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COMPARISON OF STRETCHING EXERCISES VERSUS ERGONOMIC EDUCATION FOR CHRONIC OFFICE-RELATED LOW BACK PAIN: A RANDOMIZED CONTROLLED TRIAL

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Abstract

Background

Chronic low back pain (CLBP) attributable to prolonged occupational sitting constitutes a significant musculoskeletal burden among the global office-working population.[1,2] While both therapeutic stretching and ergonomic education have individually demonstrated efficacy in alleviating CLBP, comparative evidence within a Pakistani clinical context remains sparse, and direct randomized comparisons between these two modalities are limited in the current literature.[3]

Objective

This randomized controlled trial aimed to compare the effectiveness of a structured stretching exercise protocol (Group A) versus an ergonomic education programme (Group B) on pain intensity, functional disability, lumbar range of motion (ROM), and postural outcomes in office workers with chronic low back pain over an eight-week intervention period.

Methodology

Forty office workers aged 25-50 years with CLBP of more than three months' duration were recruited from Health & Wellness Physio Rehab Centre, Abbottabad, Pakistan, using convenient sampling with random group allocation. Participants were randomized equally (n = 20 per group) into Group A (stretching exercises: hamstring, hip flexor, lumbar flexion, piriformis, cat-camel, child's pose, pelvic tilt; 3 sessions/week for 8 weeks) or Group B (ergonomic education: workstation assessment, sitting posture correction, micro-break training; equivalent session frequency). Outcomes were assessed at baseline, 4th week, and 8th week using the Visual Analog Scale (VAS), Oswestry Disability Index (ODI), lumbar flexion ROM via inclinometry, and standardized postural assessment. Data were analyzed using SPSS version 26 with a significance threshold of $p < 0.05$.

Results

Both groups demonstrated statistically significant within-group improvements from baseline across all outcome measures. However, Group A exhibited significantly superior outcomes at the 8th week compared to Group B. Group A's VAS score decreased from 7.15 ± 1.09 to 2.30 ± 0.82 versus Group B's reduction *from 6.95 ± 1.14 to 3.85 ± 0.97 ($p < 0.001$). ODI scores improved from 42.80 ± 6.21% to 14.60 ± 4.18% in Group A versus 40.95 ± 5.87% to 24.35 ± 5.52% in Group B ($p < 0.001$). Lumbar flexion ROM and postural correction scores also favoured Group A significantly at endpoint.*

Conclusion

Structured stretching exercises demonstrated clinically meaningful and statistically superior improvements over ergonomic education alone in reducing pain intensity and functional disability in office workers with chronic low back pain. Integration of targeted stretching protocols into workplace physiotherapy programmes is strongly recommended.

1. INTRODUCTION

1.1 Defining Chronic Office-Related Low Back Pain

Low back pain (LBP) is defined as pain, muscle tension, or stiffness localized to the region between the inferior costal margin and the inferior gluteal folds, with or without accompanying leg pain, persisting for a period exceeding twelve weeks, thereby qualifying as chronic in clinical classification.[1] When this pain emerges or is substantively aggravated by occupational demands characteristic of desk-based employment, including prolonged static sitting, repetitive forward flexion, and workstation-associated postural loading, it is designated as office-related chronic low back pain (OR-CLBP). This condition has emerged as one of the foremost contributors to workplace disability worldwide, imposing escalating economic and social burdens on healthcare systems and employers alike.[2]

1.2 Global Prevalence and Socioeconomic Burden

Low back pain is the single leading cause of years lived with disability globally, affecting an estimated 619 million individuals in 2020, with projections exceeding 840 million by 2050.[4] Point prevalence estimates in working-age populations range from 15% to 45%, with office-based workers demonstrating disproportionately elevated rates owing to the sedentary nature of their occupational roles.[5] In South Asian countries, including Pakistan, epidemiological data indicate a rising prevalence among urban clerical workers, with one multicenter study reporting a 12-month prevalence of LBP as high as 58% in office employees.[6] The socioeconomic toll manifests through absenteeism, presenteeism, early disability pension claims, and substantial direct healthcare expenditure, with global annual costs attributed to LBP estimated in excess of USD 100 billion.[7]

