Sri Lanka Journal of Physiotherapy and Rehabilitation Sciences

Case study

Strong, steady and straight consensus: A multidimensional exercise intervention for postmenopausal osteoporosis

R A M D Ranatunga[1*], N W W P G K S Senanayake[2], M S H Banu[3]

*Correspondence: menujadr@gmail.com https://orcid.org/0009-0003-0484-8578

Received on 29 Oct 2025
Accepted on 14 Feb 2026

ABSTRACT

Background: Osteoporosis is a systemic skeletal disorder characterized by low bone mineral density and deterioration of bone microarchitecture, leading to increased bone fragility and fracture risk in postmenopausal women. Patients with osteoporosis frequently experience pain, spinal deformities, reduced hip and trunk strength, impaired balance, and fear of falling. Exercise-based interventions provide a vital role in improving musculoskeletal function and reducing fall risk. The Strong, Steady and Straight framework, developed by the Royal Osteoporosis Society, offers an evidence-based approach to exercise prescription for osteoporosis. This study aims to evaluate the clinical applicability of multidimensional exercise programme based on the Strong, Steady and Straight framework in improving musculoskeletal and functional outcomes in a postmenopausal woman with osteoporosis.

Case: A 58-year-old postmenopausal woman with osteoporosis and thoracic kyphosis underwent an 18-week supervised physiotherapy programme, delivered twice weekly and supported by a home-based routine. The programme combined balance and gait training ("Steady"), postural and spinal strengthening ("Straight"), and safe resistance and weight-bearing exercises ("Strong"). Outcome measures were assessed at baseline, week 9, and week 18.At 18 weeks, marked improvements were observed: pain decreased (Numerical Pain Scale: pre- 7/10, post- 3/10), mobility improved, fall risk reduced (Timed Up and Go: pre-17 seconds, post-10 seconds; Five Times Sit-to-Stand: pre-20 seconds, post- 11 seconds), and walking endurance increased (6-Minute Walk Test: pre-320 m, post-410 m). Balance and gait improved significantly (Berg Balance Scale: pre-39/56, post- 49/56; Functional Gait Assessment: pre-16/30, post-24/30). Fear of falling reduced substantially (Falls Efficacy Scale: pre-44, post-28). Postural alignment improved modestly (thoracic kyphosis angle: pre-58°, post-56°), however the hip range of motion limitations persisted.

Conclusions: This case demonstrates that an individualized programme structured around the Strong, Steady and Straight framework is safe, feasible, and clinically meaningful changes in improving pain, balance, functional mobility, endurance, and fall-related confidence in osteoporosis.

Keywords: *osteoporosis, exercise, postmenopausal women, fall prevention, pain*

Introduction

Osteoporosis is a systemic skeletal disorder characterized by low bone mineral density (BMD) and deterioration of bone microarchitecture, leading to increased bone fragility and fracture risk (1). Postmenopausal women can be considered the largest at-risk population due to oestrogen deficiency, which accelerates bone resorption and contributes to both osteoporosis and osteopenia (2). In addition to skeletal fragility, individuals with osteoporosis often experience musculoskeletal complications, including chronic low back pain, spinal deformities such as thoracic kyphosis, reduced hip and trunk strength, impaired balance, and limited mobility (3). These factors collectively increase the risk of falls and subsequent fragility fractures, which remain a major cause of morbidity, mortality, and reduced quality of life in this population (4).

Although pharmacological therapies are central to osteoporosis management, exercise-based interventions are increasingly recognized as critical for addressing musculoskeletal impairments, improving functional capacity, and reducing the fall risk. The Strong, Steady and Straight framework, developed by the Royal Osteoporosis Society, provides an evidence-based guide for safe and effective exercise prescription (5). It emphasizes three complementary domains: strong, through weight-bearing and resistance training to maintain or improve bone strength; steady, through balance and functional training to reduce fall risk; and straight, through spinal care, posture correction, and back extensor strengthening to mitigate vertebral deformities and enhance mobility (6,7). Furthermore, Evidence indicates that targeted back strengthening and postural training can improve kyphosis, spinal alignment, and functional mobility, thereby contributing to reduced fracture risk and improved quality of life in osteoporotic populations (8).

Although exercise-based interventions are recommended for osteoporosis, there is limited published evidence describing the structured application of the Strong, Steady and Straight framework in clinical physiotherapy practice, particularly in Sri Lanka. Therefore, this case report aimed to provide a detailed clinical illustration of a physiotherapy-based, individualized exercise programme based on the Strong, Steady and Straight framework and to highlight its potential role in improving pain, balance, mobility, posture, and to prevent falls in a postmenopausal woman with osteoporosis.

This case study aimed to evaluate the clinical applicability of multidimensional exercise programme based on the Strong, Steady and Straight framework in improving musculoskeletal and functional outcomes in a postmenopausal woman with osteoporosis.

