

EFFECTS OF MCKENZIE VERSUS ELDOA TECHNIQUE ON PAIN AND SPINAL MOBILITY IN PATIENTS WITH ANKYLOSIS SPONDYLITIS: A RANDOMIZED CLINICAL TRIAL

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Abstract

Background: Ankylosing spondylitis (AS) is a chronic inflammatory rheumatic disorder characterized by persistent spinal pain, stiffness, restricted spinal mobility, and impaired physical function. Exercise-based physiotherapy constitutes an important component of rehabilitation; however, comparative evidence regarding the effects of McKenzie Extension Exercises and ELDOA exercises in individuals with AS remains limited.

Objective: To compare the effects of McKenzie Extension Exercises and ELDOA (Elongation Longitudinal avec Decoaptation Osteo-Articulaire) exercises on pain intensity, spinal mobility, functional ability, and disease activity in patients with ankylosing spondylitis.

Methods: A randomised controlled trial was conducted among 52 patients with AS aged 18–40 years recruited from selected physiotherapy settings in Lahore, Pakistan. Participants were randomly allocated into two equal groups. Group A received McKenzie Extension Exercises, whereas Group B received ELDOA exercises. Both groups additionally received conventional physiotherapy for 12 weeks, with three treatment sessions per week. Pain intensity, functional ability, disease activity, and spinal mobility were assessed using the Numeric Pain Rating Scale (NPRS), Bath Ankylosing Spondylitis Functional Index (BASFI), Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), and Modified Schober Test, respectively. Within-group changes were analysed using paired-samples t-tests, while between-group differences in change scores were assessed using independent-samples t-tests. Statistical significance was established at $p < 0.05$.

Results: Both groups demonstrated statistically significant improvements in all outcome measures following the 12-week intervention ($p < 0.001$). In Group A, mean NPRS scores decreased from 6.80 ± 0.90 to 3.83 ± 1.05 , BASFI scores from 5.36 ± 0.89 to 3.52 ± 0.96 , and BASDAI scores from 5.49 ± 0.78 to 3.67 ± 0.96 , while Modified Schober measurements increased from 3.48 ± 0.61 to 5.00 ± 0.67 . In Group B, NPRS scores decreased from 6.08 ± 0.81 to 3.91 ± 0.88 , BASFI scores from 4.96 ± 0.69 to 3.43 ± 0.94 , and BASDAI scores from 5.50 ± 0.81 to 4.04 ± 1.00 , whereas Modified Schober measurements increased from 3.10 ± 0.65 to 4.29 ± 0.68 . Between-group analysis demonstrated statistically significant differences in

change scores for NPRS ($p < 0.001$), BASFI ($p = 0.030$), BASDAI ($p = 0.020$), and Modified Schober Test ($p = 0.008$).

Conclusion: Both McKenzie Extension Exercises and ELDOA exercises, when combined with conventional physiotherapy, were associated with significant improvements in pain intensity, spinal mobility, functional ability, and disease activity among patients with ankylosing spondylitis. The significant between-group differences indicate differential effects of the two exercise approaches across the assessed outcomes, supporting their consideration within structured physiotherapy-based rehabilitation programmes for AS.

1. INTRODUCTION

Ankylosing spondylitis (AS) is a chronic, progressive inflammatory rheumatic disorder primarily affecting the axial skeleton, particularly the sacroiliac joints and spine. It belongs to the spondyloarthropathies and is strongly associated with the human leukocyte antigen-B27 (HLA-B27) marker [1]. Persistent inflammation at the entheses and spinal structures contributes to pain, stiffness, restricted mobility, and progressive functional impairment. Early recognition and appropriate management are important because structural changes may initially develop gradually but can ultimately result in substantial disability [2].

The reported incidence of AS ranges from approximately 0.4 to 1.4 per 10,000 person-years, while prevalence estimates range from 0.1% to 1.4% globally [3]. Symptoms commonly begin during early adulthood, with approximately 80% of individuals developing symptoms before 30 years of age. Although AS has historically been reported more frequently in males, recent evidence suggests that the sex disparity may be less pronounced than previously considered [4]. The chronic nature of the disease can result in persistent pain, stiffness, reduced spinal flexibility, postural changes, and impaired quality of life [3,4].

Pathologically, chronic inflammation may progress to fibrosis, ossification, and ankylosis of spinal structures, resulting in reduced spinal mobility and postural abnormalities. Extra-articular manifestations may also involve organs such as the eyes, cardiovascular system, and lungs [5]. Clinically, AS is characterised by inflammatory low back pain, morning stiffness, stiffness after prolonged inactivity, and progressive restriction of spinal movement. Symptoms are typically improved by physical

activity and aggravated by rest, while peripheral arthritis, enthesitis, and fatigue may also occur [6]. These impairments can interfere with bending, lifting, sitting, standing, occupational activities, and social participation, thereby reducing independence and functional capacity [7].

Beyond physical limitations, AS may have important psychosocial and socioeconomic consequences. Chronic pain and disability may contribute to anxiety, depressive symptoms, social withdrawal, work absenteeism, and financial burden [8]. Management therefore requires a comprehensive approach incorporating both pharmacological and non-pharmacological strategies. Non-steroidal anti-inflammatory drugs (NSAIDs) are commonly used for symptomatic management, while biologic therapies targeting tumour necrosis factor-alpha (TNF- α) or interleukin-17 (IL-17) pathways may be considered for patients with persistently active disease. Conventional disease-modifying antirheumatic drugs have a more limited role in axial disease but may be used for peripheral joint involvement [4,8].

Physiotherapy and therapeutic exercise are important components of long-term AS management, with interventions targeting spinal mobility, flexibility, posture, physical function, and pain [9]. Mechanical Diagnosis and Therapy (MDT), commonly known as the McKenzie Method, uses systematic assessment, repeated movements, and patient-directed exercises to identify movement patterns that modify symptoms. Its emphasis on active participation and self-management may support functional recovery and continued exercise adherence [10,11]. Although the McKenzie approach has demonstrated benefits in various spinal disorders, including improvements in

pain and functional mobility, evidence specifically examining its effectiveness in AS remains limited [12]. The inflammatory and structural characteristics of AS also warrant condition-specific investigation rather than direct extrapolation from mechanical spinal disorders [10].

ELDOA (*Étirements Longitudinaux avec Decoaptation Osteo-Articulaire*) is a posture-based stretching approach involving specific sustained positions intended to generate longitudinal tension and targeted spinal decompression. The technique is proposed to influence segmental alignment, reduce mechanical tension, and improve spinal mobility [13]. Preliminary evidence has reported potential benefits for pain, spinal mobility, and postural function in selected musculoskeletal conditions; however, its evidence base remains limited [11]. In particular, research evaluating ELDOA in AS and directly comparing it with established exercise approaches such as McKenzie exercises is scarce.

Therefore, a comparative evaluation of these interventions is warranted to determine their effects on clinically relevant outcomes in patients with AS. The present randomised clinical trial aimed to compare the effects of McKenzie Extension Exercises and ELDOA exercises on pain and spinal mobility in patients with ankylosing spondylitis, while also evaluating changes in functional ability and disease activity using the Bath Ankylosing Spondylitis Functional Index (BASFI) and Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), respectively.

