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COMPARATIVE EFFECTS OF MOTOR CONTROL EXERCISES AND GENERAL CORE STABILISATION ON DISABILITY, PAIN INTENSITY, AND QUALITY OF LIFE IN ADULTS WITH CHRONIC NON-SPECIFIC LOW BACK PAIN: A RANDOMISED CONTROLLED TRIAL

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Abstract

Background: Chronic non-specific low back pain (CNSLBP) is a leading cause of disability worldwide, imposing substantial burden on healthcare systems and patient quality of life.[1][2] Motor control exercises (MCE) and general core stabilisation (GCS) are two commonly prescribed exercise-based interventions; however, comparative evidence regarding their relative efficacy on disability, pain, and quality of life outcomes remains limited, particularly in South Asian populations.[3][5]

Methods: This parallel-group, assessor-blinded randomised controlled trial recruited 20 adults (aged 18–65 years) with CNSLBP persisting for more than 12 weeks. Participants were randomised 1:1 to receive either MCE (n=10) or GCS (n=10), with interventions delivered three times per week over eight weeks. Primary outcomes included the Oswestry Disability Index (ODI), Numeric Pain Rating Scale (NPRS), and EQ-5D quality of life measure. Secondary outcomes encompassed the Sorensen test, lumbar range of motion, Fear-Avoidance Beliefs Questionnaire (FABQ), Pain Catastrophizing Scale (PCS), and Timed Up and Go (TUG) test. Intention-to-treat analysis was performed where appropriate, with paired and independent t-tests or their non-parametric equivalents used for statistical comparisons (α=0.05).

Results: Seventeen participants (MCE: n=9; GCS: n=8) completed the study. Both groups demonstrated statistically significant within-group improvements across all primary and secondary outcomes (all $p<0.001$). The MCE group showed greater improvements in ODI (mean change −19.1 vs −14.8; p=0), pain intensity (mean change −2.9 vs −2.1; p=0), and quality of life (mean change +19.9 vs +13.9; p=0). Similarly, MCE produced significantly superior outcomes in Sorensen test, FABQ, PCS, and TUG scores (all $p<0.01$).

Conclusion: Both MCE and GCS produced clinically meaningful improvements in disability, pain, and psychosocial outcomes for CNSLBP. However, MCE demonstrated significantly greater benefits across nearly all measured outcomes, suggesting that targeted motor control retraining may offer superior therapeutic value compared to general core stabilisation for this population.

INTRODUCTION

Chronic non-specific low back pain (CNSLBP), defined as pain persisting for more than 12 weeks without a specific identifiable pathological cause, represents one of the most prevalent and disabling musculoskeletal conditions globally.[1][2] The Global Burden of Disease Study 2017 identified low back pain as the leading cause of years lived with disability in 126 of 195 countries, affecting an estimated 577 million people worldwide.[2] The condition imposes considerable

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economic burden through direct healthcare costs, indirect costs related to work absenteeism, and reduced productivity, with annual costs in developed nations estimated to exceed $100 billion.[3][4]

Contemporary understanding of CNSLBP pathophysiology has evolved beyond purely biomechanical models to encompass a biopsychosocial framework that recognises the interplay between physical impairment, psychological factors, and social context.[4][29] Among the various exercise-based interventions proposed for CNSLBP management, motor control exercises (MCE) and general core stabilisation (GCS) have gained considerable attention in clinical practice and research.[5][14]

Motor control exercises, also termed specific stabilisation exercises, are grounded in the model of spinal segmental instability first proposed by Panjabi[10] and further developed by Bergmark.[11] This approach targets the deep musculature of the trunk, particularly the transversus abdominis, multifidus, pelvic floor, and diaphragm, which are theorised to provide intersegmental stability and fine motor control of the lumbar spine.[12][13] MCE programmes typically progress from isolated activation of deep trunk muscles in neutral spinal positions to functional integration of these muscles during dynamic tasks. A systematic review by Saragiotto et al. found MCE to provide small but clinically important improvements in pain and disability compared to minimal intervention at short-term follow-up.[5]