1.3 Occupational Risk Factors and the Role of Prolonged Sitting

The aetiology of OR-CLBP is inherently multifactorial, encompassing biomechanical, psychosocial, and organizational determinants. Among office workers, prolonged uninterrupted sitting remains the most consistently implicated physical risk factor.[8] Sustained seated postures generate disproportionate compressive and shear forces across the lumbar intervertebral discs, particularly at the L4-L5 and L5-S1 segments, increasing intradiscal pressure by approximately 40% compared with standing.[9] Furthermore, sustained flexion loading of the posterior annular fibres leads to progressive creep of the viscoelastic spinal tissues, reducing the intrinsic stability of the motion segment and sensitizing nociceptive pathways.[10] Concurrent muscular deconditioning of the lumbar extensors and deep stabilizing musculature, including the multifidus and transversus abdominis, further compounds spinal vulnerability during repetitive occupational tasks.[11]

Poor workstation design exacerbates these biomechanical stresses. Elevated or recessed monitor positions promote forward head posture and compensatory thoracolumbar flexion, while inadequately positioned keyboards and pointing devices impose asymmetric loading on the cervicothoracic and lumbar spine. The absence of adequate lumbar support in office chairs deprives

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the lumbar lordosis of its natural curvature maintenance, further increasing disc loading and myofascial tension in the paraspinal musculature.[12]

1.4 Importance of Ergonomic Interventions in Workplace Health

Ergonomics applies principles of human factors science to optimize the fit between the worker and the work environment, thereby reducing physical strain and injury risk. Workplace ergonomic interventions for LBP encompass workstation modification, ergonomic training programmes, micro-break scheduling, and activity modification strategies.[13] Systematic reviews have demonstrated that ergonomic education can produce modest reductions in LBP symptoms and disability, particularly when combined with behavioural training in activity pacing and postural awareness.[14] However, the magnitude of effect tends to be moderate and diminishes over time without sustained environmental modification, suggesting that education alone may not be sufficient for durable pain relief in individuals with established CLBP.[15]

1.5 Role of Stretching Exercises in Low Back Pain Management

Therapeutic stretching constitutes a cornerstone of conservative physiotherapy management for CLBP. The primary physiological rationale rests on the restoration of extensibility within shortened or hypertonic myofascial structures, particularly the hip flexors (iliopsoas, rectus femoris), hamstrings, and piriformis, all of which exert significant mechanical influence on lumbar alignment and pelvic kinematics.[16] Tightness of the iliopsoas produces an anterior pelvic tilt, augmenting lumbar lordosis and increasing facet joint compression. Conversely, hamstring tightness restricts hip flexion, imposing compensatory lumbar flexion during activities of daily living.[17]

At the cellular and tissue level, prolonged stretching induces plastic deformation of connective tissue and promotes remodelling of the extracellular matrix, improving tissue compliance and reducing passive stiffness. Additionally, activation of the Golgi tendon organ through sustained stretch elicits autogenic inhibition of the targeted muscle, reducing baseline muscle tone and associated myofascial pain.[18] Regular dynamic stretching exercises such as the cat-camel manoeuvre simultaneously mobilize the lumbar facet joints through cyclic flexion-extension, promoting synovial fluid distribution and cartilage nutrition, while reducing joint stiffness and pain.[19]

Clinical trials have reported that consistent stretching exercise programmes produce significant reductions in LBP intensity and functional disability scores, with effect sizes comparable or superior to other passive or active physiotherapy modalities.[20] Importantly, stretching exercises are low-cost, easily teachable, and amenable to home-based practice, enhancing their practical applicability in occupational rehabilitation settings.[21]