2. CRITICAL ANALYSIS OF PREVIOUS STUDIES

Previous studies provide evidence supporting exercise-based physiotherapy for improving pain, mobility, functional capacity, and disease-related outcomes in patients with ankylosing spondylitis (AS), although considerable methodological and clinical heterogeneity exists. Alam et al. conducted a single-centre comparative experimental study involving 112 patients with AS and reported significantly greater improvements in pain, BASFI, and BASDAI when McKenzie exercises were added to NSAID therapy compared with NSAIDs

alone over 12 weeks [15]. Similarly, Oksuz and Unal demonstrated that an 8-week programme combining clinical Pilates with aerobic training produced significant improvements in BASMI, BASDAI, BASFI, physical performance, and psychosocial outcomes, with several outcomes also improving following aerobic training alone [16]. Kabul et al. further reported that soft-tissue mobilisation combined with spinal mobility exercises produced greater improvements in disease activity, functional ability, spinal mobility, and quality of life than spinal mobility exercises alone [18]. Collectively, these findings support the role of structured exercise and adjunctive physiotherapy in AS; however, differences in intervention protocols, sample sizes, outcome measures, and treatment duration limit direct comparison between studies. Moreover, the relatively small sample in the study by Kabul et al. and the single-centre design of Alam et al. may restrict generalisability [15,18].

Evidence from related spinal and musculoskeletal conditions also provides a rationale for both McKenzie and ELDOA interventions, but its applicability to AS remains uncertain. Shamshad et al. directly compared McKenzie extension exercises with ELDOA stretches in women with chronic non-specific low back pain and found significant improvements in pain, spinal range of motion, lordosis, and disability in both groups, with greater overall changes reported in the McKenzie group [14]. However, the study population consisted of patients with non-specific low back pain rather than an inflammatory spinal disorder, limiting its direct applicability to AS. Similarly, Hawrylak et al. reported greater improvements in spinal mobility and pain following McKenzie-based physiotherapy than conventional physiotherapy in patients with lumbar discopathy [19], while Selim et al. found spinal mobilisation with leg movement to produce greater improvements than McKenzie therapy and TENS in patients with lumbar disc herniation [20]. These findings demonstrate that McKenzie-based interventions may influence spinal pain and mobility, but also indicate that treatment effects may vary according to the underlying pathology. Evidence for ELDOA has likewise been reported

primarily in non-AS populations. Sajjad et al. found significant improvements in pain and disability following ELDOA in patients with lumbar disc protrusion, while Saluja et al. reported significant improvements in pain and flexibility following ELDOA in patients with piriformis syndrome, although another intervention produced greater changes [17,21]. Thus, evidence supporting ELDOA remains largely derived from mechanical musculoskeletal conditions rather than inflammatory spinal disease.

Overall, the available literature supports exercise-based and physiotherapeutic interventions for improving clinically relevant outcomes; however, an important evidence gap remains regarding the direct comparison of McKenzie and ELDOA exercises in patients with AS. Existing AS-specific studies have predominantly examined McKenzie exercises, aerobic exercise, Pilates, or manual therapy, whereas ELDOA has mainly been investigated in conditions such as chronic low back pain, lumbar disc protrusion, and piriformis syndrome [14–21]. Furthermore, the existing comparative study of McKenzie and ELDOA was conducted in patients with non-specific low back pain rather than AS [14]. Therefore, findings from mechanically mediated spinal disorders cannot be assumed to represent responses in a chronic inflammatory condition characterised by enthesitis, structural changes, and progressive spinal restriction. A randomised clinical trial directly comparing these two exercise approaches in patients with AS is consequently warranted. The present study addresses this gap by comparing McKenzie Extension Exercises and ELDOA exercises, alongside conventional physiotherapy, with respect to pain, spinal mobility, functional ability, and disease activity in patients with AS.

OBJECTIVES AND HYPOTHESIS

The objective of this study was to evaluate and compare the effects of McKenzie and ELDOA techniques on pain and spinal mobility in patients with ankylosing spondylitis. The null hypothesis (H_0) stated that there would be no statistically significant difference between McKenzie and ELDOA techniques in terms of pain relief and spinal mobility among patients

with ankylosing spondylitis, whereas the alternative hypothesis (H_1) stated that a statistically significant difference would exist between the two techniques in terms of pain relief and spinal mobility.

3. MATERIALS AND METHODS

A randomised controlled trial (RCT) was conducted to compare the effects of McKenzie Extension Exercises and ELDOA exercises on pain, spinal mobility, functional ability, and disease activity in patients with ankylosing spondylitis (AS). The study was conducted in selected physiotherapy and rehabilitation settings in Lahore, Pakistan, including Ghurki Trust Teaching Hospital (Orthopaedic Department), Rehabcure Clinic (Physical Therapy and Rehabilitation Department), Combined Military Hospital (CMH) (Physiotherapy Department), and Pakistan Kidney and Liver Institute (PKLI) (Physiotherapy and Rehabilitation Department). A total of 52 participants aged 18–40 years were included and randomly allocated equally into Group A ($n = 26$), which received McKenzie Extension Exercises, and Group B ($n = 26$), which received ELDOA exercises. The sample size was calculated using G*Power 3.1 based on an effect size of 0.80, $\alpha = 0.05$, and 80% statistical power, and was consistent with previous comparative research involving McKenzie and ELDOA interventions [14]. The study population comprised male and female patients aged 18–40 years with an established diagnosis of AS who fulfilled the predefined eligibility criteria. The study was conducted over six months, including participant recruitment, baseline assessment, a 12-week intervention period, post-intervention assessment, data collection, and statistical analysis. Both groups received three treatment sessions per week for 12 weeks. Eligible participants were recruited from the selected settings and, following enrolment and baseline assessment, were randomly assigned to the two intervention groups using computer-generated randomisation, with Group A receiving McKenzie Extension Exercises and Group B receiving ELDOA exercises. Participants were eligible if they were aged 18–40 years, male or female, had an established diagnosis of AS,

reported chronic back pain and stiffness, had an NPRS score ≥ 5 , were physically capable of performing the prescribed exercises, and provided informed consent. Participants were excluded if they had a history of spinal surgery or spinal fracture, severe cardiac, renal, or neurological comorbidities, pregnancy, or concurrent participation in another physiotherapy programme during the study period. The independent variables were McKenzie Extension Exercises and ELDOA exercises, while the primary dependent outcomes were pain intensity and spinal mobility. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), and spinal mobility was assessed using the Modified Schober Test. Secondary outcomes included functional ability, assessed using the Bath Ankylosing Spondylitis Functional Index (BASFI), and disease activity, assessed using the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI).

RANDOMISATION, ALLOCATION AND BLINDING

Following confirmation of eligibility, 52 participants were randomly allocated in a 1:1 ratio to Group A (McKenzie, $n = 26$) or Group B (ELDOA, $n = 26$) using a computer-generated randomisation sequence. Randomisation was performed by an individual independent of participant recruitment, and allocation was concealed using a centrally administered system of sequentially numbered, opaque, sealed envelopes. Group A received McKenzie Extension Exercises, whereas Group B received ELDOA exercises, with both groups receiving conventional physiotherapy alongside their respective interventions. Due to the distinct nature of the interventions, participants and treating physiotherapists were not blinded; however, outcome assessments were performed by an independent physiotherapist who was unaware of participants' group allocation. Participants were instructed not to disclose their treatment allocation during assessment, and intervention groups were coded during statistical analysis to minimise potential analytical bias.