Clinical case

A 58-year-old postmenopausal woman (1.61 m, 54 kg; BMI 20.9 kg/m^2) presented to the outpatient physiotherapy clinic with progressive low back pain for the past 4 months. She described the pain as a dull, aching discomfort localized to the lower back region, occasionally radiating to the left buttock, worsened by prolonged standing and lifting household items. She did not have any acute traumas, recent falls, or neurological symptoms such as bowel/bladder incontinence or lower limb weakness. Her past medical history included hypertension and hyperlipidaemia. She reported menopause at age 54 with no use of hormone replacement therapy.

Her family history was positive for osteoporosis (mother had a hip fracture at age 74) and type 2 diabetes. She was a non-smoker, but admitted to a sedentary lifestyle with minimal structured exercise. Dietary recall suggested low calcium intake (<500 mg/day) and inadequate vitamin D exposure, as she rarely spent time outdoors.

On physical examination, the patient appeared thin-built, well-oriented, and cooperative. Postural assessment revealed a mild thoracic kyphosis accompanied by a stooped gait. Palpation elicited tenderness over bilateral paravertebral muscles of the L1–L3 lumbar region, with palpable muscle tightness noted in the piriformis and quadratus lumborum muscles bilaterally. Range of motion was moderately restricted, particularly in flexion and rotation to both right and left sides in lumbar region, primarily due to pain. Neurological examination demonstrated no motor or sensory deficits, and deep tendon reflexes were intact. Functionally, the patient reported difficulty in rising from low chairs and carrying groceries. Although she had no history of falls, she expressed a notable fear of falling.

At baseline, the patient reported persistent low back pain rated at 7/10 on the numerical pain scale, with occasional radiation to the left buttock and posterior hip region, attributed to compensatory loading from altered lumbar mechanics. Functional assessments revealed significant impairments: the Timed Up and Go (TUG) was 16.5 seconds and the Five Times Sit-to-Stand (5TSTS) was 21.8 seconds, indicating reduced lower limb strength and mobility. Gait and balance performance were compromised, with a Functional Gait Assessment (FGA) score of 16/30 and Berg Balance Scale (BBS) score of 39/56, both reflecting a significant fall risk. Postural evaluation showed mild thoracic kyphosis. Muscular and cardiovascular endurance was reduced, with a 6-Minute Walk Test (6MWT) distance of 320 meters and Sorensen test back extensor endurance of 10 seconds. Hip examination demonstrated generalized weakness of the hip muscles with restricted range of motion, particularly in flexion, abduction, and extension, further contributing to altered biomechanics and functional limitations. The patient also expressed a strong fear of with a Falls Efficacy Scale–International (FES-I) score of 44.

Radiological imaging of the lumbar spine revealed a reduced bone density with cortical thinning and vertebral end-plate changes in L1, L2, L3 vertebral levels. Dual-energy X-ray absorptiometry (DXA) scan demonstrated reduced bone mineral density across multiple regions, with a T-score of –2.6 at the lumbar spine (L1–L4), –1.6 at the left femoral neck, –1.1 at the right femoral neck of hip. These findings revealed that osteoporosis in the lumbar spine and osteopenia in femoral neck of hip joint. Most of the biochemical investigations were within normal limits. However, serum calcium was 8.6 mg/dl, at the low-normal range and serum 25-hydroxy vitamin D was deficient at 18 ng/ml. The patient was diagnosed with primary postmenopausal osteoporosis with vitamin D deficiency.

The patient was counselled extensively regarding osteoporosis management and available treatment options. Upon prescription by her physician, she used calcium carbonate at a total daily intake of 1200 mg through diet and supplementation along with vitamin D_3 supplementation at a dose of 2000 IU per day.. Lifestyle modifications were strongly emphasized, including the incorporation of a structured weight-bearing exercise programme, postural correction strategies, and balance training aimed at reducing fall risk. She was also advised to adopt dietary adjustments to support bone health. She was referred to physiotherapy and rehabilitation for a lumbosacral stabilization-strengthening and falls prevention exercise programme, incorporating resistance training, postural correction, and functional mobility exercises.

Written informed consent was obtained from the patient prior to participation and publication of this case report. The patient was informed about the purpose of the study, the intervention procedures, potential benefits and risks, and her right to withdraw at any time without affecting her standard care. All identifying information were anonymised to ensure confidentiality.

This patient was selected because she presented with multiple, commonly co-existing clinical features of postmenopausal osteoporosis, including low back pain, thoracic kyphosis, impaired balance, functional

mobility limitations, and a pronounced fear of falling, despite the absence of prior fragility fractures. In addition, the patient was newly diagnosed, medically stable, and motivated to participate in a structured rehabilitation programme. Reporting this case addresses a gap in the literature by providing a detailed, real-world illustration of framework-based exercise prescription in a postmenopausal woman from a low-resource setting, where such case-level evidence remains limited.