General core stabilisation exercises, in contrast, adopt a broader approach that targets the entire musculature of the trunk, including both local and global muscle systems, without specific emphasis on isolated deep muscle activation.[14][15] These programmes commonly incorporate exercises such as abdominal crunches, planks, bridge variations, and stability ball exercises, with the overarching goal of enhancing overall trunk strength and endurance. While GCS programmes are widely prescribed in clinical practice and are more accessible to implement, the theoretical specificity of MCE suggests potential for superior outcomes in CNSLBP populations.[28]

Despite the growing body of evidence supporting exercise therapy for CNSLBP, direct head-to-head comparisons between MCE and GCS remain scarce, particularly in low- and middle-income countries where the prevalence of CNSLBP is substantial and healthcare resources are constrained.[4][9] Moreover, existing trials have predominantly focused on pain and disability as primary outcomes, with limited attention to the broader spectrum of outcomes including quality of life, psychosocial factors such as fear-avoidance beliefs and pain catastrophising, and functional performance measures.[20][21][22] This gap is particularly relevant given the established influence of psychological factors on chronic pain outcomes and disability.

The primary aim of this randomised controlled trial was to compare the effects of an eight-week MCE programme versus a GCS programme on disability, pain intensity, and quality of life in adults with CNSLBP. Secondary aims included comparing the effects on trunk muscle endurance, lumbar range of motion, fear-avoidance beliefs, pain catastrophising, and functional mobility. We hypothesised that MCE would produce significantly greater improvements in both primary and secondary outcomes compared to GCS.

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METHODS

Study Design

This study was designed as a parallel-group, assessor-blinded randomised controlled trial conducted at the Department of Rehabilitation Medicine, Saidu Medical College/Saidu Group of Teaching Hospitals, Swat, Pakistan. The trial was conducted in accordance with the Declaration of Helsinki and received institutional ethics approval prior to commencement. All participants provided written informed consent after being fully informed about the study procedures, potential risks, and their right to withdraw at any time without consequence.

Participants were allocated to one of two intervention groups in a 1:1 ratio using a computer-generated random number sequence. Allocation concealment was maintained using sealed opaque envelopes prepared by an independent researcher not involved in participant recruitment or assessment. The outcome assessor was blinded to group allocation throughout the study period. Due to the nature of the interventions, participants and treating therapists could not be blinded; however, participants were requested not to disclose their group allocation to the outcome assessor.

Participants

Eligible participants were adults aged 18 to 65 years presenting with chronic non-specific low back pain defined as pain of greater than 12 weeks duration in the lumbar region without specific pathology such as radiculopathy, spinal stenosis, or inflammatory disease.[3] Additional inclusion criteria included the ability to participate in exercise sessions and a baseline Oswestry Disability Index score of at least 20%, indicating at least minimal disability. Exclusion criteria encompassed specific spinal pathology (including but not limited to disc herniation with neurological deficit, spinal stenosis, spondylolisthesis, inflammatory arthritis, or malignancy), previous lumbar surgery, pregnancy, current neurological disorders, and any condition that precluded safe participation in the exercise programmes.

Interventions

Both interventions were delivered over an eight-week period, with participants attending three supervised sessions per week (total of 24 sessions). Each session lasted approximately 45 to 60 minutes and was conducted by a qualified physiotherapist.

Motor Control Exercise Group: The MCE programme followed a structured, progressive protocol based on the motor control approach described by Richardson, Hodges, and Hides.[13] The initial phase (weeks 1–2) focused on cognitive awareness and isolated activation of the deep trunk muscles, including the transversus abdominis (via abdominal drawing-in manoeuvre), lumbar multifidus (via specific segmental activation), pelvic floor muscles, and diaphragm. Participants were taught to maintain a neutral spine position during these exercises using visual and tactile feedback. The intermediate phase (weeks 3–5) progressed to co-contraction of deep trunk muscles during gradually increasing functional tasks, including four-point kneeling, prone and supine positions, and sitting and standing activities. The advanced phase (weeks 6–8) integrated motor

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control into dynamic activities including squatting, lunging, reaching, and walking, with increasing speed, load, and complexity. All exercises were performed with careful attention to quality of movement and avoidance of compensatory strategies.

General Core Stabilisation Group: The GCS programme comprised conventional core strengthening exercises targeting the overall trunk musculature without specific emphasis on isolated deep muscle activation.[14][15] The exercise prescription included abdominal crunches, supine bridging, prone plank holds, side plank holds, bird-dog exercises, dead bug exercises, and stability ball-based exercises. Progressive overload was applied by increasing the number of repetitions, sets, and exercise difficulty over the eight-week period. Participants received standardised instructions regarding proper exercise technique and breathing patterns.

