

Effect of Tendo-Achilles Stretching on Land versus Water in Non Specific Low Back Pain: A Research Protocol for Randomised Controlled Trial

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ABSTRACT

Introduction: Low Back Pain (LBP) is a prevalent condition affecting people of all ages and is difficult to manage because of its non specific nature. In addition to pain, it can alter muscle function, balance, body awareness, and joint movement.

Need of the study: Calf muscle tightness may influence posture, balance, and LBP. Evidence linking Tendo-Achilles tightness with postural control, balance, and Non specific LBP (NSLBP)-especially in aquatic therapy is currently insufficient. Moreover, the objective evaluation of muscle adaptations following targeted stretching is limited. Hence, the present study is essential to scientifically examine the effects of Tendo-Achilles stretching using ultrasonographic assessment in individuals with NSLBP.

Aim: To evaluate the effect of three weeks of Tendo-Achilles stretching on land versus water in subjects having NSLBP.

Materials and Methods: The present randomised controlled trial will be conducted at KLE University's Dr Prabhakar Kore Hospital and Medical Research Centre, Belagavi, Karnataka,

India, from January 2026 to June 2027. A total of 120 participants with NSLBP of three months to two years duration will be randomly assigned to three groups (n=40 each): Group A-conventional Transcutaneous Electrical Nerve Stimulation (TENS) and exercises, Group B-conventional TENS with land-based stretching, and Group C-conventional TENS with aquatic stretching, for three weeks (three sessions per week). Diagnostic ultrasonography will assess calf muscle length, echogenicity, and cross-sectional area. Calf flexibility, lumbar mobility, lower limb function, dynamic balance, and disability will be evaluated using the Weight Bearing Lunge Test (WBLT), Modified-Modified Schober Test (MMST), lower extremity functional scale, Y-Balance Test, and Modified Oswestry Disability Questionnaire, respectively. Analysis of Variance (ANOVA) and post-hoc Tukey's test will be used for testing the significance of the hypothesis among groups. Paired t-test or Wilcoxon signed-rank test will be used for within-group comparisons, with p<0.05 considered statistically significant.

Keywords: Hydrotherapy, Muscle stretching exercises, Rehabilitation, Ultrasonography

INTRODUCTION

The LBP is a highly prevalent musculoskeletal disorder. The term NSLBP is used when no definite pathological or structural cause can be identified despite thorough evaluation. NSLBP has emerged as a significant global public health concern. Epidemiological evidence indicates that approximately 24% of individuals across various occupational groups in different regions report experiencing LBP [1].

Conservative management remains the first-line approach for treating LBP due to its effectiveness in relieving pain and improving function. Several electrotherapeutic modalities, including Interferential Therapy (IFT), ultrasound, and other physical agents, have demonstrated therapeutic benefits [2]. TENS is widely used as a safe, non invasive, and non pharmacological modality for pain relief. High-frequency conventional TENS activates A β afferent fibres, which stimulate inhibitory interneurons responsible for suppressing nociceptive transmission via A δ and C fibres, thereby reducing pain perception [2].

Beyond pain, patients with NSLBP often demonstrate impairments such as altered muscle properties, reduced proprioception, and restricted joint range of motion [3]. Myofascial trigger points in the gluteal, pelvic, piriformis, and gastrocnemius-soleus muscle groups have also been identified as contributory sources of LBP [4]. The calf complex, composed of the gastrocnemius and soleus muscles, plays a crucial role in lower limb biomechanics [5].