1.6 Gaps in the Literature and Rationale for the Present Study

Despite the burgeoning evidence base for both ergonomic education and stretching exercises as standalone interventions for CLBP, direct head-to-head comparisons between these modalities in a controlled trial format remain limited. Existing reviews tend to pool heterogeneous intervention types, making it difficult to isolate the relative contribution of stretching versus ergonomic approaches.[22] Furthermore, the majority of available RCTs originate from high-income Western countries, and the generalizability of findings to low-to-middle-income countries such as Pakistan, where occupational physiotherapy resources are constrained, is uncertain.[3] Pakistani office workers face a unique confluence of risk factors: limited ergonomic awareness among employers, high occupational physical demands despite desk-based roles, and restricted access to specialized physiotherapy. Understanding which intervention delivers superior outcomes in this specific context is therefore of immediate clinical and public health relevance.

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1.7 Study Objective

This randomized controlled trial was designed to compare the effectiveness of a supervised stretching exercise programme versus an ergonomic education programme on pain intensity, functional disability, lumbar range of motion, and postural outcomes in office workers with chronic low back pain over an eight-week intervention period at Health & Wellness Physio Rehab Centre, Abbottabad, Pakistan.

1.8 Hypotheses

Null Hypothesis (H_0): There is no statistically significant difference in pain intensity, functional disability, lumbar range of motion, or postural outcomes between the stretching exercise group and the ergonomic education group following an eight-week intervention.

Alternative Hypothesis (H_1): The stretching exercise group will demonstrate significantly greater improvements in pain intensity, functional disability, lumbar range of motion, and postural outcomes compared to the ergonomic education group following an eight-week intervention.

2. METHODOLOGY

2.1 Study Design

This study employed a two-arm, parallel-group, assessor-blinded randomized controlled trial (RCT) design. The CONSORT (Consolidated Standards of Reporting Trials) guidelines were followed throughout the conduct and reporting of this trial.

2.2 Study Setting and Duration

The study was conducted at Health & Wellness Physio Rehab Centre, Abbottabad, Khyber Pakhtunkhwa, Pakistan, from September 2024 to December 2024 (four months). The active intervention period for each participant comprised eight consecutive weeks, with outcome assessments at baseline, the fourth week, and the eighth week.

2.3 Ethical Approval and Informed Consent

Ethical approval was obtained from the Institutional Review Board of Health & Wellness Physio Rehab Centre (Reference No. HWPRC-IRB-2024-08) prior to participant recruitment. The study was conducted in full accordance with the ethical principles of the Declaration of Helsinki (2013 revision). All prospective participants received a detailed verbal and written explanation of the study's purpose, procedures, potential risks, voluntary nature of participation, and their right to withdraw at any time without consequence. Written informed consent was obtained from each participant prior to enrolment. Participant confidentiality was preserved through anonymization of all data using unique participant codes.

2.4 Inclusion and Exclusion Criteria

2.4.1 Inclusion Criteria

- Office workers between 25 and 50 years of age
- Chronic low back pain of more than three months' duration, confirmed by clinical assessment
- Pain score of at least 3 on the Visual Analog Scale (VAS) at baseline
- Employment in desk-based work for a minimum of 6 hours per day, 5 days per week
- Both male and female participants
- Ability to participate in supervised exercise sessions at the clinic
- Willingness to provide written informed consent

2.4.2 Exclusion Criteria

- Specific spinal pathology including disc herniation with radiculopathy, vertebral fracture, spinal stenosis, spondylolisthesis, or inflammatory spondyloarthropathy
- Previous spinal surgery
- Pregnancy or postpartum period within six months
- Concurrent participation in any other physiotherapy programme or spinal rehabilitation
- Severe neurological deficits, upper or lower motor neuron lesions
- Uncontrolled systemic conditions (e.g., uncontrolled hypertension, active malignancy)
- Inability to attend at least 80% of scheduled sessions

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- Receipt of epidural steroid injections or other invasive spinal procedures within the preceding three months

2.5 Sampling Technique and Sample Size
Participants were recruited through convenient sampling from employees of local private companies, government offices, and educational institutions in Abbottabad. Eligibility was verified through clinical screening conducted by the principal investigator. Sample size was calculated using GPower software (version 3.1.9.7) based on a two-tailed independent samples t-test, with an effect size (Cohen's d) of 0.80 derived from a comparable RCT on LBP interventions,[20] alpha error probability of 0.05, and statistical power of 80%. The calculation indicated a required minimum of 26 participants (13 per group). Accounting for an anticipated dropout rate of 20%, the final recruitment target was set at 40 participants (20 per group), which was the achieved sample size.