Exercise intervention

The patient was enrolled in an 18-week, twice-weekly supervised physiotherapy programme, complemented by a simple home-based routine. Based on her diagnosis of postmenopausal osteoporosis, associated frailty and risk of fracture, the programme was structured using the "Strong, Steady and Straight" clinical framework, with priority placed on the steady and straight components.

Under the Steady component, balance and gait training and functional muscle strengthening were targeted to address her high risk of falls and reduced mobility. Exercises included semi-tandem and single-leg stance with support, toe raises and heel raises for static balance training. Progression to dynamic activities included heel-to-toe walking and directional stepping. In the 5th week, dual-task activities i.e., walking while turning the head and carrying lightweight objects, were introduced to simulate daily challenges. Gait training included increasing stride length and maintaining correct posture and heel-to-toe coordination. Later, obstacle navigation and varied-surface walking were added to improve adaptability. Lower limbs were strengthened incorporating sit-to-stand exercise, step ups, and mini-squats to restore functional mobility, reduce fall risk, and enhance lower limb muscle power essential for daily living activities.

Objectives of the Straight component were to improve spine care, correct posture and to improve back muscle endurance to reduce lower back pain symptoms and kyphotic posture. Following interventions were employed to achieve these outcomes. Postural retraining including wall slides, chin tucks, and scapular retraction exercises, reinforcing the alignment and awareness during sitting, standing, and lifting tasks. Lower back extensor muscle strengthening was done in prone lying position. Exercises were progressed from low intensity to moderate intensity using light resistance bands. Core stabilization exercises by means of pelvic tilts, modified cat and camel exercise and bridging exercises were introduced to improve the trunk stability. Education in correct bending and lifting mechanics, particularly the hip-hinge technique, was reinforced at each session to protect the lumbar spine. Furthermore, gentle stretching exercises for the paraspinal and hamstring muscles and transcutaneous electrical nerve stimulation for lower back muscles were used as pain management strategies.

The "Strong" component, although not the primary focus due to fracture risk, was incorporated at a safe level to promote bone health. Weight-bearing activities consisted mainly of daily brisk walking, gradually increased from 10 to 15 minutes. Very light impact activities, such as marching in place was introduced under supervision. Resistance training as started with the aid of resistance bands targeting major muscle groups of the lower limbs. It was progressed from 1-2 sets, 8 repetitions per set, adjusted according to her tolerance and safety. This was progressed to increasing the repetitions (from 8 to 12), and adding sets (from 1 to 2), while balance exercises progressed from supported to unsupported and from static to dynamic balance exercise.

Exercise intensity was monitored using the Borg Rating of Perceived Exertion (RPE) scale (0–10). Balance and postural exercises were maintained at an RPE of 3–4 (moderate), and resistance exercises were progressed within an RPE range of 4–6 (moderate to somewhat hard). Progression criteria were predefined. Pain was at ≤5/10 on the Numerical

Pain Scale during and after exercise, and the ability to complete prescribed repetitions with correct technique. The patient was prescribed a home exercise programme consisting of exercises and walking activities, to be performed on non-supervised days. Adherence was monitored using a self-reported exercise diary reviewed at each physiotherapy session. Over the 18-week period, adherence to the home programme averaged approximately 80%, with occasional missed sessions due to fatigue or time constraints.

The safety of the patient was prioritized throughout the intervention. Vital signs, pain levels, and balance confidence were assessed at each supervised session. Prior to and throughout the intervention, the patient was advised regarding exercise-related cardiovascular warning symptoms, including sudden excessive sweating, palpitations, dizziness, or chest discomfort. She was advised to discontinue exercise immediately and seek prompt medical evaluation if any of these symptoms were experienced. Exercises involving spinal flexion, twisting, or high-impact loading were avoided in accordance with osteoporosis safety guidelines. No falls, fractures, musculoskeletal injuries, or adverse events were reported during the supervised sessions or home programme. The patient tolerated the programme well, with only transient muscle soreness during early 5 weeks, which resolved spontaneously without modification of the intervention. Over the 18 weeks, exercises were progressively advanced to match improvements in balance, muscle strength, gait, and pain tolerance.

Outcome measurements

The outcome measurements are summarised in Table 1.