The relationship between Tendo-Achilles tightness and NSLBP may be explained through altered lower-extremity biomechanics associated with restricted ankle dorsiflexion. Limited flexibility of

the gastrocnemius-soleus complex can result in compensatory alterations in lower-limb kinematics, including changes in knee and hip movement patterns and impaired lumbopelvic stability during functional activities. These compensatory mechanisms may increase mechanical demand on the lumbar spine, thereby contributing to the development or persistence of NSLBP [6]. Furthermore, the gastrocnemius-soleus complex shares myofascial continuity with the posterior kinetic chain, which includes the hamstrings, thoracolumbar fascia, and paraspinal musculature. Tightness in this muscular chain has been shown to affect postural alignment, balance, and spinal biomechanics adversely [7]. While the calf complex may not be a primary isolated cause of LBP, its contribution through altered biomechanics and postural control warrants targeted therapeutic intervention [8]. The weight-bearing lunge test offers a simple, reliable, and cost-effective method for assessing ankle and calf muscle flexibility in clinical settings [9].

Ultrasonography has emerged as a reliable tool for evaluating calf muscle architecture by measuring muscle thickness, fascicle length, and pennation angles during both static and dynamic conditions [10]. This imaging technique allows real-time visualisation of muscle behaviour during stretching.

Individuals with LBP frequently report lower limb symptoms such as pain, paresthesia, weakness, and claudication, leading to greater functional limitations than those with isolated back pain. Altered postural control and trunk muscle activation are commonly observed in both acute and Chronic LBP (CLBP) [11,12]. Calf muscle tightness, a component of motor system impairment,

significantly influences static and dynamic balance as well as mobility [13].

AquaStretch™ is a specialised manual therapy technique performed in a warm-water aquatic environment, integrating sustained manual traction with active-assisted movements. The technique is performed by a trained physiotherapist who provides manual assistance while the patient performs active stretching. Sessions are conducted in a pool maintained at 32-34°C with water depth at approximately mid-chest level. The active-assisted movements target the posterior kinetic chain, including the calf musculature, with specific attention to ankle dorsiflexion range and associated muscle extensibility. AquaStretch™ has demonstrated improvements in range of motion following a single treatment session in healthy individuals [14], though long-term outcomes remain underexplored.

Primary Objectives:

1. To evaluate the effect of conventional TENS and exercises on pain, postural balance and diagnostic ultrasonography findings of calf muscles in individuals with NSLBP.
2. To evaluate the effect of conventional TENS with land-based Tendo-Achilles stretching on pain, postural balance, and diagnostic ultrasonography findings of calf muscles in individuals with NSLBP.
3. To evaluate the effect of conventional TENS with aquatic Tendo-Achilles stretching on pain, postural balance, and diagnostic ultrasonography findings of calf muscles in individuals with NSLBP.

Secondary Objectives:

- To compare the effect of aquatic versus land-based Tendo-Achilles stretching programme combined with conventional TENS therapy on pain, postural balance, and diagnostic ultrasonography findings of calf muscles in individuals with NSLBP.

Null hypothesis (H_0): There will be no significant difference in the effect of Tendo-Achilles stretching in water versus land, along with TENS, on diagnostic ultrasonography findings, pain, postural balance, lower limb function, lumbar mobility, and disability in subjects with NSLBP.

Alternate hypothesis (H_1): There will be a significant difference in the effect of Tendo-Achilles stretching in water versus land, along with TENS, on diagnostic ultrasonography findings, pain, postural balance, lower limb function, lumbar mobility, and disability in subjects with NSLBP.

REVIEW OF LITERATURE

The LBP is a highly prevalent musculoskeletal disorder affecting individuals across all age groups. While stretching is widely studied in NSLBP, Aquastretch™ currently has limited empirical evidence despite promising clinical observations for improving the range of motion and function [14].

Keane LG compared AquaStretch with supervised land-based stretching in individuals with CLBP. A total of 29 participants were randomised into AquaStretch, land-based stretching, and control groups. The AquaStretch group demonstrated significant improvements in pain ($p=0.006$), kinesiophobia ($p=0.029$), and disability ($p=0.001$). AquaStretch was also found to be more time-efficient and cost-effective than land-based stretching [14].