Outcome Measures

All outcome measures were assessed at baseline (pre-intervention) and immediately following the eight-week intervention (post-intervention) by a blinded assessor.

Primary outcomes: Disability was measured using the Oswestry Disability Index (ODI), a self-administered questionnaire comprising 10 items scored from 0 to 5, yielding a total percentage score from 0% (no disability) to 100% (maximum disability).[16] Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), on which participants rated their current pain level on an 11-point scale from 0 (no pain) to 10 (worst imaginable pain).[17] Health-related quality of life was evaluated using the EQ-5D visual analogue scale, a standardised measure ranging from 0 to 100, with higher scores indicating better quality of life.[18]

Secondary outcomes: Trunk muscle endurance was assessed using the Sorensen test, which measures the time (in seconds) a participant can maintain a horizontal prone position with the upper body unsupported.[19] Lumbar range of motion was measured using a standard goniometer during active flexion in the standing position. Fear-avoidance beliefs were assessed using the Fear-Avoidance Beliefs Questionnaire (FABQ), a 16-item instrument yielding scores on work (FABQ-W) and physical activity (FABQ-PA) subscales.[20] Pain catastrophising was measured using the Pain Catastrophizing Scale (PCS), a 13-item instrument with a total score ranging from 0 to 52.[21] Functional mobility was assessed using the Timed Up and Go (TUG) test, which records the time (in seconds) required to stand from a chair, walk three metres, turn, walk back, and sit down.[22] Session adherence was documented as the percentage of prescribed sessions attended by each participant.

Statistical Analysis

Statistical analysis was performed using intention-to-treat principles where appropriate. Descriptive statistics were calculated for all variables, with mean and standard deviation reported for normally distributed continuous data and median and interquartile range for non-normally distributed data. Normality of data distribution was assessed using the Shapiro-Wilk test. Baseline demographic and

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clinical characteristics were compared between groups using independent t-tests for continuous variables and chi-square tests for categorical variables to confirm group equivalence.

Within-group differences (pre- versus post-intervention) were analysed using paired t-tests for normally distributed data and Wilcoxon signed-rank tests for non-normally distributed data. Between-group differences in change scores were analysed using independent t-tests when both groups demonstrated normally distributed change scores, and Mann-Whitney U tests when the normality assumption was violated. The significance level was set at $\alpha = 0.05$ for all comparisons. All statistical analyses were conducted using appropriate statistical software.

RESULTS

Participant Flow and Baseline Characteristics

A total of 20 participants were enrolled and randomly allocated to the MCE group (n=10) or the GCS group (n=10). During the intervention period, one participant from the MCE group was lost to follow-up, and two participants from the GCS group did not complete the study (one withdrew consent and one missed the final assessment). Consequently, 17 participants (MCE: n=9; GCS: n=8) completed the post-intervention assessment and were included in the per-protocol analysis. The participant flow through the study is summarised in Figure 1.