2.6 Randomization and Allocation Concealment
Following eligibility confirmation and baseline assessment, participants were randomized in a 1:1 ratio using computer-generated random numbers (sealed opaque envelopes method). The randomization sequence was generated by an independent statistician not involved in the clinical assessment or intervention delivery. Allocation concealment was maintained until the point of enrolment, at which point the sealed envelope was opened by the treating physiotherapist.

2.7 Blinding
Full blinding of participants and treating physiotherapists was not feasible given the nature of the interventions. However, all outcome assessments were performed by a research assistant blinded to group allocation (assessor blinding). Participants were instructed not to reveal their group assignment to the assessor. Statistical analysis was conducted on coded data by the independent statistician, maintaining blinding until after analysis was complete.

2.8 Intervention Protocols
2.8.1 Group A: Structured Stretching Exercise Protocol
Participants in Group A attended three supervised sessions per week for eight weeks (24 sessions total) at the rehabilitation centre, each session lasting 45-60 minutes. Additionally, participants were instructed to perform a standardized home exercise programme once daily on non-clinic days. The exercise protocol was designed and supervised by a licensed physiotherapist with post-graduate training in musculoskeletal rehabilitation. All exercises were preceded by a five-minute warm-up consisting of low-intensity walking in place and gentle lumbar range-of-motion movements.

Table 1. Structured Stretching Exercise Protocol — Group A

Exercise	Starting Position	Technique	Hold (sec)	Reps	Sets	Rest (sec)	Progression
Hamstring Stretch (Supine)	Supine lying, knees extended	Passive SLR to first resistance	30	3	2-3	15	Increase hold to 45 sec at Week 5; add dorsiflexion Week 7
Hip Flexor / Iliopsoas Stretch	Half-kneeling (lunge position)	Posterior pelvic tilt, anterior lunge, maintain neutral lumbar spine	30	3	2-3	15	Arms overhead to intensify stretch Week 5; add hip internal rotation Week 7

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Lumbar Flexion Stretch (Knee-to-Chest)	Supine, knees bent	Draw both knees to chest, hands clasped below knees, gentle pull	30	3	2-3	15	Progress to single-leg pull alternating each limb from Week 5
Piriformis Stretch (Figure-4)	Supine, hip and knee flexed	Cross ankle over opposite knee, pull thigh toward chest	30	3 / side	2	15	Seated piriformis stretch added from Week 5 for variability
Cat-Camel Exercise	Quadruped (hands and knees)	Alternate full lumbar flexion (cat) and extension (camel) smoothly	5	10	3	20	Increase to 15 repetitions per set from Week 5
Child's Pose Stretch	Kneeling, sitting on heels	Reach arms forward on floor, sink hips toward heels, forehead to mat	45	3	2	15	Lateral reach (right/left) added from Week 5 for lateral flexion component
Pelvic Tilt Exercise	Supine, knees flexed, feet flat	Flatten lumbar curve to floor using abdominal contraction; hold, release	10	10-15	3	10	Standing pelvic tilt against wall added Week 5; functional integration Week 7

Each supervised session concluded with a 10-minute cool-down consisting of breathing exercises and gentle passive lumbar rotation. A standardized home exercise instruction booklet was issued to each participant at Week 1. Compliance with the home exercise programme was monitored through a structured daily log diary reviewed at each clinic session.

2.8.2 Group B: Ergonomic Education Programme

Participants in Group B attended ergonomic education sessions with equivalent session frequency (3 sessions per week for 8 weeks), each lasting 45-60 minutes, delivered in a structured curriculum-based format. Sessions were delivered in small groups of 3-5 participants with individualized workstation assessments using standardized ergonomic evaluation checklists.[13] Printed ergonomic pamphlets in both English and Urdu were distributed at Session 1.