Seif HE et al., investigated the effect of adding gastrocnemius stretching to conventional stretching programmes in individuals with CLBP. Forty participants aged 25-40 years were randomly allocated into two groups. The control group received stretching exercises for the back, hamstrings, and iliopsoas muscles, along with abdominal strengthening and postural training. The experimental group received the same programme with the addition of gastrocnemius stretching. Post-intervention analysis revealed greater improvements in pain,

trunk mobility, disability, and lumbosacral alignment in the experimental group ($p<0.01$), demonstrating the added benefit of gastrocnemius stretching in CLBP rehabilitation [15].

Shamshad M et al., conducted a randomised clinical trial comparing McKenzie extension exercises and ELDOA {Étirages Longitudinaux avec Décoaptation Ostéo-Articulaire meaning Longitudinal Osteo-Articular Decoaptation Stretching (also known as LOADS)} stretching in females with chronic NSLBP. Both groups showed significant improvements in pain, disability, lordosis angle, and spinal range of motion after four weeks ($p<0.05$). However, McKenzie extension exercises demonstrated superior outcomes compared to ELDOA [16].

Casiano VE et al., conducted a systematic review examining the role of exercise therapy in NSLBP and found that multi-modal interventions combining stretching with strengthening and aerobic components yielded the most consistent improvements across pain, disability, and functional outcomes. The review highlighted that targeted stretching of the posterior kinetic chain, including hamstrings and calf musculature, contributed meaningfully to pain reduction and improved mobility in CLBP [17].

Reis e Silva M and Lerebourg L demonstrated that limited calf muscle flexibility can adversely affect postural alignment and emphasised the importance of including ankle mobility and calf flexibility assessment in rehabilitation programs for individuals with LBP. However, the study was limited by its relatively small sample size and cross-sectional design. Additionally, the findings may not be generalisable to all populations, as only healthy young adults were included in the study [18].

Recent studies suggest that stretching the calf muscles and posterior kinetic chain can improve pain, mobility, and disability in individuals with CLBP or NSLBP. However, evidence regarding aquatic Tendo-Achilles stretching in NSLBP is limited, and no studies have objectively assessed calf muscle architectural changes using diagnostic ultrasonography following stretching interventions. Additionally, most existing studies have small sample sizes and short follow-up periods. Therefore, the present study is designed to address these gaps. Thus, the present study aims to evaluate the effect of three weeks of Tendo-Achilles stretching on land versus water in subjects having NSLBP.

MATERIALS AND METHODS

The present randomised controlled trial will be conducted at KLE University's Dr Prabhakar Kore Hospital and Medical Research Centre and associated tertiary care hospitals and screening camps in Belagavi, Karnataka, India, from January 2026 to June 2027. The research reference number KAHER/EC/24-25/391 has been accepted by the KAHER Ethics Committee on Human Subjects for a PhD Research Project. The study is registered in Clinical Trials Registry India with reference number CTRI/2025/02/080327. Informed consent will be obtained from each participant. Participants will be invited through screening camps, advertisements, and posters.

Inclusion criteria: The participants will be subjects with NSLBP without radiculopathy from three months to two years duration having Tendo-Achilles tightness, aged between 20-40 years, with MMST values below the normative range (i.e., lumbar flexion <5.67 cm (≥ 1 SD below the normative mean of 6.85 ± 1.18 cm) and/or lumbar extension <1.68 cm (≥ 1 SD below the normative mean of 2.42 ± 0.74 cm), indicating reduced lumbar mobility [19].

WBLT <12 cm in females and <13 cm in males who are willing to adhere to the treatment plan recommendations for the duration of the trial [20].

Exclusion criteria: Participants with specific LBP, any upper/lower limb fractures in the past six months, or any other condition/infection that can prevent the participants from participating in the study.