OUTCOME MEASUREMENT TOOLS

Bath Ankylosing Spondylitis Functional Index (BASFI)

The Bath Ankylosing Spondylitis Functional Index (BASFI) is a 10-item self-reported questionnaire designed to assess functional limitations in adults with ankylosing spondylitis (AS). The first eight items evaluate activities requiring functional spinal and musculoskeletal capacity, including putting on socks, bending to pick up objects, reaching high shelves, rising from a chair or the floor, standing, climbing stairs, and looking over the shoulder, whereas the final two items assess the ability to perform physically demanding tasks and routine home- or work-related activities. Participants report their ability to perform these activities during the preceding week. Each item is rated using a visual analogue scale (VAS) or numerical rating scale (NRS) from 0 to 10, where 0 represents no difficulty and 10 represents inability to perform the activity. The final BASFI score is calculated by adding the scores of all 10 items and dividing the total by 10, producing a score ranging from 0 to 10, with higher scores indicating greater functional limitation. BASFI has demonstrated good consistency, sensitivity to change, and greater responsiveness than other functional indices; for example, it has demonstrated a 20% improvement compared with 6% for the Dougados Functional Index ($p = 0.004$). It also demonstrates moderate-to-high test-retest reliability and established construct validity, with strong associations with spinal mobility measured by the Bath Ankylosing Spondylitis Metrology Index (BASMI) and patient-perceived functional status. Its responsiveness and ease of administration make it suitable for detecting functional changes during physiotherapy and for both clinical and research applications [22].

Bath Ankylosing Spondylitis Disease Activity Index (BASDAI)

The Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) is a six-item self-reported questionnaire used to assess disease activity in adults with AS during the preceding seven days. It evaluates six domains: fatigue or tiredness, neck/back/hip pain related to AS, peripheral joint pain or swelling, localised tenderness, severity of morning stiffness, and

duration of morning stiffness. Each item is rated on a 0–10 VAS or NRS, where 0 represents no symptoms and 10 represents the most severe symptoms. Items 1–4 assess fatigue, spinal pain, peripheral joint pain or swelling, and tenderness, respectively, while items 5 and 6 assess the severity and duration of morning stiffness; duration is assessed from 0 to 2 or more hours. To calculate the final BASDAI score, the scores for the severity and duration of morning stiffness are averaged, this value is added to the scores of items 1–4, and the resulting total is divided by 5. The final score ranges from 0 to 10, with higher scores indicating greater disease activity. BASDAI demonstrates strong test–retest reliability ($p < 0.001$) and established content validity and has demonstrated greater ability than some alternative indices, including the Newcastle Enthesis Index, to capture disease activity. It is also responsive to clinical change; a three-week physiotherapy intervention has been associated with a 16.4-percentage-point improvement in BASDAI ($p = 0.009$), supporting its sensitivity to changes in disease status [23].

Schober Test (Modified Schober Test)

The Schober Test and its modifications are clinical measures of lumbar spinal flexion and are commonly used to assess restricted spinal mobility in patients with AS and other spondyloarthropathies. For the Schober procedure, the participant stands upright while the examiner identifies the lumbosacral reference point and marks the required anatomical landmarks. In the original technique, the L5 spinous process is identified and a reference line is marked at 10 cm above it. The participant then performs maximal forward trunk flexion, as if attempting to touch the toes, and the difference between the standing and flexed measurements is recorded as an indicator of lumbar flexion. The Modified Schober Test uses the posterior superior iliac spines (PSIS) as anatomical references, with a point marked 5 cm below and another 10 cm above the midpoint, providing a modified and more precise assessment of lumbar mobility. A limited increase in the measured distance during forward flexion indicates restricted lumbar range of motion and may be associated with AS

or other spinal restrictions. The reported reliability of the Original Schober Test is high, with an ICC of 0.90–0.96 and validity coefficients of $r = 0.68$ –0.90. The Modified Schober Test demonstrates ICC values of 0.92–0.96 and validity coefficients of $r = 0.59$ –0.97, while the Modified Modified Schober Test has reported reliability of ICC = 0.91–0.95 and validity of $r = 0.67$ [24,25]. The spinal segments assessed by the different Schober methods are summarised as follows: Original Schober: L2/L3–S1; Modified Schober: L2/L3–S1; Modified Modified Schober: L1/L2–S1; and Wolfson Modified Schober: T12/L1–S1 [24,25].

Numeric Pain Rating Scale (NPRS)

The Numeric Pain Rating Scale (NPRS) is a self-reported, unidimensional instrument used to quantify pain intensity in adults. Participants rate their current or experienced pain on a numerical scale from 0 to 10, where 0 indicates no pain, 1–3 indicates mild pain, 4–6 indicates moderate pain, and 7–10 indicates severe pain. The NPRS is simple to administer and is widely used in clinical and research settings to assess changes in pain intensity. It demonstrates high test–retest reliability, with reported reliability coefficients ranging from 0.95 to 0.96, and high validity, with correlation coefficients of 0.86–0.95 when compared with the Visual Analogue Scale (VAS) and other established pain assessment measures [26,27].

INTERVENTION PROTOCOLS

Both intervention groups received the same conventional physiotherapy programme in addition to their respective exercise interventions. Conventional treatment consisted of heat therapy to reduce pain and stiffness, Transcutaneous Electrical Nerve Stimulation (TENS) for pain relief, soft-tissue mobilisation of the paraspinal muscles, and light warm-up activities including slow walking and gentle stretching. Active spinal range-of-motion exercises involving flexion, extension, lateral bending, and rotation were performed. Respiratory training was provided before thoracic range-of-motion exercises, followed by postural correction before commencement of the exercise programme.

Group A: McKenzie Extension Exercises

The McKenzie Extension Exercise programme was implemented to reduce spinal pain, improve lumbar and thoracic extension, and enhance spinal mobility in patients with ankylosing spondylitis. The supervised programme was administered three times per week for approximately 40–50 minutes per session, supplemented by daily home exercises of approximately 10–15 minutes, for a total intervention period of 12 weeks. The exercise

protocol included prone lumbar extension, standing lumbar extension, prone press-ups, cat-camel stretching, seated lumbar extension, and pelvic tilts, as detailed in Table 3.1. Exercise intensity was progressed according to individual tolerance, with holding duration gradually increased from 5 to 10 seconds over the first 4–6 weeks and repetitions subsequently increased as tolerated. The protocol was based on previously reported McKenzie exercise approaches [12,14,19].

