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EFFECT OF RESISTANCE BAND EXERCISES AS AN ADJUNCT TO CONVENTIONAL PHYSIOTHERAPY ON PAIN, DISABILITY AND QUALITY OF LIFE IN PATIENTS WITH CHRONIC LOW BACK PAIN

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ABSTRACT-

Background: Even though standard physiotherapy is widely used, chronic low back pain still drives up costs borne by patients and the health system and remains one of the biggest disabilities in the world. While exercise is always strongly recommended as first-line management in clinical guidelines, none of them clearly indicates what kind of exercise will be most beneficial, and the additional value of resistance band training, if combined with regular physiotherapy treatment, is not well known.

Objective: The objective is to compare the effects of resistance band exercises performed in addition to conventional physiotherapy on the intensity of pain, the level of functional disability and quality of life for those who suffer from chronic low back pain versus conventional physiotherapy alone.

Methods: The study was of prospective, random, parallel-assessor blinded, controlled type and was performed in the Physiotherapy Out-Patient Department of a tertiary care Teaching Hospital. Thirty individuals suffering from chronic non specific low back pain (LBP) who had had at least 3 months of persistent pain were randomly allocated in a 1:1 ratio based on a computer-generated list of sequentially opaque, sealed envelopes. A total of 30 adults did have chronic non specific low back pain (LBP) of at least three months duration and were randomly allocated in a 1:1 ratio based on a computer-generated list of sequentially opaque, sealed envelopes. Group A (n = 15) was group that received conventional physiotherapy - Heat therapy, Electrotherapy, Stretching and lumbar stabilisation exercises. Group B (n = 15) received the same conventional programme, along with a supervised, progressive exercise programme utilising elastic resistance bands focusing on the trunk, hip and lower limb musculature three times a week for 4–6 weeks. A blinded rater collected outcomes at baseline and at the end of the intervention, which were the Visual Analogue Scale for pain, the Modified Oswestry Disability Index for disability and the WHOQOL BREF for quality of life. Paired t test and independent t tests were for group comparisons and Cohen's d was the effect size measure for between group t tests.

Results: Significant improvements, between $p<0.001$, occurred from baseline with both groups on all outcomes. Pain reduction was greater in Group B than Group A (mean change 3.55 versus 1.57 cm, $p < 0.001$, $d = 3.80$). Disability improved more in Group B than Group A (mean MODI reduction 16.27% versus 10.13%, $p < 0.001$, $d = 2.19$). The improvement in all four WHOQOL BREF domains was found to be significantly larger in Group B, and the highest in the two domains of physical health and social relationships, with d around 2.2. There was moderate but negative correlation between baseline BMI and the amount of pain and disability improvement.

Conclusion: The addition of a structured and progressive resistance band exercise programme to conventional physiotherapy resulted in significantly better outcomes for those patients with chronic low back pain in regard to pain, disability, and quality of life compared to conventional physiotherapy alone. Portable restuvian training is now available where resistance bands can be incorporated into basic rehab interventions for this condition at low cost, portably, and easily at home, thus making it a viable and

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clinically beneficial option. Further larger multicentre trials with longer follow-up are required to confirm these data, and to test their long-term duration.

Keywords – Chronic low back pain (CLBP), Non-specific low back pain, Resistance band exercise, Elastic resistance training, Conventional physiotherapy, Therapeutic exercise.

Introduction

Low back pain is one of the most frequent musculoskeletal problems encountered in clinical practice and is a major cause of disability worldwide. In general terms, it is pain, muscle tension or stiffness in the area below the costal margin and above the inferior gluteal fold, either with or without pain spreading down the one or both lower limbs and lasting for more than a day [1]. It is found in almost all ages, professions and geographical areas and has been increasing in the last 30 years, although medical science and rehabilitation have been progressing.

The Global Burden of Disease study estimated that in 2020 there were an estimated 619 million people affected by low back pain, with this number expected to increase to nearly 843 million in 2050 with the ageing of the population and the increase in sedentary lifestyles [1]. Low back pain has been consistently in the top spot for years lived with disability (YLD) among the 204 countries and territories analysed in this study since 1990 [1]. The International Association for the Study of Pain also reports a point prevalence of approximately 7.5 percent of the global population in 2017 (or approximately 577 million people at any point in time) [2]. These statistics illustrate that low back pain is not something to ignore or take lightly, but a significant public health problem in terms of quality of health service provision as well as income status.

The economic and occupational burden of low back pain is also impressive. The condition costs nearly 149 million working days annually, and there are significant losses of productivity for both people and countries [3]. In those under the age of 45, a low back pain visit to a physician is the second most common cause after the common cold and is one of the more common causes for surgical interventions and hospital admission. [3] Thirty years later, in 2021, the number of working age low back pain cases jumped to 452.8 million, up by over fifty percent from 1990 [4]. The number of people affected has also increased over this time, though the rates have gone down when age-standardised [4]. The burden is also unevenly distributed with post-menopausal women being at an increased risk of low back pain compared to age matched men [5] and the rapid urbanisation and changing occupational patterns are also exacerbating this problem in many middle income countries [6].