Weeks 1-4 (Foundational Education Phase):

- Optimal sitting posture: neutral lumbar lordosis, 90-90-90 joint angles, bilateral symmetric weight distribution
- Desk ergonomics: chair height adjustment so that thighs are parallel to the floor, feet flat, adequate seat depth (2-3 finger breadths from popliteal fossa to seat edge)
- Monitor height: top of screen at or slightly below eye level, arm's length viewing distance (50-70 cm), reduction of screen glare
- Lumbar support: use of rolled towel or ergonomic lumbar roll positioned at L3-L4 level to maintain natural lordosis
- Foot positioning: feet flat on floor; footrest provision for short-statured participants
- Keyboard and mouse positioning: keyboard at elbow height, slight negative tilt; mouse within easy reach; wrist rest use for static periods
- Micro-break education: scheduled 2-minute movement breaks every 30 minutes using

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timer alerts; shoulder rolls, neck retraction, standing hip extension demonstrated

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Weeks 5-8 (Behavioural Reinforcement Phase):

- Review and reinforcement of foundational ergonomic principles
- Activity pacing principles and sitting time reduction strategies
- Follow-up individual workstation assessment visits to verify implementation of adjustments
- Compliance monitoring through structured weekly self-report checklists reviewed at each clinic session
- Motivational interviewing to address barriers to ergonomic compliance

2.9 Outcome Measures

2.9.1 Visual Analog Scale (VAS)

Pain intensity was assessed using the Visual Analog Scale, a 100 mm horizontal line with anchors at 0 (no pain) and 100 (worst imaginable pain). The VAS is a well-validated, highly reliable tool for quantifying pain intensity in musculoskeletal conditions, with test-retest reliability coefficients ranging from 0.71 to 0.99.[23]

2.9.2 Oswestry Disability Index (ODI)

Functional disability was quantified using the Oswestry Disability Index (version 2.1), a disease-specific questionnaire comprising 10 items. Total scores are expressed as a percentage (0-100%), with higher scores indicating greater disability. The ODI demonstrates excellent test-retest reliability (ICC = 0.99) and strong construct validity in populations with CLBP.[24]

2.9.3 Lumbar Range of Motion

Lumbar flexion and extension ROM was measured using a calibrated dual-inclinometer technique. The inclinometry method demonstrates high intra-rater reliability (ICC = 0.87-0.97) and acceptable inter-rater reliability for lumbar flexion measurement in clinical settings.[25]

2.9.4 Postural Assessment

A standardized postural assessment was conducted using the New York Posture Rating Chart adapted for the lumbar and pelvic region. Lateral sagittal plane photographs were analyzed using PostureScreen software. Inter-rater reliability of photographic postural analysis has been reported as moderate to high (ICC = 0.75-0.91).[26]

2.10 Statistical Analysis

All data were entered and analyzed using SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean ± standard deviation, frequency, percentage) were computed for all demographic and outcome variables. The Shapiro-Wilk test was used to evaluate normality of distribution. Within-group changes across three time points were analyzed using one-way repeated-measures ANOVA with Bonferroni post-hoc correction. Between-group comparisons at each time point were performed using independent samples t-tests. Effect sizes were calculated using Cohen's d and partial eta-squared (η^2). The level of statistical significance was set at $p < 0.05$ (two-tailed). Intent-to-treat analysis was adopted as the primary analysis framework, with missing data handled through last observation carried forward (LOCF).

3. RESULTS

3.1 Participant Flow and Demographics

Forty participants were successfully enrolled and randomized: 20 to Group A (Stretching Exercises) and 20 to Group B (Ergonomic Education). One participant in Group B withdrew at Week 6 citing work relocation; intent-to-treat analysis was applied. No adverse events were recorded in either group throughout the intervention period. Baseline demographic and clinical characteristics are presented in Table 2.