Sample size calculation: The sample size was calculated based on Keane LG who reported mean VAS scores of 21.50 ± 4.65 for AquaStretch and 24.46 ± 3.54 for land-based stretching. [14]:

Sample Size Formula: $n = (Z\alpha/2 + Z\beta)^2 \times (SD_1^2 + SD_2^2) / (\bar{x}_1 - \bar{x}_2)^2$

Where:

$Z\alpha/2 = Z(1-\alpha/2) = 1.96$ (at 95% confidence interval)

$Z\beta = Z(1-\beta) = 0.84$ (at 80% power)

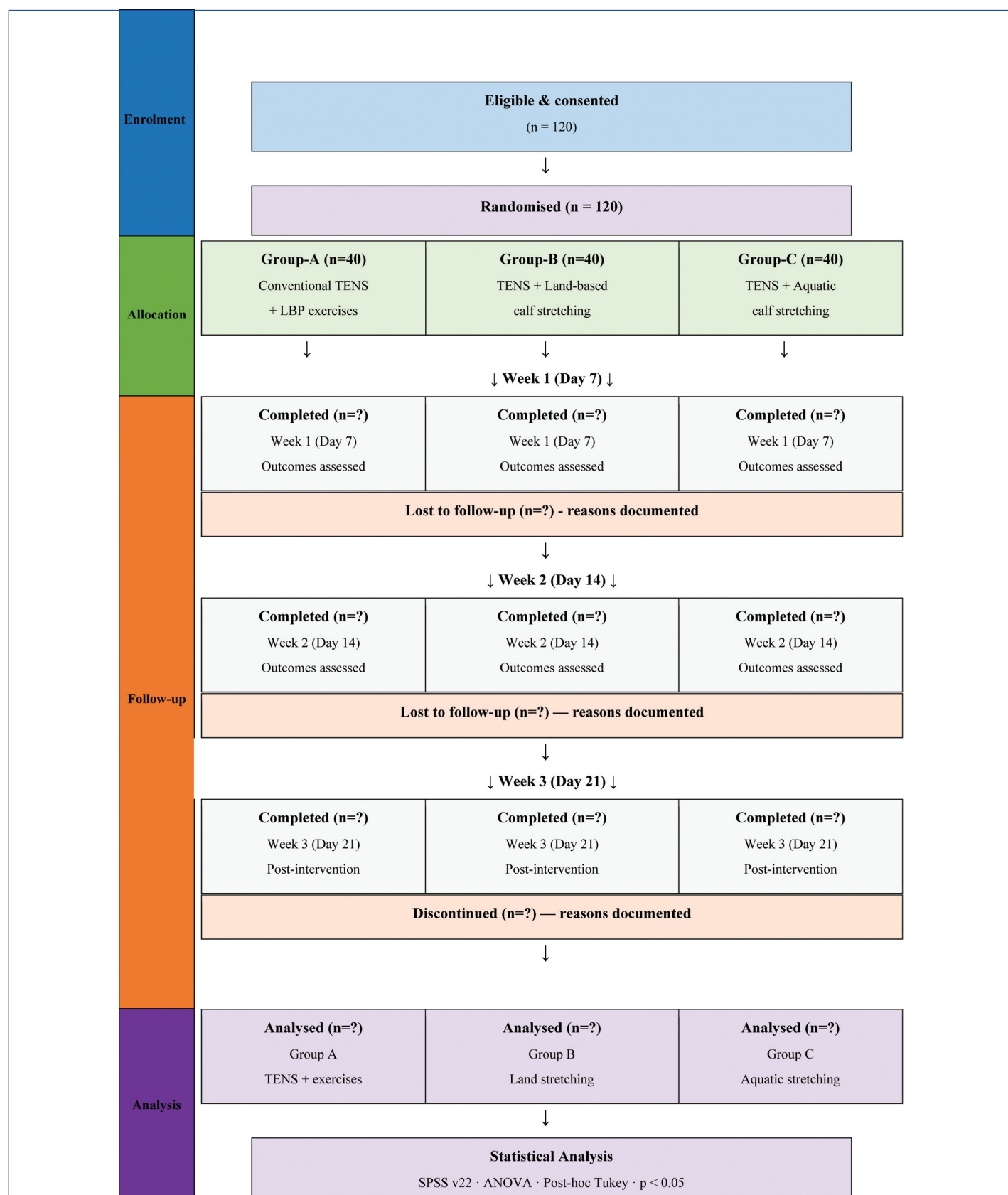
($Z\alpha/2 = 1.96$, $Z\beta = 0.84$)