Low back pain is generally classified by duration as acute, subacute and chronic, and chronic low back pain is defined as pain lasting for 12 weeks or more, often with remissions and relapses [3]. The vast majority of acute episodes do not become chronic pain, but these few do lead to the bulk of the disability, health care utilization and cost of the condition [3]. It is also classified according to the presumed causes into specific and non specific forms, the latter being the most common form encountered in primary care and physiotherapy practice as no structural or pathological abnormality can be identified [3]. The population studied in the present study is the case of chronic non specific low back pain, which is a diagnosis of exclusion, implying an interaction between altered spinal biomechanics, deconditioning of the trunk musculature and psychosocial contributors rather than a single anatomical lesion.

A shift in understanding in the last 20 years has occurred from a biomedical model to a biopsychosocial model, in which biological, psychological and social factors all play a role in the way chronic LBP is experienced and the amount of disability that ensues [7]. At a biological level, chronic back pain often has a component of "deconditioning" of the paraspinal and abdominal muscles, meaning that the deep stabilising muscles (such as the transversus abdominis and multifidus) are not functioning as well as they once were; or they are not firing when they are supposed to fire; and/or there is compensatory overactivity of the more superficial muscles (such as erector spinae). This changed recruitment pattern can also continue abnormal loading of the spine well after the initial "incident" has passed and the strengthening and timing of the activation of these muscles is now one of the main goals of exercise based rehabilitation. Fear avoidance beliefs, catastrophising and low self efficacy in managing pain are also all

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consistently related to greater disability and less good treatment results, which is why purely passive or purely biomechanical interventions only provide moderate and temporary benefits.

Chronic low back pain is more than a localized pain and has a profound impact on activities like bending, lifting, sitting and lying for long durations, standing and walking, and eventually on work participation, household duties, sleep and social interaction [12]. This is also true for health related quality of life, where patients have often reported a decrease in vitality, physical functioning and a decrease in general health perception [15]. Due to the interdependent yet different nature of disability and quality of life, integrated clinical studies are now examining both aspects simultaneously to gain a more holistic understanding of the impact of an intervention on the patient's life with the condition.

There has been a shift in the current management of chronic low back pain from the use of pharmacological and passive treatment modalities towards an active management, exercise and multidisciplinary approach. The American College of Physicians (ACP) recommends that non drug therapies (such as exercise, multidisciplinary rehabilitation, motor control exercise and cognitive behavioural therapy) be tried first, before giving a choice to pharmacological treatments for individuals who are not responding sufficiently [8]. The National Institute for Health and Care Excellence (NICE) provides similar recommendations and the results of a comparative review of 22 clinical practice guidelines from around the world showed that there was a strong overall consensus that therapeutic exercise should be a key part of care, though these guidelines were not specific about one particular exercise modality over another due to a lack of evidence supporting one over the other [9,10]. This non-specificity allows physiotherapists to have many options in choosing which exercises to use, both aerobic, motor control, core stabilisation, stretching, and resistance training, and rarely with much guidance on which to compare.
There is a traditional, or conservative, approach to physiotherapy for chronic low back pain, which generally involves patient education, manual therapy, general therapeutic exercise and postural corrective exercises, and sometimes includes some form of electrotherapy modalities like transcutaneous electrical nerve stimulation. It can be a beneficial treatment that improves pain and function in many patients, but may not be as effective on strength, especially the deep trunk stabilising muscles unless an exercise protocol is specifically designed to provide progressive resistance [16]. Sessions are also often limited in what they can do, in how long and in the availability of equipment at the gym, and patients are expected to maintain a home exercise programme after just a couple of weeks of supervised exercise. Gentle stretching and mobility exercises are helpful for improving flexibility, but may not have a progressive overload mechanism built in, which can lead to a plateau once initial gains have been made. This practical constraint has fostered a renewed interest in resistance based methods which are a simple and relatively inexpensive method of incorporating measurable and progressive resistance into physiotherapy.

The benefits of resistance training for chronic low back pain have been thought to occur through several interconnected mechanisms: increased motor unit recruitment, hypertrophy of the trunk muscles, increased proprioception and postural control, and psychological benefits, such as increased self-efficacy and decreased fear avoidance behaviour [21]. A systematic review and meta analysis which pooled data from 10 randomized controlled trials (RCTs) of resistance training and chronic non specific low back pain (cNSLBP) showed that there was significant reduction in pain intensity, quality of life and disability in the resistance training group compared to various comparison groups (pooled standardised mean difference (SMD) for disability was negative 2.76 [18]).