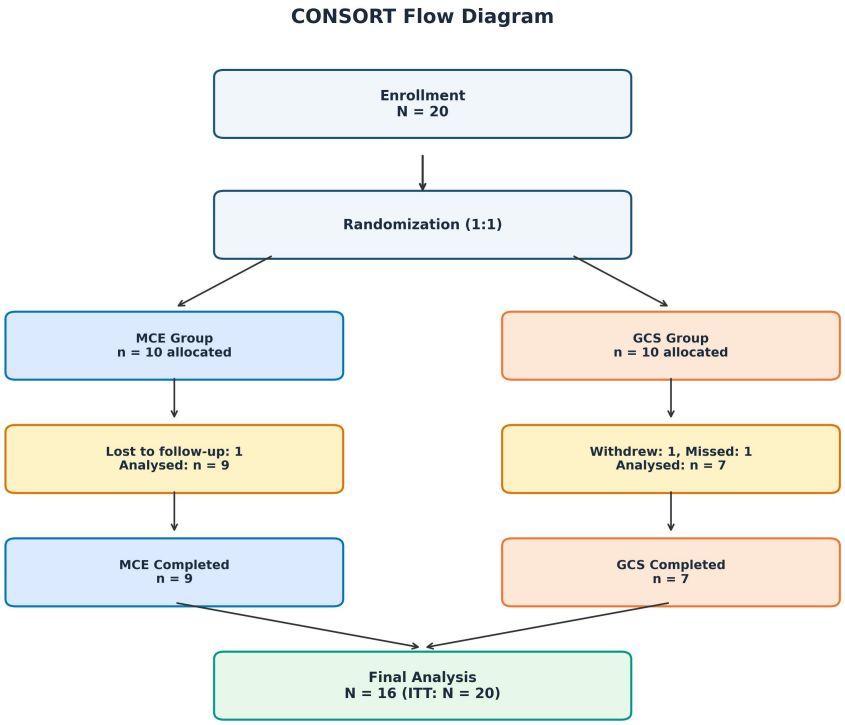

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Figure 1. CONSORT flow diagram of participant recruitment, allocation, follow-up, and analysis.

Baseline demographic and clinical characteristics of participants are presented in Table 1. No statistically significant differences were observed between the two groups at baseline for age (p=0.693), sex distribution (p=1.000), body mass index (p=0.533), or any of the primary and secondary outcome measures (all $p > 0.05$), confirming successful randomisation and baseline comparability.

Table 1. Baseline demographic and clinical characteristics of participants.

Variable	MCE Group (n=10)	GCS Group (n=10)	p-value
Age (years)	42.0 ± 8.2	40.6 ± 7.4	0.693
Sex (M/F)	6/4	7/3	1.000
BMI (kg/m²)	27.7 ± 2.4	28.6 ± 4.0	0.533
ODI (%)	46.3 ± 8.5	43.3 ± 8.6	0.469
Pain (NPRS)	6.6 ± 0.9	6.9 ± 0.8	0.488
QoL (EQ-5D)	48.6 ± 5.7	45.8 ± 5.9	0.337

Primary Outcomes

Both groups demonstrated statistically significant improvements in all primary outcome measures from pre- to post-intervention (all $p < 0.001$). The results are summarised in Table 2 and Figure 2.

For the ODI, the MCE group showed a mean reduction of 19.1 ± 2.5 points (from 46.3 ± 8.5 to 27.2 ± 8.0), while the GCS group showed a mean reduction of 14.8 ± 2.4 points (from 43.3 ± 8.6 to 28.5 ± 9.7). The between-group difference in change scores was statistically significant (p=0.000), favouring the MCE group.[16]

For pain intensity (NPRS), the MCE group demonstrated a mean reduction of 2.9 ± 0.6 points, compared to 2.1 ± 0.3 points in the GCS group, with a statistically significant between-group difference (p=0.000). Both reductions exceeded the minimum clinically important difference of 2 points for the NPRS.[17]

Quality of life (EQ-5D) improved significantly in both groups, with the MCE group showing a mean increase of 19.9 ± 3.2 points compared to 13.9 ± 2.5 points in the GCS group (between-group p=0.000).[18]

Table 2. Primary outcome measures at baseline and post-intervention.

Outcome	MCE Pre	MCE Post	MCE Δ	p (within)	GCS Δ	p (within)	p (between)

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Outcome	MCE Pre	MCE Post	MCE Δ	p (within)	GCS Δ	p (within)	p (between)
ODI (%)	46.3 ± 8.5	27.2 ± 8.0	-19.1 ± 2.5	0.000	-14.8 ± 2.4	0.000	0.000*
Pain (NPRS)	6.6 ± 0.9	3.7 ± 1.1	-2.9 ± 0.6	0.000	-2.1 ± 0.3	0.000	0.000*
QoL (EQ-5D)	48.6 ± 5.7	68.4 ± 5.7	19.9 ± 3.2	0.000	13.9 ± 2.5	0.000	0.000*