Table 1 McKenzie Extension Exercise Protocol

Exercise	Duration/Repetitions	Frequency	Targeted Muscles/Area
Prone Lumbar Extension	10–12 repetitions, 5–10-second hold	3–5 sets	Erector spinae, multifidus, lumbar extensors
Standing Lumbar Extension	10 repetitions, 5-second hold	3–5 sets	Erector spinae, lumbar extensors
Prone Press-ups	8–10 repetitions, 10-second hold	3–4 sets	Lumbar extensors, core stabilisers
Cat-Camel Stretch	10 repetitions	Daily	Spinal mobility, thoracic and lumbar flexibility
Seated Lumbar Extension	10–12 repetitions, 5-second hold	3–5 sets	Lumbar extensors, erector spinae
Pelvic Tilts	10–12 repetitions	Daily	Abdominals, lumbar stabilisers

Note. Exercise progression was based on individual tolerance, with gradual increases in holding duration and repetitions.

Group B: ELDOA Exercises

The ELDOA (Elongation Longitudinal avec Decoaptation Osteo-Articulaire) programme was designed to promote spinal decompression, postural correction, and spinal flexibility in patients with ankylosing spondylitis. Supervised sessions were conducted three times per week for approximately 30–40 minutes per session, supplemented by daily home exercises of approximately 10 minutes, over a 12-week period. The programme consisted of segment-specific ELDOA exercises targeting L5–S1, L4–

L5, L3–L4, T12–L2, and the cervical/upper thoracic region, together with scapular retraction exercises, as presented in Table 3.2. Hold duration was progressively increased by approximately 5–10 seconds per week, while repetitions were increased from 2 to 4 sets according to individual tolerance. Particular emphasis was placed on maintaining correct posture, segmental alignment, controlled breathing, and spinal decompression throughout each exercise.

Table 2 ELDOA Exercise Protocol

Exercise	Duration/Repetitions	Frequency	Targeted Muscles/Area
ELDOA L5–S1	30–45-second hold × 3	Daily	Lumbar spine, multifidus, erector spinae
ELDOA L4–L5	30–45-second hold × 3	Daily	Lumbar extensors, gluteals
ELDOA L3–L4	30–45-second hold × 3	Daily	Mid-lumbar spine, core stabilisers
ELDOA T12–L2	30–45-second hold × 3	Daily	Thoracolumbar extensors, obliques
ELDOA Cervical/Upper	20–30-second hold × 3	Daily	Cervical extensors, upper

Thoracic			trapezius, rhomboids
Scapular Retraction with ELDOA	15–20 repetitions	3 sets	Trapezius, rhomboids, postural muscles

Note. Hold duration was increased by approximately 5–10 seconds per week, and the number of sets was progressed from 2 to 4 according to participant tolerance, with emphasis on postural control and spinal decompression.

Ethical approval was obtained from the relevant institutional ethics/research committee before commencement of the study, and written informed consent was obtained from all participants after explaining the study objectives, procedures, potential risks, benefits, voluntary nature of participation, and right to withdraw at any stage without consequence. Participant privacy and confidentiality were maintained throughout the study, and all research data were coded and used solely for research purposes. Data were collected at baseline and following the 12-week intervention at Ghurki Trust Teaching Hospital, Rehabcure Clinic, Combined Military Hospital (CMH), and Pakistan Kidney and Liver Institute (PKLI), Lahore, Pakistan. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), spinal mobility using the Modified Schober Test, functional ability using the Bath Ankylosing Spondylitis Functional Index (BASFI), and disease activity using the Bath Ankylosing Spondylitis Disease Activity Index

(BASDAI). Outcome assessments were performed by a physiotherapist blinded to group allocation, while exercise performance, participant safety, adherence, and any adverse events were monitored throughout the intervention. Data were entered, coded, checked for completeness, and analysed using SPSS version 26.0. Continuous variables were presented as mean $\pm$ standard deviation (SD), whereas categorical variables were expressed as frequencies and percentages. The Kolmogorov–Smirnov test was used to assess data normality. For normally distributed data, paired-samples *t*-tests were used to assess within-group changes, while independent-samples *t*-tests were used to compare between-group changes in outcome scores. Appropriate non-parametric tests were applied when normality assumptions were violated. Statistical significance was set at $p \leq 0.05$, with all tests performed as two-tailed analyses.

'EFFECTS OF MCKENZIE VERSUS ELDOA TECHNIQUE ON PAIN AND SPINAL MOBILITY IN PATIENTS WITH ANKYLOSING SPONDYLITIS: A RANDOMIZED CLINICAL TRIAL