In the spectrum of resistance training options, elastic resistance bands have gained considerable popularity as they are both practical and economical and are versatile in use. Whereas free weights or resistance machines offer constant resistance, elastic bands offer progressive resistance based on the amount of stretch applied to them, enabling a ‘loading curve' to match the strength curve of the muscle being trained and allowing for fine gradations of resistance by varying the colour and length of the elastic bands. They are low weight and low cost, which is important for home based programmes as long-term adherence is critical for maintaining benefit in chronic pain management and a patient's home is where they will be adhering in the long term. Elastic band training has been shown to have benefits in healthy adults, older adults with poor muscle strength and balance, and in patients with sarcopenia [21,22,24]. A randomized controlled trial with desk job workers with chronic neck pain demonstrated a greater improvement in pain,

disability and quality of life from the addition of a resistance component to typical care than from typical care alone, which is consistent with the general idea that a structured resistance program can improve outcomes in chronic musculoskeletal pain [25].

Evidence is still more limited when applied to chronic low back pain, specifically. A trial that has been often cited compared the two groups of adults with moderate to severe non specific low back pain, both of whom had multidisciplinary rehabilitation, and one had general exercise, the other did progressive resistance training with elastic bands, and both groups were followed up over 12 months [16]. Another trial recently compared elastic resistance band exercise with conventional weight based resistance training in 60 participants over 6 weeks, and found that both exercise modalities resulted in similar improvements in disability and pain, with greater adherence rates in the elastic band group (92.2 percent vs. 83.9 percent) [17]. This is clinically relevant as people often fail to adhere to exercise programs provided to reduce chronic pain.

Although positive findings have been obtained, there are still some gaps in the literature. The majority of studies that have looked at resistance band training compared it to other forms of exercise that have also used resistance, such as general exercise or conventional weighted resistance training, but not to resistance bands as an adjunct to conventional physiotherapy. While the number of trials is still fairly small, the duration of follow-up is highly variable, and relatively few trials have compared disability, measured with a validated instrument like the Oswestry Disability Index, with other measures of quality of life such as the WHOQOL BREF, both within the same trial population. This combination of gaps suggests a compelling need for additional controlled research to determine if resistance band exercise in combination with traditional physiotherapy is an effective intervention for improved disability and quality of life in patients with chronic LBP.

Therefore, the present study was undertaken to assess the effect of resistance band training in addition to conventional physiotherapy on pain, disability and quality of life in patients with chronic low back pain to provide practical, clinically relevant data for physiotherapists and patients who consider using simple, low cost resistance band training as an addition to conventional physiotherapy.

2. Materials and Methods:

2.1 Study design

This study was designed as a prospective, randomized, parallel group, assessor blinded, two arm controlled clinical trial, according to Consolidated Standards of Reporting Trials (CONSORT) 2010 guidelines for non pharmacological interventions. Chronic low back pain patients were randomly allocated to one of two parallel treatment groups: Group A – conventional physiotherapy versus Group B – conventional physiotherapy plus a structured progressive resistance band exercise programme as an adjunct. A parallel group design with concurrent control arm was selected for this trial because it offered the most compelling evidence for causal inference of the additional benefit of resistance band training compared with conventional physiotherapy, and assessor blinding reduced detection bias when measuring the largely self reported outcomes of this trial.

2.2 Setting and duration

The study was done in the Department of Physiotherapy and Orthopaedics, Prakash Hospital, Sector Omega 1, Greater Noida, Uttar Pradesh, India which is a tertiary care teaching hospital and where the physiotherapy services are provided to the mixed urban and semi urban people. The six-month study period encompassed the development of the intervention protocol and ethics approval, recruitment, an intervention phase of four to six weeks per participant, baseline assessment, and data analysis and write up for each participant in a physiotherapy outpatient department.

2.3 Ethical considerations

The study protocol was approved by the Institutional Ethics Committee of Prakash Hospital before enrolment of any subject and was registered with the Clinical Trials Registry of India (CTRI) Registration number CTRI/2026/06/112857, prior to the recruitment of any subjects, as per the requirements of the International Clinical Trials Registry Platform of the World Health Organization and ICMJE policy on Trial Registration. The study was

conducted in accordance with the ethical principles of the Declaration of Helsinki and the National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (ICMR) guidelines. Informed consent was obtained from all participants, with the purpose, procedures, risks and benefits of the study fully explained to the participants in a language the participant understood. Participants were informed of their right to withdraw at any time without affecting their current clinical care and all data were coded using a unique identifier for each participant with identifying information kept separately and only accessible to the principal investigator. The resistance band programme was offered to the control group at no cost following the post intervention assessment and an adverse event during the study was documented on a structured log and reported to the ethics committee as necessary.

2.4 Participants

Adults suffering from chronic non specific low back pain, pain that lasted for 12 weeks or more and which had no definite pathoanatomical origin (fracture, malignancy, infection, or major structural deformity). Accessible population comprised of a series of consecutive patients of physiotherapy and orthopaedics outpatient departments of the study hospital during the recruitment period.

Eligible patients had the following characteristics: age between 30 and 55 years, either sex, clinically diagnosed NSCLBP of at least 3 months duration, pain score of 4 cm or more on a 10 cm VAS, had to be able to read or understand the study language and provide written informed consent, and be prepared to follow the intervention schedule (4-6 weeks) and follow up assessments.