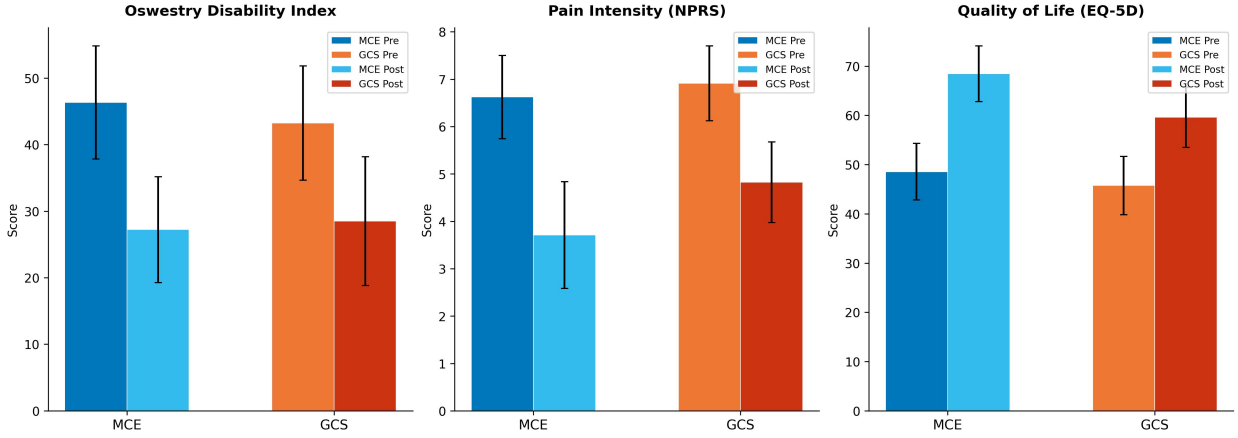

Figure 2. Comparison of primary outcomes (mean ± SD) between MCE and GCS groups at pre- and post-intervention. ODI = Oswestry Disability Index; NPRS = Numeric Pain Rating Scale; EQ-5D = European Quality of Life-5 Dimensions.

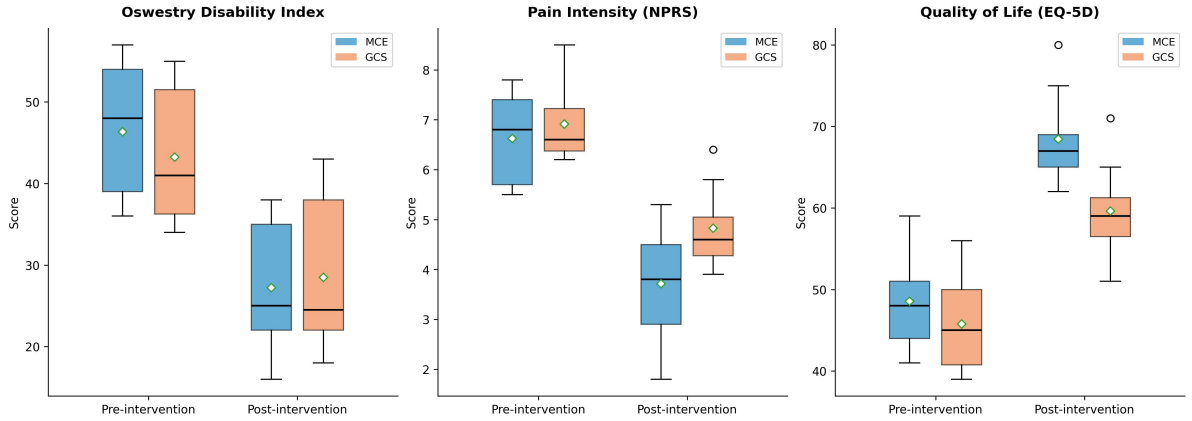

Figure 3. Box plots showing the distribution of primary outcomes at pre- and post-intervention for MCE and GCS groups. Diamonds indicate mean values; horizontal lines within boxes indicate medians.

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Secondary Outcomes

Both groups demonstrated significant within-group improvements across all secondary outcome measures (all $p < 0.001$). The between-group comparisons are presented in Table 3 and Figure 4.