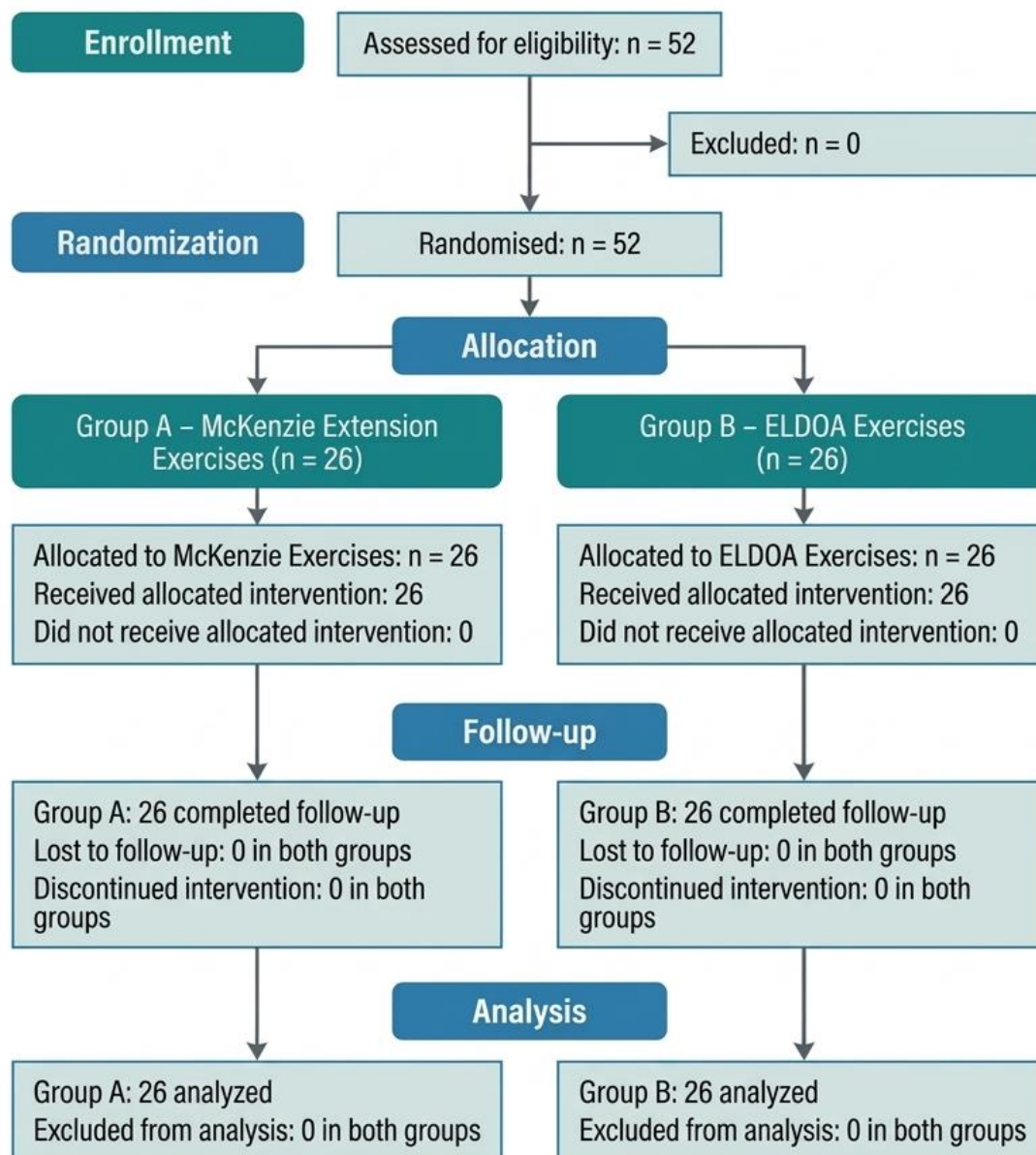


Figure 1. CONSORT flow diagram illustrating the patient screening, eligibility, randomization, allocation, follow-up, and statistical analysis processes for the randomized clinical trial comparing McKenzie Extension Exercises and ELDOA Exercises in patients with Ankylosing Spondylitis.

4. DATA ANALYSIS AND RESULTS

Interpretation. As presented in Table 3, the two intervention groups demonstrated broadly comparable baseline characteristics in terms of age, BMI, and duration of ankylosing spondylitis. Males constituted 57.7% of the

McKenzie Extension Exercises group and 61.5% of the ELDOA Exercise group. HLA-B27 negativity was more frequent in the McKenzie group (73.1%), whereas the ELDOA group had an equal distribution of HLA-B27-negative and HLA-B27-positive participants (50.0% each).

Non-smokers represented the majority of participants in both groups, accounting for 65.4% in the McKenzie group and 61.5% in the ELDOA group.

Interpretation. As presented in Table 4, both intervention groups demonstrated improvement across all measured outcomes after 12 weeks. NPRS scores decreased from 6.80 ± 0.90 to 3.83 ± 1.05 in the McKenzie Extension Exercises group and from 6.08 ± 0.81 to 3.91 ± 0.88 in the ELDOA Exercises group. BASFI scores decreased from 5.36 ± 0.89 to 3.52 ± 0.96 and from 4.96 ± 0.69 to 3.43 ± 0.94 , respectively, while BASDAI scores decreased from 5.49 ± 0.78 to 3.67 ± 0.96 in the McKenzie group and from 5.50 ± 0.81 to 4.04 ± 1.00 in the ELDOA group. Conversely, Modified Schober Test measurements increased from 3.48 ± 0.61 to 5.00 ± 0.67 in the McKenzie group and from 3.10 ± 0.65 to 4.29 ± 0.68 in the ELDOA group, indicating improved spinal mobility following both interventions.

Interpretation. As shown in Table 5, all baseline, 12-week, and change scores for NPRS, BASFI, BASDAI, and Modified Schober demonstrated normal distributions in both groups, with all p values $> .05$. The lowest p value was observed for baseline BASDAI in the McKenzie group ($p = .053$); therefore, the

normality assumption was satisfied for all outcome variables.

Interpretation. As shown in Table 6, both McKenzie Extension Exercises and ELDOA Exercises produced statistically significant within-group improvements across all outcome measures. NPRS, BASFI, and BASDAI scores significantly decreased after 12 weeks in both groups ($p < .001$), while Modified Schober measurements significantly increased, indicating improved spinal mobility ($p < .001$). The paired-samples t tests demonstrated significant changes from baseline to 12 weeks for all assessed outcomes in both intervention groups.

Interpretation. As presented in Table 7, statistically significant between-group differences were observed for all outcome variables. The change in NPRS was significantly greater in the McKenzie Extension Exercises group than in the ELDOA Exercise group, $t(50) = 5.773$, $p < .001$. Significant differences were also observed for BASFI, $t(50) = 2.237$, $p = .030$; BASDAI, $t(50) = 2.405$, $p = .020$; and Modified Schober, $t(50) = 2.760$, $p = .008$. Both groups demonstrated improvement from baseline to 12 weeks, while the magnitude of change differed significantly between the two intervention groups across pain, functional ability, disease activity, and spinal mobility.

Table 3: Baseline Characteristics of Participants in the McKenzie Extension Exercises and ELDOA Exercise Groups

Characteristic	McKenzie Extension Exercises ($n = 26$)	ELDOA Exercise ($n = 26$)
Age, years	27.58 ± 6.22	28.62 ± 6.20
Age range, years	18–39	19–38
BMI, kg/m^2	23.40 ± 2.58	22.19 ± 3.41
BMI range, kg/m^2	18.00–28.40	18.00–31.30
Duration of AS, years	5.84 ± 3.37	5.23 ± 2.21
Duration range, years	1.00–13.60	1.00–10.60
Gender, n (%)		
Male	15 (57.7)	16 (61.5)
Female	11 (42.3)	10 (38.5)
HLA-B27 status, n (%)		
Negative	19 (73.1)	13 (50.0)
Positive	7 (26.9)	13 (50.0)
Smoking status, n (%)		
No	17 (65.4)	16 (61.5)
Yes	9 (34.6)	10 (38.5)

Note. Values are presented as mean $\pm$ standard deviation (SD) for continuous variables and frequency (n) and

percentage (%) for categorical variables. BMI = body mass index; AS = ankylosing spondylitis; HLA-B27 = human leukocyte antigen-B27.

Table 4: Descriptive Statistics of Clinical Outcome Measures Before and After McKenzie Extension and ELDOA Exercise Interventions

Outcome Measure	Intervention Group	Assessment	n	M ± SD
Numeric Pain Rating Scale (NPRS)	McKenzie Extension Exercises	Baseline	26	6.80 ± 0.90
		12-week	26	3.83 ± 1.05
	ELDOA Exercises	Baseline	26	6.08 ± 0.81
		12-week	26	3.91 ± 0.88
Bath Ankylosing Spondylitis Functional Index (BASFI)	McKenzie Extension Exercises	Baseline	26	5.36 ± 0.89
		12-week	26	3.52 ± 0.96
	ELDOA Exercises	Baseline	26	4.96 ± 0.69
		12-week	26	3.43 ± 0.94
Bath Ankylosing Spondylitis Disease Activity Index (BASDAI)	McKenzie Extension Exercises	Baseline	26	5.49 ± 0.78
		12-week	26	3.67 ± 0.96
	ELDOA Exercises	Baseline	26	5.50 ± 0.81
		12-week	26	4.04 ± 1.00
Modified Schober Test (MST)	McKenzie Extension Exercises	Baseline	26	3.48 ± 0.61
		12-week	26	5.00 ± 0.67
	ELDOA Exercises	Baseline	26	3.10 ± 0.65
		12-week	26	4.29 ± 0.68

Note. M = mean; SD = standard deviation; n = number of participants; NPRS = Numeric Pain Rating Scale; BASFI = Bath Ankylosing Spondylitis Functional Index; BASDAI = Bath Ankylosing Spondylitis Disease Activity Index; MST = Modified Schober Test.