Exclusion criteria were a specific identifiable cause of low back pain such as vertebral fracture, spondylolisthesis with instability, malignancy, infection or inflammatory spondyloarthropathy; prior lumbar spine surgery; neurological deficit suggestive of significant nerve root or cord compromise; uncontrolled cardiovascular, respiratory or metabolic disease contraindicating resistance exercise; pregnancy; body mass index above 35 kg per square metre; receipt of spinal injection, manipulation or any other physiotherapy intervention for low back pain within the preceding four weeks; and cognitive impairment precluding reliable self report of outcome measures.

2.5 Sample size

A priori sample size was calculated in the same manner as for comparison of two independent means, using the means and pooled standard deviations for pain reduction in similar published trials of resistance or core strengthening exercise in addition to conventional physiotherapy for chronic LBP. The pooled SD was ~ 1.0 cm and the minimum clinically important difference (MCID) between groups was ~ 1.0 cm on the VAS, and using alpha of 0.05 and power of 0.8, the required number of participants per group was ~ 16. The target number of participants per group was 15-18, with an allowance for the expected drop out rate of about 10 per cent. The final case analysis data reported here included 30 participants, with 15 participants in each of the two groups. Sample size calculation was carried out by using G Power version 3.1.

2.6 Randomisation and allocation concealment

A computer-generated, one-to-one random allocation sequence, generated using block randomisation scheme with blocks of four and six, randomly varied, was used to ensure approximate balance of the groups throughout recruitment, and patients were randomly allocated to either Group A or Group B. The sequentially numbered, opaque, sealed envelope technique was used to ensure allocation concealment. A statistician not involved in participant recruitment or assessment generated the sequence of allocations, put them into consecutively numbered opaque envelopes, sealed them and opened them immediately after a participant's baseline assessment and eligibility determination was completed by the treating physiotherapist.

2.7 Blinding

Considering the physical nature of the intervention, it was not possible to blind the participants and treating therapists to group allocation. To minimize detection and assessment bias, the study included the use of assessor blinding wherein at the post intervention timepoint an independent assessor who was not involved in delivering either intervention recorded the outcome measures, without knowing the group each participant was allocated to. The

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participants were advised not to talk to the outcome assessor about what they are going to do during their exercise sessions.

2.8 Interventions

Both groups were treated with their allocated intervention for 4–6 weeks, with the treatment provided on site, supervised by a trained physiotherapist.

Group A was a control group, which was given a standardised programme of conventional physiotherapy, three times per week for four to six weeks (12 to 18 sessions) of about 30 to 40 minutes duration each. Sessions involved hot moist pack or superficial heat therapy to the lumbar region for 10 – 15 minutes, TENS or interferential therapy as a conventional electrotherapeutic modality, lumbar stabilization and stretching exercises (pelvic tilts, knee to chest stretch, cat camel mobility exercise, hamstrings stretch, hip flexors stretch, and low load abdominal bracing; 2 – 3 sets of 10 repetitions without resistance at home, home exercise advice including the same stretching and mobility exercises performed once daily on non supervised days, and postural correction advice and ergonomic education.

The experimental group (Group B) was given the same conventional physiotherapy programme as Group A, with the same duration and frequency, supplemented with a structured, supervised, progressive elastic resistance band exercise programme at the end of each conventional exercise programme, focusing on the musculature of the trunk, hips and lower limbs. This included a 5 minute warm up of light aerobic exercise; resisted hip extension with band in prone and standing positions, 2-3 sets of 10-12 reps each side, targeting gluteus maximus, erector spinae; resisted trunk rotation in standing and seated positions, 2-3 sets of 10-12 reps each side, targeting obliques and transversus abdominis; banded bird dog, 2-3 sets of 8-10 reps each side, with light band resistance, targeting the multifidus and deep spinal stabilisers; resisted hip abduction with band in standing position, 2-3 sets of 10-12 reps each side, targeting gluteus medius and lateral trunk stabilisers; and a cool down of static stretching, 30 seconds per muscle group. Resistance levels were progressed based on a colour coded elastic band system where progression to the next resistance was only made when the participant could successfully complete two consecutive sessions with a self reported Borg CR ten exertion rating of 5 or 6 or less and correct form. All resistance band sessions conducted directly supervised for proper technique & to monitor adverse response (pain flare, dizziness or excessive fatigue). Group B participants also received a take home resistance band and a pictorial exercises sheet, and instructed to complete a low intensity version of the programme on non supervised days.

Each supervised session was recorded on a standardised log and adherence to the sessions was expressed as a percentage of prescribed supervised sessions. The adherence to the protocol was pre specified at 80 percent or more of supervised sessions, and those participants who did not meet the adherence criterion were included in the intention to treat analysis but were marked for a sensitivity analysis by per protocol. Consistency of delivery of the resistance band programme was ensured by periodically reviewing the exercise delivery technique against a standardised technique checklist.