Table 1. Pre and post intervention scores of exercise programme based on "Strong, Steady and Straight" framework designed for osteoporosis

Outcome measure	Pre-intervention score (Week 0)	Post-intervention score (Week 9)	Post-intervention score (Week 18)
NPS for pain	7/10	5/10	3/10
TUG (seconds) (>13.5s indicates falls risk)	17	13	10
5TSTS (seconds)	20	18	11
FGA	16/30	20/30	24/30
BBS	39/56	44/56	49/56
Postural alignment (Thoracic kyphosis angle, degrees via inclinometer)	58°	58°	56°
6MWT (meters)	320 m	385 m	410 m
Fear of falling (FES-I score, minium-16, maximum-64)	44	30	28

NPS: Numerical Pain Scale, TUG: Timed Up and Go, 5TSTS: Five Times Sit-to-Stand, FGA: Functional Gait Assessment, BBS: Berg Balance Scale, 6MWT: 6-Minute walk test, FES-I: Falls Efficacy Scale - International

Discussion

This case study emphasized the multifactorial impairments associated with osteoporosis, encompassing pain, postural deformity, reduced mobility, lower limb weakness, and impaired balance, all of which contributed to functional limitations and an elevated fear of falling. At baseline, the patient exhibited pronounced thoracic kyphosis, restricted lumbar and hip range of motion, and poor gait performance. Following an 18-week physiotherapy-led programme, significant improvements were achieved across several outcome

domains, including pain reduction, functional mobility (TUG, 5TSTS), balance (BBS, FGA), endurance (6MWT), postural alignment, and psychological confidence (FES-I). These findings reinforced the multidimensional rehabilitation strategies in osteoporosis management.

The changes observed in this case aligned with existing evidence indicating that multidimensional exercise interventions primarily influence neuromuscular and functional outcomes rather than bone structure in the short term (9). Improvements in functional mobility (TUG, 5TSTS) and reduction in fear of falling (FES I) mirror findings from larger controlled studies where combined resistance and balance training enhanced lower limb strength, balance, and confidence in postmenopausal osteoporotic women, even within 12 weeks of training duration (10). Similarly, it is evident that exercise interventions significantly improve physical performance measures such as the Berg Balance Scale and timed mobility tests, factors strongly associated with fall risk and independence, whereas changes in bone mineral density are modest and often emerge only with longer duration and combination approaches (11). Postural alignment improvements often require extended and targeted interventions beyond general functional training. Furthermore, while evidence supports that exercise can slightly attenuate bone loss over longer periods, its effects on bone density in the absence of multimodal, high impact, or longer duration protocols remain limited.

However, a potential confounding factor in this case is the concurrent initiation of pharmacological therapy, including oral alendronate, calcium, and vitamin D supplementation. These treatments are known to primarily influence bone mineral density and fracture risk over longer durations, typically requiring several months to years to demonstrate measurable skeletal effects. In contrast, the observed improvements in pain, balance, gait, functional mobility, endurance, and fear of falling occurred progressively over an 18-week period and are more likely attributable to neuromuscular, postural, and functional adaptations induced by the exercise programme.

From the patient's perspective, the programme was acceptable and empowering. She reported reduced pain, improved ability to manage household tasks, and greater confidence in mobility. Importantly, her fear of falling decreased substantially, which she described as a key factor in regaining independence. However, the improvements in thoracic kyphosis were modest, reflecting the challenge of reversing long-standing postural deformities. Furthermore, hip range of motion restrictions, particularly in flexion and extension, persisted despite functional gains, underscoring the need for more targeted interventions.

This case study has several limitations that should be acknowledged. The single-case design limits the generalisability, as the observed outcomes may not be representative of the broader postmenopausal osteoporotic population. The lack of long-term follow-up limits the ability to determine the durability of functional improvements, sustained adherence, and potential effects on fracture risk and bone mineral density. Furthermore, the concurrent initiation of pharmacological therapy (alendronate, calcium, and vitamin D) prevents clear isolation of the independent effects of the exercise intervention, and synergistic effects between medication and exercise cannot be excluded.

Future research should include larger, well-designed randomized controlled trials to evaluate the effectiveness, safety, and adherence of "Strong, Steady, Straight" based exercise programs in diverse populations with osteoporosis, including those with vertebral fractures or severe frailty.

Conclusions

This case emphasized that structured, individualized programmes integrating the Strong, Steady, Straight framework are safe, feasible, and clinically meaningful in improving musculoskeletal and

functional outcomes in osteoporosis. By addressing bone health, fall prevention, and spinal stability simultaneously, such interventions provide a comprehensive, evidence-based strategy to enhance quality of life and independence in affected individuals.

Author Affiliations

[1]Faculty of Medicine, University of Colombo, Sri Lanka, [2]Department of Allied Health Sciences, Faculty of Medicine, University of Colombo, Sri Lanka, [3]Department of Nutrition and Dietetics, Wayamba University of Sri Lanka

Author Declarations

Competing interests: The authors declare no conflicts of interest related to this research.

Funding: self-funded.

Acknowledgements: We thank the participant who was involved in this study.

Author contributions: All authors have contributed to the manuscript through data collection, data analysis, and writing.

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