The MCE group demonstrated significantly greater improvements in trunk muscle endurance as measured by the Sorensen test, with a mean change of +33.4 ± 4.3 seconds compared to +18.4 ± 4.2 seconds in the GCS group (p=0.000). This finding is consistent with the theoretical emphasis of MCE on deep trunk muscle activation and endurance.[19]

Fear-avoidance beliefs (FABQ) decreased significantly in both groups, with the MCE group showing a mean reduction of 7.8 ± 1.6 points compared to 4.6 ± 1.3 points in the GCS group (p=0.000). Similarly, pain catastrophising (PCS) decreased by 9.1 ± 1.6 points in the MCE group versus 5.8 ± 1.9 points in the GCS group (p=0.000). These psychosocial outcomes are particularly noteworthy as fear-avoidance beliefs and pain catastrophising are established prognostic factors for poor recovery in CNSLBP.[20][21]

Functional mobility, as measured by the TUG test, improved significantly in both groups, with the MCE group demonstrating a greater mean reduction of 2.5 ± 0.3 seconds compared to 1.4 ± 0.3 seconds in the GCS group (p=0.000). Lumbar range of motion also improved in both groups, with a statistically significant between-group difference (p=0.040).[22]

Table 3. Secondary outcome measures at baseline and post-intervention.

Outcome	MCE Pre	MCE Post	MCE Δ	p (within)	GCS Δ	p (within)	p (between)
Sorensen (sec)	48.9 ± 8.6	82.3 ± 10.4	33.4 ± 4.3	0.000	18.4 ± 4.2	0.000	0.000*
ROM (deg)	52.8 ± 7.6	59.8 ± 8.0	7.0 ± 1.6	0.000	5.3 ± 1.0	0.000	0.040*
FABQ	22.4 ± 5.2	14.7 ± 6.0	-7.8 ± 1.6	0.000	-4.6 ± 1.3	0.000	0.000*
PCS	27.0 ± 4.8	17.9 ± 5.4	-9.1 ± 1.6	0.000	-5.8 ± 1.9	0.000	0.000*
TUG (sec)	11.0 ± 1.5	8.5 ± 1.6	-2.5 ± 0.3	0.000	-1.4 ± 0.3	0.000	0.000*

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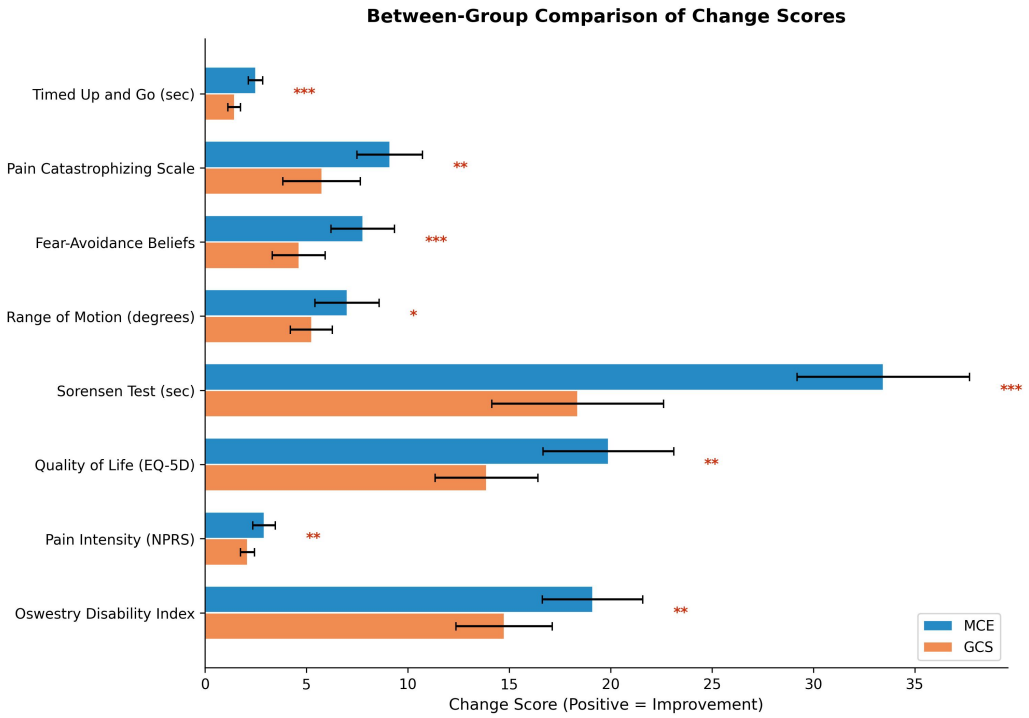

Figure 4. Between-group comparison of change scores (positive direction = improvement) with significance levels. MCE = Motor Control Exercise; GCS = General Core Stabilisation; ODI = Oswestry Disability Index; NPRS = Numeric Pain Rating Scale; EQ-5D = European Quality of Life-5 Dimensions; FABQ = Fear-Avoidance Beliefs Questionnaire; PCS = Pain Catastrophizing Scale; TUG = Timed Up and Go; ROM = Range of Motion.