Table 5: Shapiro–Wilk Test of Normality for Outcome Variables in the McKenzie Extension Exercises and ELDOA Exercise Groups

Group	Outcome Variable	Assessment	Shapiro–Wilk (W)	p	Distribution
McKenzie	NPRS	Baseline	0.979	.858	Normal
		12 weeks	0.952	.258	Normal
		Change	0.947	.198	Normal
	BASFI	Baseline	0.968	.581	Normal
		12 weeks	0.959	.366	Normal
		Change			

		Change	0.974	.718	Normal
	BASDAI	Baseline	0.923	.053	Normal
		12 weeks	0.987	.982	Normal
		Change	0.968	.584	Normal
	Modified Schober	Baseline	0.955	.298	Normal
		12 weeks	0.953	.274	Normal
		Change	0.963	.464	Normal
ELDOA	NPRS	Baseline	0.947	.194	Normal
		12 weeks	0.974	.719	Normal
		Change	0.963	.456	Normal
	BASFI	Baseline	0.968	.574	Normal
		12 weeks	0.966	.521	Normal
		Change	0.982	.920	Normal
	BASDAI	Baseline	0.978	.839	Normal
		12 weeks	0.939	.124	Normal
		Change	0.954	.285	Normal
	Modified Schober	Baseline	0.963	.445	Normal
		12 weeks	0.964	.479	Normal
		Change	0.944	.165	Normal

Note. NPRS = Numeric Pain Rating Scale; BASFI = Bath Ankylosing Spondylitis Functional Index; BASDAI = Bath Ankylosing Spondylitis Disease Activity Index; $p > .05$ indicates no significant departure from normality.

Table 6: Within-Group Comparison of Outcome Measures at Baseline and 12 Weeks in the McKenzie Extension Exercises and ELDOA Exercise Groups

Outcome Measure	Intervention Group	Assessment	M ± SD	Mean Difference	95% CI	t	df	p
NPRS	McKenzie Extension Exercises	Baseline	6.80 ± 0.90	2.98	2.78–3.17	31.552	25	< .001
		12 weeks	3.83 ± 1.05					
	ELDOA Exercises	Baseline	6.08 ± 0.81	2.17	1.96–2.38	21.000	25	< .001
		12 weeks	3.91 ± 0.88					
BASFI	McKenzie Extension Exercises	Baseline	5.36 ± 0.89	1.83	1.63–2.04	18.716	25	< .001
		12 weeks	3.52 ± 0.96					
	ELDOA Exercises	Baseline	4.96 ± 0.69	1.53	1.33–1.72	16.138	25	< .001
		12 weeks	3.43 ± 0.94					

BASDAI	McKenzie Extension Exercises	Baseline	5.49 ± 0.78	1.82	1.64– 1.99	21.012	25	< .001
		12 weeks	3.67 ± 0.96					
	ELDOA Exercises	Baseline	5.50 ± 0.81	1.46	1.21– 1.71	12.096	25	< .001
		12 weeks	4.04 ± 1.00					
Modified Schober Test	McKenzie Extension Exercises	Baseline	3.48 ± 0.61	–1.52*	–1.68 to –1.36	–19.612	25	< .001
		12 weeks	5.00 ± 0.67					
	ELDOA Exercises	Baseline	3.10 ± 0.65	–1.19*	–1.38 to –1.01	–13.307	25	< .001
		12 weeks	4.29 ± 0.68					

Note. M = mean; SD = standard deviation; CI = confidence interval; NPRS = Numeric Pain Rating Scale; BASFI = Bath Ankylosing Spondylitis Functional Index; BASDAI = Bath Ankylosing Spondylitis Disease Activity Index; df = degrees of freedom. Within-group comparisons were performed using paired-samples *t* tests. *P* < .05 was considered statistically significant. *Mean differences for NPRS, BASFI, and BASDAI were calculated as baseline – 12 weeks; for the Modified Schober Test, the difference was also calculated as baseline – 12 weeks, hence the negative values.

Table 7: Between-Group Comparison of Changes in NPRS, BASFI, BASDAI, and Modified Schober Scores

Outcome variable	McKenzie Extension Exercises (<i>n</i> = 26), <i>M</i> ± <i>SD</i>	ELDOA Exercise (<i>n</i> = 26), <i>M</i> ± <i>SD</i>	Mean difference	95% CI	<i>t</i>	<i>df</i>	<i>p</i>
Change in NPRS	2.98 ± 0.48	2.17 ± 0.53	0.81	[0.53, 1.09]	5.773	50	< .001
Change in BASFI	1.83 ± 0.50	1.53 ± 0.48	0.31	[0.03, 0.58]	2.237	50	.030
Change in BASDAI	1.82 ± 0.44	1.46 ± 0.62	0.36	[0.06, 0.66]	2.405	50	.020
Change in Modified Schober	1.52 ± 0.39	1.19 ± 0.46	0.33	[0.09, 0.56]	2.760	50	.008

Note. NPRS = Numeric Pain Rating Scale; BASFI = Bath Ankylosing Spondylitis Functional Index; BASDAI = Bath Ankylosing Spondylitis Disease Activity Index; CI = confidence interval. Change scores were calculated from baseline to 12 weeks. Independent-samples *t* tests were used for between-group comparisons. Levene's test indicated homogeneity of variance for all outcome variables (*p* > .05).

5. DISCUSSION***NPRS and Pain Intensity***

Both McKenzie Extension Exercises and ELDOA significantly reduced pain intensity after 12 weeks. NPRS decreased from 6.80 ± 0.90 to 3.83 ± 1.05 in the McKenzie group and from 6.08 ± 0.81 to 3.91 ± 0.88 in the ELDOA group, with significantly greater change in the McKenzie group ($p < .001$). These findings are consistent with Shamshad et al., who directly compared McKenzie and ELDOA exercises and reported significant pain reduction in both groups, with greater improvement following McKenzie exercise [28]. Similar reductions in pain following McKenzie-based interventions have been reported in patients with spinal disorders, including lumbar spondylolisthesis and chronic low back pain [29,36,38]. Al-Banawi et al. also reported significant improvements in pain, disability, and spinal mobility following McKenzie-based exercise [30]. The improvement may be related to repeated controlled spinal extension and increased movement tolerance. ELDOA may similarly reduce symptoms through axial elongation, postural alignment, and myofascial loading; previous studies have reported improvements in pain and disability following ELDOA-based interventions [34,35]. However, the evidence for ELDOA is largely derived from non-AS populations.

BASFI

Both interventions produced significant improvements in functional ability, with BASFI decreasing from 5.36 ± 0.89 to 3.52 ± 0.96 in the McKenzie group and from 4.96 ± 0.69 to 3.43 ± 0.94 in the ELDOA group ($p < .001$). The between-group difference was also statistically significant ($p = .030$). These findings are supported by Gur Kabul et al., who reported significant improvements in functional outcomes following spinal mobility exercise and soft-tissue mobilisation in patients with AS [31]. McKenzie-based rehabilitation has likewise demonstrated improvements in functional disability among patients with spinal disorders [30,36]. The observed functional gains may reflect reduced pain and stiffness together with improved spinal mobility and movement confidence. Repeated spinal movements may

contribute to these changes with McKenzie exercise, whereas ELDOA may facilitate functional improvement through spinal elongation, postural control, and targeted myofascial tension.