Table 2. Baseline Demographic and Clinical Characteristics

Variable	Group A — Stretching (n = 20)	Group B — Ergonomics (n = 20)	p-value
Age (years), Mean ± SD	36.45 ± 6.82	37.10 ± 7.15	0.762
Gender: Male, n (%)	11 (55%)	12 (60%)	0.745
Gender: Female, n (%)	9 (45%)	8 (40%)	0.745
Duration of LBP (months), Mean ± SD	18.30 ± 8.47	17.85 ± 9.12	0.873
Work hours/day, Mean ± SD	8.65 ± 1.12	8.70 ± 0.98	0.882
BMI (kg/m^2), Mean ± SD	26.42 ± 3.18	25.98 ± 3.42	0.652
Baseline VAS (0-10), Mean ± SD	7.15 ± 1.09	6.95 ± 1.14	0.553
Baseline ODI (%), Mean ± SD	42.80 ± 6.21	40.95 ± 5.87	0.326
Lumbar Flexion ROM (°), Mean ± SD	48.35 ± 7.64	47.90 ± 8.22	0.848

Note: p-values from independent samples t-test (continuous) and chi-square (categorical). No significant between-group differences at baseline (all $p > 0.05$).

3.2 Primary Outcome: Pain Intensity (VAS)

Both groups demonstrated significant within-group reductions in VAS scores across the intervention period. Group A exhibited a substantially greater magnitude of improvement. The mean VAS in Group A declined from 7.15 ± 1.09 at baseline to 4.65 ± 0.94 at Week 4 and 2.30 ± 0.82 at Week 8. Group B demonstrated a reduction from 6.95 ± 1.14 at baseline to 5.40 ± 1.07 at Week 4 and 3.85 ± 0.97 at Week 8. Between-group comparison at Week 8 was highly significant ($p < 0.001$), with Cohen's $d = 1.72$ indicating a large effect size in favour of Group A.

Table 3. Within-Group and Between-Group Comparison of VAS Scores

Time Point	Group A Mean ± SD	Group B Mean ± SD	Mean Diff (95% CI)	p-value	d
Baseline	7.15 ± 1.09	6.95 ± 1.14	0.20 (−0.49 to 0.89)	0.553	0.18
Week 4	4.65 ± 0.94	5.40 ± 1.07	0.75 (0.14 to 1.36)	0.016	0.75
Week 8	2.30 ± 0.82	3.85 ± 0.97	1.55 (1.01 to 2.09)	**< 0.001**	**1.72**
Within-group p (Repeated ANOVA)	**< 0.001**	**< 0.001**	—	—	—

3.3 Secondary Outcome: Functional Disability (ODI)

The Oswestry Disability Index scores followed a parallel pattern. Group A improved from 42.80 ± 6.21% at baseline to 27.40 ± 5.63% at Week 4 and 14.60 ± 4.18% at Week 8, representing a mean absolute reduction of 28.20 percentage points. Group B improved from 40.95 ± 5.87% to 31.60 ± 5.44% at Week 4 and 24.35 ± 5.52% at Week 8, a mean reduction of 16.60 percentage points. The between-group difference at Week 8 was highly significant ($p < 0.001$; $\eta^2 = 0.48$, large effect).

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Table 4. Oswestry Disability Index (ODI) Scores Across Time Points

Time Point	Group A Mean ± SD (%)	Group B Mean ± SD (%)	Mean Diff (95% CI)	p-value	η²
Baseline	42.80 ± 6.21	40.95 ± 5.87	1.85 (−1.84 to 5.54)	0.326	0.03
Week 4	27.40 ± 5.63	31.60 ± 5.44	4.20 (0.93 to 7.47)	0.013	0.15
Week 8	14.60 ± 4.18	24.35 ± 5.52	9.75 (6.88 to 12.62)	**< 0.001**	**0.48**

3.4 Lumbar Flexion ROM and Postural Assessment

Lumbar flexion ROM improved significantly in both groups. Group A demonstrated a mean increase from 48.35 ± 7.64° to 68.75 ± 6.92° by Week 8, compared with Group B's improvement from 47.90 ± 8.22° to 58.40 ± 7.15°. The between-group difference at Week 8 (10.35°; 95% CI: 6.07 to 14.63; $p < 0.001$) was clinically meaningful. Postural assessment scores also favoured Group A significantly at Week 8 (74.85 ± 7.62 vs. 66.40 ± 8.37; $p = 0.001$; $d = 1.06$).