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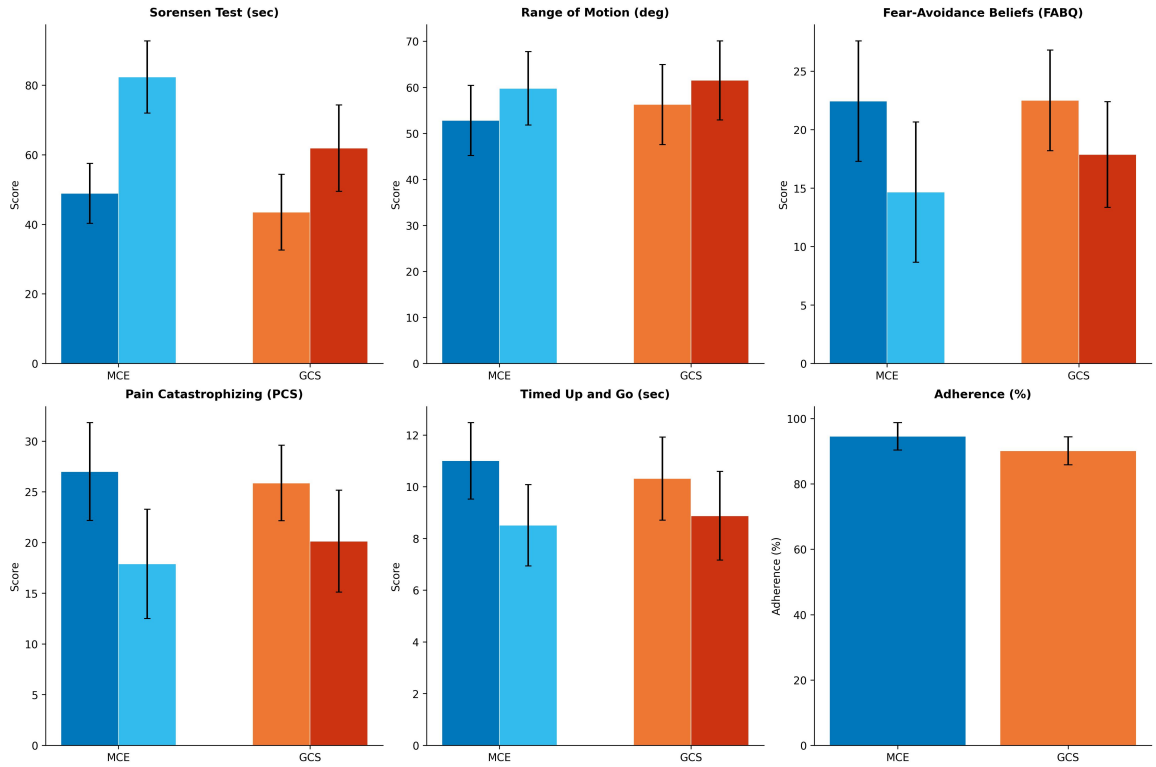

Figure 5. Comparison of secondary outcomes (mean ± SD) between MCE and GCS groups at pre- and post-intervention.

Session adherence was high in both groups, with the MCE group attending a mean of 94.4% and the GCS group attending a mean of 90.1% of prescribed sessions, indicating excellent compliance with both intervention programmes.

DISCUSSION

This randomised controlled trial compared the effects of an eight-week motor control exercise programme versus a general core stabilisation programme in adults with chronic non-specific low back pain. The principal finding was that while both interventions produced statistically significant and clinically meaningful improvements across all measured outcomes, the MCE group demonstrated significantly greater improvements in nearly all primary and secondary outcomes compared to the GCS group.