BASDAI

BASDAI scores significantly decreased in both groups, from 5.49 ± 0.78 to 3.67 ± 0.96 in the McKenzie group and from 5.50 ± 0.81 to 4.04 ± 1.00 in the ELDOA group ($p < .001$), with a significant between-group difference ($p = .020$). Gur Kabul et al. similarly reported significant improvements in BASDAI following a rehabilitation programme incorporating spinal mobility exercises and soft-tissue mobilisation in patients with AS [31]. These findings are also consistent with previous evidence supporting exercise-based rehabilitation in AS [33]. The reduction in BASDAI may partly reflect improvements in pain, stiffness, and physical function. However, exercise-related improvement in BASDAI should not be interpreted as direct suppression of inflammatory disease activity. McKenzie exercises emphasise repeated spinal movement, whereas ELDOA emphasises sustained elongation and postural positioning. The significant between-group difference therefore represents a difference in the magnitude of change rather than definitive evidence that one intervention is universally superior.

Modified Schober

Lumbar spinal mobility improved significantly in both groups. Modified Schober measurements increased from 3.48 ± 0.61 cm to 5.00 ± 0.67 cm with McKenzie exercise and from 3.10 ± 0.65 cm to 4.29 ± 0.68 cm with ELDOA ($p < .001$), with a significant between-group difference ($p = .008$). These findings are consistent with Gur Kabul et al., who reported improvements in mobility-related outcomes following spinal mobility-based rehabilitation in patients with AS [31]. McKenzie exercise may improve mobility through repeated spinal extension and progressive exposure to movement, whereas ELDOA may contribute through axial elongation, postural alignment, and flexibility of surrounding tissues. Improvements in spinal mobility following

McKenzie-based interventions have also been reported in low back pain populations [30,36,38], while ELDOA studies have demonstrated mobility-related benefits in other spinal conditions [34,35]. Nevertheless, differences in diagnosis, intervention protocols, and outcome measures limit direct comparison with the present AS population [39].

Comparison of Overall Treatment Effects

Overall, both interventions produced significant within-group improvements in pain, functional limitation, disease activity, and spinal mobility. Significant between-group differences were also observed for NPRS, BASFI, BASDAI, and Modified Schober scores. The findings are consistent with the direct comparison by Shamshad et al., which demonstrated significant improvements following both McKenzie and ELDOA interventions [28]. Evidence from McKenzie-based studies further supports improvements in pain, disability, and spinal mobility [29,30,36,38]. In contrast, evidence supporting ELDOA remains comparatively limited and is predominantly based on other spinal conditions, including cervical radiculopathy and lumbar disc protrusion [34,35]. Therefore, the present study extends the available evidence by evaluating both interventions in individuals with AS using disease-specific measures such as BASFI and BASDAI. Differences in study populations, intervention duration, protocols, and outcome measures should nevertheless be considered when comparing the magnitude of effects across studies [40].

6. CONCLUSION

This randomised controlled trial found that both McKenzie Extension Exercises and ELDOA significantly improved pain intensity, functional ability, disease activity, and lumbar spinal mobility in patients with ankylosing spondylitis after 12 weeks. Significant within-group improvements were observed in NPRS, BASFI, BASDAI, and Modified Schober scores, with significant between-group differences in the magnitude of change. These findings indicate that both exercise approaches may provide beneficial effects in the rehabilitation of patients with ankylosing spondylitis.

7. LIMITATIONS

The study was limited by its relatively small sample of 52 participants and non-probability sampling, which may restrict generalisability. Participant and therapist blinding was not feasible, although the outcome assessor was blinded. The use of conventional physiotherapy in both groups limited the ability to isolate the effects of each exercise programme. Additionally, home-exercise adherence was not objectively monitored, follow-up beyond 12 weeks was unavailable, and outcomes such as quality of life, fatigue, thoracic mobility, and inflammatory markers were not assessed.

8. RECOMMENDATIONS

Future research should use larger multicentre randomised controlled trials with probability-based sampling and longer follow-up periods. Including a usual-care or control group, objectively monitoring home-exercise adherence, and assessing additional outcomes such as quality of life, fatigue, thoracic mobility, and inflammatory markers may provide more comprehensive evidence of treatment effects.

REFERENCES

1. Ebrahimiadib N, Berijani S, Ghahari M, Pahlaviani FG. Ankylosing spondylitis. *J Ophthalmic Vis Res.* 2021;16(3):462.
2. Hwang MC, Ridley L, Reveille JD. Ankylosing spondylitis risk factors: a systematic literature review. *Clin Rheumatol.* 2021;40(8):3079-93.
3. Crossfield SS, Marzo-Ortega H, Kingsbury SR, Pujades-Rodriguez M, Conaghan PG. Changes in ankylosing spondylitis incidence, prevalence and time to diagnosis over two decades. *RMD Open.* 2021;7(3).
4. Rashid MU, Khurshid A, Shaukat H, Ashraf FF, Lodhi MH, Naveed A, Habib MF. Disease patterns of ankylosing spondylitis associated treatment patterns and drug utilization among affected patients. *Pak J Health Sci.* 2024;13-8.

5. Alexander M. Ankylosing spondylitis pathogenesis and pathophysiology. In: Ankylosing Spondylitis-Recent Concepts. IntechOpen; 2023 Jan 10.
6. Murphy SN, Nguyen BA, Singh R, Brown NJ, Shahrestani S, Neal MT, Patel NP, Kalani MA. A brief human history of ankylosing spondylitis: a scoping review of pathogenesis, diagnosis, and treatment. *Surg Neurol Int.* 2022;13:297.
7. Agrawal P, Tote S, Sapkale B. Diagnosis and treatment of ankylosing spondylitis. *Cureus.* 2024;16(1).
8. Perrotta FM, Scriffignano S, Ciccio F, Lubrano E. Therapeutic targets for ankylosing spondylitis—recent insights and future prospects. *Open Access Rheumatol.* 2022;14:57-66.
9. Le QA, Kang JH, Lee S, Delevry D. Cost-effectiveness of treatment strategies with biologics in accordance with treatment guidelines for ankylosing spondylitis: a patient-level model. *J Manag Care Spec Pharm.* 2020;26(10):1219-31.
10. Alam I, Khan NN, Shahaly S, Ahmed RA, Salek AK, Uddin T. A comparative study between NSAID with McKenzie exercise versus NSAID treatment in ankylosing spondylitis. *SAS J Med.* 2023;2:66-73.
11. Rastin L. The effectiveness of McKenzie approach in treating radicular low back pain. (no journal details).
12. Alam I, Khan NN, Shahaly S, Ahmed RA, Salek AK, Uddin T. Functional outcome of McKenzie exercise in patients with ankylosing spondylitis—a single center study in Bangladesh. *Saudi J Med.* 2023;8(2):44-50.
13. Sajjad AG, Javed MS, Rasul A, Hussain SA, Naqvi SA. Comparison of the effects of decompression and ELDOA on pain and disability in lumbar disc protrusion. *Rehman J Health Sci.* 2021;3(2):92-6.
14. Shamshad M, Kanwal R, Butt R, Haider HM. Effects of ELDOA technique versus McKenzie extension exercises on non-specific low back pain patients: a randomized clinical trial. *Rehabil J.* 2022;6(03):429-34.
15. Alam I, Khan NN, Shahaly S, Ahmed RA, Salek AK, Uddin T. Functional outcome of McKenzie exercise in patients with ankylosing spondylitis—a single center study in Bangladesh. *Saudi J Med.* 2023;8(2):44-50.
16. Oksüz S, Unal E. Comparison of the effects of aerobic training alone versus aerobic training combined with clinical Pilates exercises on the functional and psychosocial status of patients with ankylosing spondylitis: a randomized controlled trial. *Physiother Theory Pract.* 2023;39(1):61-71.
17. Sajjad AG, Javed MS, Rasul A, Hussain SA, Naqvi SA. Comparison of the effects of decompression and ELDOA on pain and disability in lumbar disc protrusion. *Rehman J Health Sci.* 2021;3(2):92-6.
18. Gur Kabul E, Basakci Calik B, Oztop M, Cobankara V. The efficacy of manual soft-tissue mobilization in ankylosing spondylitis: a randomized controlled study. *Int J Rheum Dis.* 2021;24(3):445-55.
19. Hawrylak A, Demidaś A, Chromik K, Hawrylak A. The effectiveness of the McKenzie method in treating lumbar discopathy. *Hum Mov.* 2021;22(4):98-104.
20. Selim MN, Mokhtar MM, Mohamed MH, Abonour AA, Abdelmutilibe SM, Essa MM. Comparison between efficacy of spinal mobilization with leg movement versus McKenzie technique in patients with lumbar disc herniation. *Sport TK-Rev EurAm Ciencias Del Deporte.* 2022;12(2):1-5.