2.9 Outcome measures

The blinded outcome assessor measured all outcome measures at baseline, 48 hours prior to the first treatment session, and 48 hours after the last treatment session (post intervention).

The main outcome was pain intensity measured on a 10 cm horizontal Visual Analogue Scale ranging from 0 (no pain) to 10 (the worst pain imaginable), with participants indicating the point on the scale that best represented their average intensity of their low back pain over the previous 24–48 hours. The MCD for this measure in chronic LBP is generally reported to be around 1.5–2.0 cm.

The secondary outcome was Functional disability measured by the Modified Oswestry Disability Index, a 10 item self report questionnaire of disability, ranging from 0 (no disability) to 5 (maximum disability) on each of the following categories: Pain intensity, Personal care, Lifting, Walking, Sitting, Standing, Sleeping, Social life, Travelling and Homemaking or work. The total score is a percentage, calculated as follows: MODI total percent is equal to the sum

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of scores on the ten sections divided by 50 multiplied by 100. The interpretation of scores is based on the standard severity bands of 0–20 percent (minimal disability), 21–40 percent (moderate disability), 41–60 percent (severe disability), 61–80 percent (crippled), and 81–100 percent (bed bound or possible exaggeration of symptoms). The normal MCID for this instrument lies between 6% and 10%.

The other secondary outcome was health related quality of life by WHOQOL BREF, an abbreviated version of 26 items of the World Health Organization Quality of Life, which comprises four domain scores, including physical health, psychological wellbeing, social relationships and environment, in addition to two standalone items on overall quality of life and satisfaction with health. The WHOQOL BREF scoring manual applied to the raw domain scores resulted in a scale of 0 to 100, with higher scores signifying a higher level of quality of life, except for the items where reverse scoring was used before calculating the domain scores.

At baseline, these additional factors were recorded for descriptive and covariate adjustment: age, sex, and occupation category, body mass index and duration of symptoms.

2.10 Data management

The personally identifying information was stored with each participant having a unique numeric identifier at enrolment and none of this information was entered into the analysis dataset. The outcome assessor's data was collected on paper case report forms and then entered into a structured workbook for data entry with pre defined value coding and missing value conventions. A 10 percent random check of records entered was conducted independently to assure accuracy of transcription and range checks were performed at the time of data entry to highlight values that fell outside of the range for the appropriate data item and subject to verification against the source data.

2.11 Statistical analysis

All data were coded, entered, cleaned and analysed using IBM SPSS Statistics version 26.0. A two tailed p value of less than 0.05 was considered statistically significant for all analyses. Continuous variables were expressed as mean and standard deviation, and categorical variables as frequencies and percentages. Normality of continuous data was assessed using the Shapiro Wilk test given the relatively small sample size, and homogeneity of variance was evaluated using Levene's test. Baseline characteristics were compared between groups using the independent samples t test for continuous variables and the chi square test for categorical variables. Within group comparisons between pre and post intervention scores were analysed using the paired samples t test, and between group comparisons of post intervention outcomes and change scores were analysed using the independent samples t test. Where the assumption of normality was violated, corresponding non parametric tests, the Wilcoxon signed rank test for within group comparisons and the Mann Whitney U test for between group comparisons, were applied. Treatment effect magnitude was estimated using Cohen's d, with values of 0.2, 0.5 and 0.8 representing small, medium and large effects respectively. All analyses followed the intention to treat principle.

3. Results

3.1 Baseline characteristics

Table 1 summarizes the demographic and clinical characteristics of the subjects of both groups at baseline. Both groups were similar in terms of symptom duration ($p>0.05$), sex distribution ($p>0.05$) and category of occupation ($p>0.05$). The mean age and body mass index (BMI) were significantly different between the groups, with Group B participants being older with a lower mean body mass index (BMI) than Group A. This baseline imbalance is declared and the analysis of a larger data set from this design in the future would need to take into account the effects of age and BMI on rehabilitation outcomes as well as use a between group t test, for both variables may plausibly affect rehabilitation outcomes, separately from treatment allocation.

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Variable	Group A (n=15) Mean ± SD	Group B (n=15) Mean ± SD	Test Statistic	p-value
Age (years)	37.40 ± 6.63	44.53 ± 7.07	t=-2.85	0.008
BMI (kg/m2)	26.94 ± 1.80	24.42 ± 2.06	t=3.56	0.001
Duration of symptoms (months)	11.25 ± 4.86	12.39 ± 4.64	t=-0.66	0.514
Gender (chi-square)	-	-	chi2=0.56	0.456
Occupation (chi-square)	-	-	chi2=1.85	0.396

3.2 Normality of change scores

Shapiro Wilk testing of the pre to post change score for each outcome, computed separately within each group, showed that eleven of the twelve group by outcome distributions did not deviate significantly from normality, supporting use of the paired t test for within group comparisons (Table 2). The single exception was the VAS change score in Group A, which showed mild deviation from normality; a Wilcoxon signed rank test was run as a sensitivity check for this comparison and confirmed the same conclusion of a highly significant within group reduction, so the parametric result is reported for consistency across outcomes.