$$n = (1.96 + 0.84)^2 \times (4.65^2 + 3.54^2) / (21.50 - 24.46)^2$$

$$= 30.56 \approx 31$$

While considering a 21% attrition rate, 120 participants (40 per group) will be recruited to maintain equal group allocation and provide an additional safety margin for attrition.

Participants will be randomly assigned to one of three study groups using simple randomisation through the sealed opaque envelope method [Table/Fig-1]. The sequence will be generated by an



[Table/Fig-1]: Consolidated Standards of Reporting Trials (CONSORT) flow diagram.

Outcomes assessed at each time point: Diagnostic Ultrasonography • WBLT • MMST • Y-Balance Test • LEFS • MODQ

Outcome assessor: Licensed physiotherapist | USG operator: Qualified radiologist (≥5 years experience, ICC ≥0.80)

independent statistician. Sealed, sequentially numbered opaque envelopes will be prepared before the commencement of the study and opened only after informed consent is obtained. The allocation concealment will be maintained by a research coordinator not involved in assessment or data analysis.

Study Procedure

Group A- Conventional TENS with Exercises for LBP: Participants will receive conventional TENS applied to the lower back with a frequency of 100 Hz and pulse duration of 200 μ s for 15 minutes, followed by the standardised LBP exercise protocol [Table/Fig-2]. All sessions will be administered three times per week for three weeks (9 sessions total).

Week/ Exercise	Group A (TENS+ Exercises)	Group B (TENS+Land Stretching+ Exercises)	Group C (TENS+Aquatic Stretching+ Exercises)
Week 1	Static back (10 reps $\times$ 3 sets) Pelvic bridging (10 reps $\times$ 3 sets)	Calf stretching on land (30 sec $\times$ 10 reps $\times$ 3 sets)+Static back (10 reps $\times$ 3 sets) Pelvic bridging (10 reps $\times$ 3 sets)	Calf stretching in water (30 sec $\times$ 10 reps $\times$ 3 sets)+Static back (10 reps $\times$ 3 sets) Pelvic bridging (10 reps $\times$ 3 sets)
Week 2	Week 1 exercises+Lumbar rotation (10 reps $\times$ 3 sets) Knee to chest (10 reps $\times$ 3 sets) Cat camel (10 reps $\times$ 3 sets)	Calf stretching on land+Week 1 exercises+Lumbar rotation (10 reps $\times$ 3 sets) Knee to chest (10 reps $\times$ 3 sets) Cat camel (10 reps $\times$ 3 sets)	Calf stretching in water+Week 1 exercises+Lumbar rotation (10 reps $\times$ 3 sets) Knee to chest (10 reps $\times$ 3 sets) Cat camel (10 reps $\times$ 3 sets)
Week 3	Weeks 1+2 exercises progressed to 15 reps $\times$ 3 sets	Calf stretching on land+Weeks 1+2 exercises progressed to 15 reps $\times$ 3 sets	Calf stretching in water+Weeks 1+2 exercises progressed to 15 reps $\times$ 3 sets

[Table/Fig-2]: Exercise intervention protocol for all three groups.

Group B-Conventional TENS with land-based calf stretching and exercises: Participants will receive conventional TENS as described for Group A, followed by calf stretching on land and the standardised LBP exercise protocol. Total session duration: 30 minutes, three times per week for three weeks.