21. Saluja J, Parmar R, Patel G. A comparative study between elongation longitudinaux avec decoaption osteo articulaire (ELDOA) and nerve flossing technique (NFT) to improve pain and flexibility in piriformis syndrome-an experimental study. *Arch Physiother Glob Res*. 2023;26(2).
22. Calin A, Garrett S, Whitelock H, Kennedy LG, O'hea J, Mallorie P, Jenkinson T. A new approach to defining functional ability in ankylosing spondylitis: the development of the Bath Ankylosing Spondylitis Functional Index. *J Rheumatol*. 1994;21(12):2281-5.
23. Garrett S, Jenkinson T, Kennedy LG, Whitelock HE, Gaisford PE, Calin A. A new approach to defining disease status in ankylosing spondylitis: the Bath Ankylosing Spondylitis Disease Activity Index. *J Rheumatol*. 1994;21(12):2286-91.
24. Tousignant M, Poulin L, Marchand S, Viau A, Place C. The Modified-Modified Schober Test for range of motion assessment of lumbar flexion in patients with low back pain: a study of criterion validity, intra-and inter-rater reliability and minimum metrically detectable change. *Disabil Rehabil*. 2005;27(10):553-9.
25. Hershkovich O, Grevitt MP, Lotan R. Schober test and its modifications revisited—what are we actually measuring? Computerized tomography-based analysis. *J Clin Med*. 2022;11(23):6895.
26. Forchheimer MB, Richards JS, Chiodo AE, Bryce TN, Dyson-Hudson TA. Cut point determination in the measurement of pain and its relationship to psychosocial and functional measures after traumatic spinal cord injury: a retrospective model spinal cord injury system analysis. *Arch Phys Med Rehabil*. 2011;92(3):419-24.
27. Stratford PW, Spadoni G. The reliability, consistency, and clinical application of a numeric pain rating scale. *Physiother Can*. 2001;53(2):88-91.
28. Shamshad M, Kanwal R, Butt R, Haider HM. Effects of ELDOA technique versus McKenzie extension exercises on non-specific low back pain patients.: a randomized clinical trial. *The Rehabilitation Journal*. 2022 Sep 30;6(03):429-34.
29. Salsabil H. *Effectiveness of the McKenzie Treatment Protocol booklet for the patients suffering with Lumbar Spondylolisthesis: A Randomized Clinical Trial* (Doctoral dissertation, Bangladesh Health Professions Institute, Faculty of Medicine, the University of Dhaka, Bangladesh).
30. Al-Banawi LA, Youssef EF, Shanb AA, Shanb BE. Effects of the addition of hands-on procedures to McKenzie exercises on pain, functional disability and back mobility in patients with low back pain: A randomised clinical trial. *The Malaysian Journal of Medical Sciences: MJMS*. 2023 Jun 27;30(3):122.
31. Gur Kabul E, Basakci Calik B, Oztop M, Cobankara V. The efficacy of manual soft-tissue mobilization in ankylosing spondylitis: A randomized controlled study. *International Journal of Rheumatic Diseases*. 2021 Mar;24(3):445-55.
32. Youssef EF, Abulsaad MS, Abdelnaeem AO. Effects of Mulligan mobilization technique on pain, cervical range of motion, proprioception, and disability in cervical spondylosis. *Benha International Journal of Physical Therapy*. 2025 Jun 1;3(1):190-200.
33. Batool I. Physiotherapy assessment and intervention of patients with ankylosing spondylitis: Self-study material for physiotherapy students.

34. Arif R, Azfar H, Waseem A, Nawaz S, Sajjad AG. Effects of modified ELDOA technique in patients with cervical radiculopathy: ELDOA technique in patients with cervical radiculopathy. Pakistan BioMedical Journal. 2022 Jun 30:144-9.
35. Sajjad AG, Javed MS, Rasul A, Hussain SA, Naqvi SA. Comparison of the effects of decompression and eldoa on pain and disability in lumbar disc protrusion. Rehman Journal of Health Sciences. 2021 Dec 31;3(2):92-6.
36. Aqil F, Iqbal MA, Karim S, Iqbal MU, Akram MJ, Mehreen Z, Mufti R. Comparison of Mckenzie approach versus Lumbar Stabilization Exercises in the treatment of chronic low back pain. Rehman Journal of Health Sciences. 2021 Jul 1;3(1):24-31.
37. Aqil F, Iqbal MA, Karim S, Iqbal MU, Akram MJ, Mehreen Z, Mufti R. Comparison of Mckenzie approach versus Lumbar Stabilization Exercises in the treatment of chronic low back pain. Rehman Journal of Health Sciences. 2021 Jul 1;3(1):24-31.
38. Anies YM, Al-Azab IM. Impact of McKenzie extension exercise approach on patients with chronic low back pain with radiculopathy: a randomized controlled trial. International journal of therapies and rehabilitation research. 2017;6(2):29-36.
39. Shahid N, Kiran Q, Tariq S, Younas H, Rasool T, Azfar H, Saifullah F, Ali S. Effects of Elongation Longitudinaux Articular Vertebral and Columnar Decoaption Osteo Articulaire versus Upper Thoracic Mobilization on Forward Head Posture in Upper Cross Syndrome. The Healer Journal of Physiotherapy and Rehabilitation Sciences. 2025 Aug 23;5(2):19-26.
40. Batool FA, Kiran QU, Mubashar HU, Gull MA, Batool AM, Ashraf SA. Hamstring muscle tightness and chronic low back pain an analytical study on general population. Pakistan Journal of Medical & Health Sciences. 2022;16(09).