Outcome (Change Score)	Group	Shapiro-Wilk W	p-value	Normally Distributed?
VAS change	Group A	0.850	0.017	No
VAS change	Group B	0.922	0.209	Yes
MODI change	Group A	0.910	0.134	Yes
MODI change	Group B	0.929	0.261	Yes
WHOQOL Physical change	Group A	0.933	0.304	Yes

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Outcome (Change Score)	Group	Shapiro-Wilk W	p-value	Normally Distributed?
WHOQOL Physical change	Group B	0.932	0.289	Yes
WHOQOL Psychological change	Group A	0.944	0.434	Yes
WHOQOL Psychological change	Group B	0.883	0.052	Yes
WHOQOL Social change	Group A	0.975	0.929	Yes
WHOQOL Social change	Group B	0.945	0.453	Yes
WHOQOL Environmental change	Group A	0.918	0.179	Yes
WHOQOL Environmental change	Group B	0.951	0.537	Yes

3.3 Pain intensity

Both groups showed a statistically significant within group reduction in VAS pain score from baseline to post intervention, but the magnitude of improvement was substantially greater in Group B (Table 3). The between group comparison of change scores confirmed that resistance band training produced significantly greater pain reduction than conventional physiotherapy alone, with a very large effect size (Table 4).

Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	Within-Group p-value	Within-Group Cohen's d
Group A (Conventional PT)	5.17 ± 0.66	3.60 ± 0.78	<0.001	3.40
Group B (Conventional PT +	5.41 ± 0.54	1.86 ± 0.71	<0.001	6.13

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Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	Within-Group p-value	Within-Group Cohen's d
Resistance Band)				

Table 4. Between group comparison of mean pain reduction.

Comparison	Group A Mean Change ± SD	Group B Mean Change ± SD	Between-Group p-value	Between-Group Cohen's d
VAS pain reduction	1.57 ± 0.46	3.55 ± 0.58	<0.001	3.80

Group B achieved more than double the mean pain reduction observed in Group A, confirming that conventional physiotherapy alone is an effective analgesic intervention while showing that the addition of resistance band training does not compromise, and in fact substantially augments, this effect.

3.4 Functional disability

Both groups showed statistically significant reductions in MODI disability score from baseline, with a larger reduction again observed in Group B (Table 5). The between group comparison of change scores favoured Group B (Table 6). Using standard MODI severity bands, the Group B sample moved on average from the severe disability band toward the upper end of the moderate disability band more decisively than Group A, consistent with the biomechanical rationale that progressive resistance training of the trunk and hip musculature produces greater gains in functional capacity, reflected in domains such as lifting, standing and walking, than conventional physiotherapy alone.

Table 5. Within group change in MODI disability score, percent.

Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	Within-Group p-value	Within-Group Cohen's d
Group A (Conventional	60.67 ±	50.53 ±	<0.001	4.36

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Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	Within-Group p-value	Within-Group Cohen's d
PT)	7.00	7.19		
Group B (Conventional PT + Resistance Band)	68.40 ± 10.29	52.13 ± 11.33	<0.001	5.09

Table 6. Between group comparison of mean MODI disability reduction.

Comparison	Group A Mean Change ± SD	Group B Mean Change ± SD	Between-Group p-value	Between-Group Cohen's d
MODI disability reduction (%)	10.13 ± 2.33	16.27 ± 3.20	<0.001	2.19

3.5 Quality of life

All four WHOQOL BREF domains improved significantly from baseline in both groups, indicating that structured physiotherapy of either type was associated with meaningful gains in perceived quality of life over the intervention period (Table 7). The magnitude of improvement was consistently and significantly larger in Group B across all four domains (Table 8), with the largest between group effect sizes seen in the physical health and social relationships domains and the smallest, though still large, effect seen in the environmental domain. The greater relative benefit in the physical health domain is biologically plausible, since this domain most directly captures mobility, activities of daily living and pain or discomfort, the constructs most proximally targeted by a strengthening intervention. The comparatively smaller, though still significant, gain in the environmental domain is also plausible, since this domain reflects factors such as financial resources and home environment that a physiotherapy intervention would not be expected to influence as directly.

Table 7. WHOQOL BREF domain scores, pre versus post, by group.

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Domain	Grp A Pre	Grp A Post	Grp A p	Grp B Pre	Grp B Post	Grp B p
Physical	45.22 ± 5.21	51.35 ± 4.62	<0.001	47.83 ± 5.22	59.91 ± 5.37	<0.001
Psychological	50.86 ± 5.18	57.17 ± 5.48	<0.001	47.53 ± 4.64	59.11 ± 4.42	<0.001
Social	51.92 ± 6.87	55.63 ± 7.00	<0.001	49.71 ± 5.50	56.73 ± 5.47	<0.001
Environmental	50.63 ± 4.92	53.82 ± 4.38	<0.001	50.13 ± 4.84	55.67 ± 4.70	<0.001

Table 8. Between group comparison of mean WHOQOL BREF domain change scores.