Group C-Conventional TENS with aquatic calf stretching and exercises: Participants will receive conventional TENS as described for Group A, followed by calf muscle stretching performed in a warm-water pool (32-34°C, mid-chest depth) under the supervision of a trained physiotherapist, and the standardised LBP exercise protocol. Total session duration: 30 minutes, three times per week for three weeks. Safety protocols, including non-slip pool footwear, therapist supervision, and pre-session health screening will be employed to mitigate water-related risks.

Outcome Measures

Diagnostic ultrasonography: Ultrasound examinations will be performed by a qualified radiologist with a minimum of five years

of experience in musculoskeletal ultrasonography. Intra-rater and inter-rater reliability will be assessed at the start of the study using Intraclass Correlation Coefficients (ICC). ICC values ≥ 0.75 will be considered indicative of good reliability, and values ≥ 0.90 as excellent reliability [21].

Weight-Bearing Lunge Test (WBLT): will be employed to evaluate calf muscle flexibility. The participant will lunge forward toward a wall while keeping the heel on the ground, and the maximum distance between the great toe and the wall will be recorded as the flexibility measure. Normative WBLT values in adults aged 20-30 years ranged from 12.1-13.9 cm in females and 13.6-14.9 cm in males [20].

Modified-Modified Schober Test (MMST): will be used to assess lumbar mobility. The change in distance between the midpoint of the posterior superior iliac spines and a point 15 cm above during forward flexion will represent lumbar flexion, with higher values indicating greater mobility [19].

Y-Balance Test (YBT): Assesses dynamic balance of the lower limb through single-leg reach in the anterior, posteromedial, and posterolateral directions. Reach distances are normalised to limb length to calculate a composite score. An anterior reach asymmetry >4 cm and lower composite reach scores have been associated with increased risk of lower-extremity injury [22].

Lower Extremity Functional Scale (LEFS): A self-reported 20-item questionnaire that evaluates lower-limb function on a 5-point scale, from 0 (extreme difficulty/unable to perform activity) to 4 (no difficulty). Total scores range from 0 to 80, with higher scores reflecting better function. A minimum detectable change of 9 points and a Minimum Clinically Important Difference (MCID) of nine points will indicate meaningful clinical improvement [23].

Modified Oswestry Disability Questionnaire (MODQ): A 10-item self-reported tool will be used to assess the impact of LBP on daily activities. Scores will be expressed as a percentage (score/50 $\times$ 100), with higher values representing greater functional disability. Disability classification: 0-20%=minimal disability; 21-40%=moderate disability; 41-60%=severe disability; 61-80%=crippling back pain; 81-100%=bed-bound or exaggerating [24].

Outcome measures will be evaluated at baseline, Day 7, Day 14, and Day 21. A licensed physiotherapist will conduct the outcome assessments.

The schedule for enrolment, interventions and assessments is presented in [Table/Fig-3] as Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT).

STATISTICAL ANALYSIS

Data will be analysed using Statistical Package for the Social Sciences (SPSS) version 22.0. Normality of data will be tested using the Shapiro-Wilk test. ANOVA and post-hoc Tukey's test will be used for testing the significance of the hypothesis among groups. Paired t-test or Wilcoxon signed-rank test will be used for within-group comparisons based on normality. Statistical significance will be determined by a probability value of less than 0.05.

Time point	Enrolment	Allocation	Baseline (Pre)	Day 7	Day 14	Day 21 (Post)
Eligibility screening	X					
Informed consent	X					
Allocation		X				
Group A – TENS+Exercises			X	X	X	X
Group B – TENS+Land Stretching+Exercises			X	X	X	X
Group C – TENS+Aquatic Stretching+Exercises			X	X	X	X
Diagnostic ultrasonography			X	X	X	X
WBLT			X	X	X	X
MMST			X	X	X	X
Y-Balance Test			X	X	X	X

LEFS			X	X	X	X
MODQ			X	X	X	X

[Table/Fig-3]: Schedule of enrolment, interventions, and assessments (participant timeline – SPIRIT).

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