Table 5. Lumbar Flexion ROM and Postural Assessment Scores

Outcome & Time Point	Group A Mean ± SD	Group B Mean ± SD	Mean Diff (95% CI)	p-value	d
Lumbar Flexion ROM (°) — Baseline	48.35 ± 7.64	47.90 ± 8.22	0.45 (−4.44 to 5.34)	0.848	0.06
Lumbar Flexion ROM (°) — Week 4	58.60 ± 7.18	52.75 ± 7.46	5.85 (1.43 to 10.27)	0.010	0.80
Lumbar Flexion ROM (°) — Week 8	68.75 ± 6.92	58.40 ± 7.15	10.35 (6.07 to 14.63)	**< 0.001**	**1.47**
Postural Score (0-100) — Baseline	52.40 ± 8.14	53.15 ± 7.96	0.75 (−5.56 to 4.06)	0.759	0.09
Postural Score (0-100) — Week 8	74.85 ± 7.62	66.40 ± 8.37	8.45 (3.38 to 13.52)	**0.001**	**1.06**

4. DISCUSSION

4.1 Interpretation of Principal Findings

The central finding of this randomized controlled trial is that a supervised, multimodal stretching exercise programme produced significantly greater improvements in pain intensity, functional disability, lumbar range of motion, and postural alignment compared with an ergonomic education programme among office workers with chronic low back pain over an eight-week intervention period. Both interventions demonstrated clinically meaningful within-group improvements, affirming the individual therapeutic value of each approach. Nonetheless, the magnitude and consistency of benefit in Group A was substantially superior across all measured outcomes, with between-group effect sizes at Week 8 reaching Cohen's d values of 1.72 (VAS) and 1.47 (Lumbar Flexion ROM).

4.2 Physiological Mechanisms Underlying Stretching Superiority

The superior outcomes achieved through stretching exercises can be attributed to several interacting physiological mechanisms. Chronic low back pain in office workers is substantially driven by adaptive shortening of the hip flexors and hamstrings consequent to sustained seated posture. Tightening of the iliopsoas muscle in

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habitual sitters produces an anterior pelvic tilt with concurrent accentuation of lumbar lordosis and increased facet joint compression loading.[16] Stretching exercises directly target this myofascial dysfunction, restoring hip flexor extensibility and thereby normalizing lumbopelvic kinematics, which reduces abnormal mechanical nociceptive input at sensitized spinal structures.

At the neurophysiological level, prolonged stretching activates mechanoreceptors within the musculotendinous junction and joint capsule, engaging the gate control mechanism to modulate pain signal transmission at the dorsal horn level.[18] Additionally, sustained stretch stimulates the production of endogenous endorphins and reduces circulating levels of pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumour necrosis factor-alpha (TNF-α), which are elevated in chronic musculoskeletal pain states.[27] The cat-camel exercise cyclically mobilizes the lumbar facet joints, promoting synovial fluid circulation and cartilage nutrition while desensitizing periarticular nociceptors through movement-induced analgesia.[19]

The pelvic tilt exercise component simultaneously activates the deep lumbar stabilizers, principally the transversus abdominis and lumbar multifidus, which are frequently inhibited in individuals with CLBP.[28] Restoration of deep stabilizer function reduces excessive motion at the injured motion segment, creating a more favourable mechanical environment for tissue healing and pain resolution.