Domain	Group A Mean Change	Group B Mean Change	Between-Group p-value	Between-Group Cohen's d
Physical	6.13 ± 2.30	12.07 ± 3.00	<0.001	2.22
Psychological	6.31 ± 2.63	11.58 ± 2.63	<0.001	2.00
Social	3.71 ± 1.40	7.02 ± 1.58	<0.001	2.22

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Domain	Group A Mean Change	Group B Mean Change	Between-Group p-value	Between-Group Cohen's d
Environmental	3.19 ± 1.54	5.55 ± 1.67	<0.001	1.47

Table 9. Summary of between group statistical comparisons across all outcome measures.

Outcome Measure	Between-Group p-value	Between-Group Cohen's d	Direction of Benefit
VAS (pain)	<0.001	3.80	Group B > Group A
MODI (disability)	<0.001	2.19	Group B > Group A
WHOQOL - Physical	<0.001	2.22	Group B > Group A
WHOQOL - Psychological	<0.001	2.00	Group B > Group A
WHOQOL - Social	<0.001	2.22	Group B > Group A
WHOQOL - Environmental	<0.001	1.47	Group B > Group A

3.6 Distribution of change scores and individual level response

Boxplots of individual within patient change scores for VAS and MODI showed minimal overlap between the interquartile ranges of the two groups, consistent with the large between group effect sizes reported above. Individual patient trajectories for VAS pain score showed a consistent downward, improving, slope for nearly every participant in both groups, with Group B trajectories converging on a lower post intervention pain score and showing less spread between patients at follow up than Group A, suggesting a more uniform treatment response when resistance band training was added.

3.7 Exploratory correlation analysis

Pearson correlations were computed between baseline demographic variables and the two primary change scores across the pooled sample of 30 participants, to explore potential predictors of treatment response (Table 10). Baseline BMI showed a moderate negative correlation with both VAS reduction ($r = -0.53$) and MODI reduction ($r = -0.52$),

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suggesting that participants with higher baseline BMI tended to show smaller improvements, a plausible finding given the biomechanical load that body mass places on the lumbar spine during rehabilitation. VAS reduction and MODI reduction were strongly positively correlated with each other (r = 0.71), indicating that participants who experienced greater pain relief also tended to experience greater functional improvement. Age and symptom duration showed weak, non significant correlations with outcome change. Because BMI also differed significantly between groups at baseline, this correlation reinforces the recommendation that an analysis adjusting for baseline BMI and age should be considered as the primary between group analysis in any larger confirmatory trial.

Table 10. Pearson correlation matrix, baseline variables and primary outcome change scores, N = 30, pooled.

Variable	Age	BMI	Duration (months)	VAS change	MODI change
Age	1.00	-0.17	0.01	0.38	0.17
BMI	-0.17	1.00	0.01	-0.53	-0.52
Duration (months)	0.01	0.01	1.00	0.07	0.08
VAS change	0.38	-0.53	0.07	1.00	0.71
MODI change	0.17	-0.52	0.08	0.71	1.00

Discussion

Chronic low back pain (cLBP) is one of the most common causes of disability in the world, and is still a major public health concern, due to its multifactorial etiology, reoccurrence and its heavy burden on physical, psychological and social health. Pain relief, function and quality of life improvements are important treatment goals that must be met that can still be targeted by intervention, and this must be done in a sustained manner. While conventional physiotherapy continues to be the mainstay of conservative care, the use of progressive resistance exercise is emerging as a means of achieving potentially better results as it is thought to help correct muscle weakness, motor control issues and spinal instability. The current trial was designed to evaluate the effects of conventional physiotherapy in comparison to conventional physiotherapy plus resistance band exercises on adults with chronic low back pain. The participants who did the progressive resistance training with resistance bands in addition to conventional physiotherapy had a greater decrease in pain intensity, a lower disability score, and more significant improvements in quality of life than the group who did only conventional physiotherapy, suggesting that exercise training with resistance bands is more beneficial than conventional exercise training when treating OCD.

Groups were broadly comparable in the distribution of sex and occupational profile, and there were no significant differences in the duration of symptoms between groups, with the groups being broadly comparable in overall

numbers, but statistically significant differences in age and body mass index between the two groups were seen. Although these differences were relatively small, they are not necessarily the only reasons for the observed superiority of the experimental intervention; similar baseline imbalances have been reported in other RCTs with smaller samples despite proper randomisation. The overall improvements in all primary outcome measures of the experimental group are therefore more likely to be due to the therapeutic effect of resistance band exercise than to differences in demographic factors alone, although larger trials with stratified randomisation would help to account for the demographic differences in the groups and improve the internal validity of the findings.

The primary aim of this investigation was to evaluate the effects of pain reduction, a key factor in the choice of patients to seek care for chronic LBP, as it is the most frequent cause of reduced mobility, decreased participation in occupational and recreational activities and disruption of sleep and psychological distress. The difference in VAS score was statistically significant in both groups, but the VAS score difference was significantly higher in the group training with resistance band in addition to the conventional physiotherapy. This means that conventional physiotherapy is effective at reducing pain but adding progressive resistance training can have additional analgesic effects that are likely to have clinical relevance to functional activities.