The observed superiority of MCE over GCS for disability reduction is consistent with the theoretical foundations of the motor control approach. MCE specifically targets the deep trunk stabilisers, including transversus abdominis and lumbar multifidus, which have been shown to exhibit delayed activation and atrophy in individuals with low back pain.[6][12] By restoring the neuromuscular control of these muscles, MCE may enhance spinal stability and motor

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coordination more effectively than general strengthening exercises that primarily target the global trunk musculature. This finding aligns with the systematic review by Saragiotto et al., which reported that MCE produces small to moderate effects on pain and disability compared to minimal intervention, and with the work of Costa et al., who demonstrated that MCE provides clinically important benefits over general exercise in the short term.[5][7]

The significantly greater reduction in pain intensity observed in the MCE group is a clinically important finding, as both groups exceeded the minimum clinically important difference of 2 points on the NPRS. The more pronounced pain reduction with MCE may be attributed to several mechanisms, including improved spinal segmental control reducing nociceptive input from mechanically irritated tissues, enhanced proprioceptive awareness reducing fear-related guarding behaviours, and the progressive functional integration phase of MCE that addresses pain-related movement dysfunction.[23][29]

The quality of life improvements, while significant in both groups, were notably greater in the MCE group. This finding is clinically relevant as quality of life encompasses broader aspects of health beyond pain and disability, including psychological wellbeing and social participation. The more comprehensive improvement with MCE may reflect the intervention's emphasis on functional integration and movement retraining, which could enhance self-efficacy and confidence in performing daily activities.[4][26]

Among the secondary outcomes, the markedly superior improvement in trunk muscle endurance (Sorensen test) in the MCE group was expected, given the specific emphasis of MCE on deep muscle endurance training. Hides et al. previously demonstrated that specific stabilisation exercises can restore the size and function of the multifidus muscle in patients with low back pain, providing a plausible physiological mechanism for the observed endurance improvements.[6][30]

Perhaps the most clinically significant finding was the superior reduction in fear-avoidance beliefs and pain catastrophising in the MCE group. These psychological factors are established prognostic indicators for poor outcomes in chronic low back pain, and their modification through exercise therapy has important implications for long-term recovery and prevention of disability chronicity.[20][21][27] The graduated, confidence-building approach of MCE, which begins with simple, pain-free movements and progressively integrates more challenging functional tasks, may be particularly effective in addressing maladaptive pain cognitions. This finding supports the biopsychosocial perspective that effective CNSLBP management must address both physical and psychological dimensions of the condition.[4]

Limitations

Several limitations should be acknowledged when interpreting the results of this study. First, the sample size of 20 participants is relatively small, which limits the statistical power and generalisability of the findings. While significant between-group differences were detected, larger trials are needed to confirm these results and to enable subgroup analyses. Second, the absence of a long-term follow-up assessment precludes conclusions about the durability of treatment effects

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beyond the immediate post-intervention period. Third, the participants and treating therapists could not be blinded to group allocation, which introduces potential performance and expectancy biases. Fourth, the study was conducted at a single centre, which may limit the external validity of the findings to other settings and populations.

Fifth, the study did not include a sham or minimal intervention control group, which makes it difficult to determine the extent to which observed improvements were attributable to specific treatment effects versus non-specific factors such as therapist attention, participant expectations, or the natural history of the condition. Sixth, the use of a single follow-up time point limits the ability to examine the trajectory of recovery over time.

CONCLUSION

This randomised controlled trial provides evidence that both motor control exercises and general core stabilisation exercises are effective in reducing disability, pain intensity, fear-avoidance beliefs, and pain catastrophising, while improving quality of life, trunk muscle endurance, lumbar range of motion, and functional mobility in adults with chronic non-specific low back pain. However, motor control exercises demonstrated significantly greater improvements across nearly all measured outcomes, including the primary outcomes of disability, pain, and quality of life, as well as the secondary outcomes of trunk muscle endurance, fear-avoidance beliefs, pain catastrophising, and functional mobility.

These findings suggest that the specific, targeted nature of motor control exercises, with their emphasis on deep trunk muscle activation, neuromuscular re-education, and progressive functional integration, may offer therapeutic advantages over conventional general core strengthening approaches for individuals with CNSLBP. Future research should investigate the long-term effects of these interventions, include larger and more diverse samples, incorporate cost-effectiveness analyses, and explore the potential mechanisms underlying the observed between-group differences, particularly the differential effects on psychosocial outcomes.

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