4.3 Comparison with Existing Literature

Our findings are broadly consistent with and extend the existing evidence base. A Cochrane systematic review demonstrated that active exercise-based interventions for chronic LBP produced moderate-to-large reductions in pain (mean difference -10 mm VAS) and disability compared with passive or educational comparators.[20] Similarly, a multicentre RCT reported that targeted exercise programmes for office workers with CLBP produced superior reductions in ODI scores compared with ergonomic advice at 3-month follow-up, consistent with our Week 8 findings.[11] Earlier work on sedentary workers reported that exercises specifically addressing hip flexor and hamstring extensibility produced pain reductions approximately 35% greater than ergonomic advice alone,[21] a finding aligning with our observed absolute between-group VAS difference of 1.55 points at Week 8.

Studies supporting the efficacy of ergonomic education as a standalone intervention typically demonstrate modest and time-limited benefits, as the educational approach does not directly address the underlying myofascial and biomechanical deficits that perpetuate CLBP.[14,15] This biological reality likely explains the more moderate improvement seen in Group B, which nonetheless improved significantly from baseline, affirming the value of ergonomic education as an adjunct rather than a primary therapeutic modality.

4.4 Clinical Implications

These findings carry several direct implications for occupational physiotherapy practice in Pakistan and comparable low-to-middle-income settings. Structured stretching exercise programmes should be prioritized as the primary therapeutic modality in physiotherapy management plans for office workers presenting with CLBP.[3,6] The exercises employed in this protocol are low-cost, require minimal equipment, and can be performed in clinic and at home, making them highly feasible for implementation in resource-constrained environments. Ergonomic education is best positioned as a complementary component within a broader multimodal programme rather than as a standalone primary intervention.

4.5 Strengths of the Study

- RCT design with computer-generated randomization and allocation concealment, minimizing selection bias
- Assessor blinding maintained throughout to reduce detection bias
- Standardized, reproducible exercise protocol with detailed progression criteria, ensuring intervention fidelity
- Multiple validated outcome measures assessing pain, disability, mobility, and posture

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- Intent-to-treat analysis approach ensuring conservative and unbiased effect estimation
- Contextual relevance: first Pakistani clinical trial directly comparing these two modalities in an office worker population

4.6 Limitations and Future Directions

- Relatively small sample size (n = 40) limits subgroup analyses and generalizability
- Single-centre design in Abbottabad may restrict generalizability to other Pakistani contexts
- Absence of a combined (stretching + ergonomic education) arm precludes assessment of synergistic effects
- Long-term follow-up beyond 8 weeks was not conducted; durability of effects and relapse rates remain unknown
- Participant blinding was not feasible, introducing potential performance and reporting bias
- Objective compliance monitoring for home exercises was limited to self-report diaries

Future research should address these limitations through multi-centre trials with larger samples, inclusion of a combined intervention arm, objective compliance monitoring via wearables, and long-term follow-up of 6-12 months.

5. CONCLUSION

This randomized controlled trial provides robust evidence that a structured multimodal stretching exercise programme is significantly superior to an ergonomic education programme in reducing pain intensity and functional disability, and improving lumbar range of motion and postural alignment in office workers with chronic low back pain over an eight-week intervention period. Large effect sizes across all primary and secondary outcome measures at endpoint affirm the clinical meaningfulness of these differences. Both interventions produced significant within-group improvements, underscoring the individual therapeutic value of ergonomic education as an adjunct strategy; however, its standalone efficacy is insufficient to match the direct tissue-level, neurophysiological, and biomechanical benefits conferred by targeted stretching exercises. These findings advocate strongly for the systematic integration of structured stretching exercise protocols into occupational physiotherapy and workplace rehabilitation programmes, particularly in office-based work environments where prolonged sedentary behaviour is unavoidable. Clinicians are encouraged to prioritize exercises targeting hip flexor, hamstring, and lumbar myofascial extensibility, combined with lumbar stabilizer activation, as the cornerstone of management for this population. Ergonomic education should be retained as a complementary component to reduce ongoing mechanical loading during work hours. Future multi-centre trials with long-term follow-up and combined intervention arms are warranted to further refine evidence-based guidelines for the management of office-related chronic low back pain.

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