There are a number of physiological mechanisms that could account for this decrease in pain when using resistance bands. Progressive resistance exercise boosts the activation of the deep stabilising muscles of the lumbar spine (transversus abdominis, multifidus, erector spinae and gluteal muscles). These muscles act better allowing for better segmental spinal stability, which decreases abnormal mechanical loading on structures like intervertebral discs, facet joints, ligaments and paraspinal tissues. Resistance exercise additionally induces a neuromuscular adaptation that enhances postural control and movement efficiency, thereby decreasing compensatory movement patterns frequently observed in chronic low back pain, and increases the release of endogenous pain inhibitory pathways (endorphins) and activation of descending inhibitory pathways, both of which likely explain the higher degree of pain reduction in the experimental group.

This study corroborates an increasing amount of literature that highlights the importance of enhancing exercise in chronic LBP rehabilitation. Hayden et al. found that structured exercise therapy was most effective in decreasing pain and disability compared with minimal intervention or usual care, and that exercise is one of the most promising conservative treatment options that is available [29]. In a separate systematic review, Delitto and colleagues also suggested exercise therapy as a first line treatment, stating that strengthening and stabilisation exercises have been shown to improve pain and function in patients with chronic low back pain [26]. While the recommendations include different modalities of exercise, it is the current findings that demonstrate that resistance band exercise alone can further strengthen the effects of traditional physiotherapy.

Similar results have been reported in recent trials. A muscle strengthening programme was found to improve lumbar muscle endurance and decrease pain intensity when compared to an aerobic walking programme [33] and individualised resistance training programmes have been shown to result in greater improvements in pain and physical performance among adults with chronic low back pain; this is partly due to progressive loading, which restores muscle strength and increases confidence in movement. The present study corroborates these findings and suggests that elastic band progressive resistance is a convenient and cost-effective method for providing a progressive strengthening program in the clinical setting.

Elastic resistance bands offer several benefits over traditional weight training tools. They offer progressive resistance to stretch as the band action extends further, meaning that patients can move as their comfort level allowing movement while minimizing excess joint loading and minimizing fear of movement. They are low cost, easy to transport, do not need extensive clinical facilities and are suitable for home-based programs, promoting adherence to treatment, especially in chronic musculoskeletal conditions in which physical activity is a key factor to reduce recurrence of the disease. This may, however, be a demonstration of the combined effect of adherence to the resistance band based programme, which was simple and convenient, as well as the physiological effects of resistance training, and may not be equal to that seen in other trials.

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Also, differences in psychological factors are likely to have played a role in what is observed. Chronic pain often results in fear of movement, loss of confidence, anxiety and avoidance behaviour that contributes to the development of disability. Progressive resistance training slowly introduces patients to functional movement within a safe environment so they can gain confidence and decrease fear of physical activity. This behaviour change adaptation partly accounted for the enhanced global outcomes of the resistance band exercise group compared to the conventional physiotherapy group alone, and is supported by the contemporary pain neuroscience framework which focuses on the importance of addressing both impairment and maladaptive beliefs about movement.

This trial, along with the results of other trials, suggests that progressive resistance exercise can be incorporated into standard physiotherapy treatment of chronic LBP. Traditional physio was effective and clinically relevant but the resistance band exercise was better in all outcome measures, suggesting that progressive muscular exercise is beneficial.

Limitations

The findings in this trial are limited by several factors that should be considered when interpreting its findings. The sample size was reasonable for the primary comparison calculated a priori, but is small and larger multi-centre trials would yield more accurate estimates of the effects and would be more generalisable. Physical nature of the intervention made blinding of participants and/or treating therapists impossible, but the use of assessor blinding for the outcome measurement may have reduced the risk of performance bias. Follow up was only conducted at the immediate post intervention time point, and more long-term follow up is required to establish whether the benefits were sustained after supervised sessions were completed. There were some modest differences between groups in terms of age and BMI, but these should be accounted for statistically in future analyses of larger datasets with this design. Lastly, the trial was performed in one centre and in a patient group that may not be ideal for generalisability to other clinical settings and patients.

5. Conclusion

In people with chronic low back pain, both conventional physiotherapy and conventional physiotherapy with resistance band exercises proved to be effective in reducing pain, improving functional ability and enhancing quality of life. The number of resistance band exercises added led to a significantly greater improvement in all of the outcome measures assessed (pain intensity, functional disability and quality of life) than standard physiotherapy. The results indicate that the use of resistance band exercise as a simple, low-cost clinically effective adjunct to conventional physiotherapy and a progressive resistance band training programme as a complementary component of a routine rehabilitation programme may improve recovery and functional independence and play a role in patients' quality of life in chronic low back pain. These findings should be confirmed by larger multicentre trials with longer follow up periods to determine the durability of the benefits observed.

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