language prompts and video access. These observations argue for the routine inclusion of structured expert feedback in future iterations to provide objective anchors for technical execution.

The supportive tools addressed the second aim by documenting internal state without replacing external scoring. Somatic screening captured a shift from perceived asymmetry and cervical tension to equal shoulder contact and smoother movement. Body mapping recorded a progression from local markings to full-body contours, alongside reports of post-practice relaxation and whole-body energy. These trajectories are compatible with evidence that somatic methods deepen awareness and that mapping externalizes bodily states to aid reflection [44,45,46,47,48].

Finally, the study demonstrated feasibility and ecological validity through an individualized intervention delivered in everyday contexts and paired with low-burden, reliably scored assessments. The design provides a workable template for applied settings where access to laboratories is limited.

4.1. Limitations

This report described a single participant with prior experience in the 3D Movement Method, a short

observation window, and study-specific functional batteries that require further validation. Self-evaluation prompts emphasized clarity and specificity but did not elicit rich affective content, which may have constrained interoceptive description. These factors limited generalizability.

4.2. Future studies

Future work should expand the sample, evaluate retention at follow-up, refine anchors and prompts for both self-ratings and expert scoring, and test whether concise expert feedback narrows the gap between self-judgment and independent scoring while preserving feasibility in everyday contexts.

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Because English is not the authors' first language, ChatGPT (GPT-5 Thinking, OpenAI) was used solely for proofreading and clarity edits. No scientific content or interpretation was produced by the tool. All content was written, verified, and approved by the authors.

Author Contributions

Conceptualization; writing-review and editing: Z.M.; methodology; writing-original draft preparation: E. S.

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Institutional Review Board Statement

This study involved a single healthy, competent adult participant and used non-invasive, low-risk procedures. According to institutional and national guidelines, formal ethical approval was not required. All procedures complied with the principles of the Declaration of Helsinki.

Informed Consent Statement

Written informed consent was obtained from the participant to publish this paper. The participant gave explicit permission for anonymized data and images to be used in scientific publications.

Data Availability Statement

The case study data, including audio, video, and written materials generated or analyzed during this study, are not

publicly available. However, these materials may be obtained from the corresponding author upon reasonable request and are subject to privacy and ethical considerations.

Conflicts of Interest

Z.M. is a co-author, the inventor of the 3D Movement Method, and the founder of Zarina del Mar LLC. E.S. serves as a consultant for the same company. Although Z.M. designed the intervention, all participant assessments were conducted by independent experts to mitigate potential bias. The authors declare no other competing interests.

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