Original Research

Movement System Impairment-Based Classification Treatment Versus General Exercises for Chronic Low Back Pain: Randomized Controlled Trial

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Background. Treatment for chronic low back pain (LBP) includes different forms of exercises, that to date have resulted in only small to moderate treatment effects. To enhance the treatment effects, different classification systems have been developed to classify people with LBP into more homogeneous subgroups leading to specific treatments for each subgroup.

Objective. The purpose of this study was to compare the efficacy of a treatment based on the Movement System Impairment (MSI) model with a treatment consisting of symptom-guided stretching and strengthening exercises in people with chronic LBP.

Design. The study was a 2-arm, prospectively registered, randomized controlled trial with a blinded assessor.

Setting. The study setting was a university physical therapy clinic in Brazil.

Patients. A total of 148 participants with chronic LBP participated in the study.

Interventions. Participants were randomly allocated to an 8-week treatment of either treatment based on the MSI-based classification system or symptom-guided stretching and strengthening exercises.

Measurements. Measures of pain intensity, disability, and global impression of recovery were obtained by a blinded assessor at baseline and at follow-up appointments at 2, 4, and 6 months after randomization.

Results. There were no significant between-group differences for the primary outcomes of pain intensity at 2 months (mean difference = 0.05, 95% CI = –0.90 to 0.80) and disability at 2 months (mean difference = 0.00, 95% CI = –1.55 to 1.56). There also were no statistically significant differences between treatment groups for any of the secondary outcome measures.

Limitations. Participants and physical therapists were not masked.

Conclusions. People with chronic LBP had similar improvements in pain, disability, and global impression of recovery with treatment consisting of symptom-guided stretching and strengthening exercises and treatment based on the MSI model.

Low back pain (LBP) is the leading cause of years lived with disability in 86 countries, and is either the second or third leading cause in 67 countries.[1] The global age-standardized point prevalence of LBP in 2010 was estimated to be 9.4%.[2] LBP is considered recurrent in nature,[3] with recurrence rates ranging from 20% to 65% depending on the follow-up time.[4–7] The clinical course of chronic LBP is characterized by moderate levels of pain and disability that persist after a follow-up of 12 months.[8]

Treatment for chronic LBP includes different forms of exercise[3,9–12] that, to date, have resulted in only small to moderate treatment effects.[13–20] A possible explanation for the limitation in size of treatment effects could be related to sample heterogeneity.[21] About 90% of all patients with LBP receive the diagnosis of nonspecific LBP, which is based on exclusion of specific pathologies.[22] To enhance treatment effects, different classification systems have been developed to assign people with LBP to more homogeneous subgroups leading to specific treatments for each subgroup.[23–28] Assessing the treatment effects of classifying and treating people with LBP based on their classification is a top priority in LBP research.[3,29,30]

The Movement System Impairment (MSI)-based classification model[31–33] is one of the classification systems available to guide treatment of LBP. The MSI classification system involves a standardized examination with several tests of movements and positions to identify mechanically based impairments. It allows the classification of people with LBP into 1 of 5 possible subgroups. The treatment based on the MSI model includes education and exercise prescription to correct classification-specific impairments of movements and postures that are associated with LBP symptoms. The primary objective of treatment based on the MSI model is to minimize specific lumbar spine movements, encourage movement in other joints, and avoid extreme lumbar spine postures in specific directions. Although validity[34] of the subgroups and reliability[35–39] of clinicians to classify based on the MSI classification model have been previously reported, randomized clinical trials involving this classification system are limited.[40]

Therefore, the objective of this study was to compare the efficacy of a treatment based on the MSI classification model with a treatment consisting of symptom-guided stretching and strengthening exercises in people with chronic LBP. Exercise therapy including stretching and strengthening exercises was chosen as the comparison group because it is recommended as a first-line treatment in the management of patients with chronic LBP.[9,11] Our hypothesis was that treatment based on the MSI model would result in greater improvements in pain and disability than treatment consisting of symptom-guided stretching and strengthening exercises.

Methods

Design Overview

This study was a 2-arm, prospectively registered, randomized controlled trial with a blinded assessor. The methods used in this study were previously described in the published protocol.[41]

Settings and Participants

This trial was conducted in an outpatient physical therapy clinic in the Pontificia Universidade Catolica de Minas Gerais, Belo Horizonte, Brazil. To be included, participants of both sexes, between 18 and 65 years of age, had to have nonspecific LBP for more than 3 months and a current minimum pain intensity of 3 on an 11-point numeric pain rating scale.[42,43] They also had to be able to stand and walk independently and be literate in Portuguese. The participants were recruited from orthopedic outpatient clinics and by advertising on radio media. Potential participants were told to contact the blinded assessor by phone or email. They were screened for eligibility at their first visit to the university clinic. Participants were excluded if they presented any contraindications to exercise according to the guidelines of the American College of Sports Medicine,[44] serious cardio-respiratory diseases, previous spinal surgery, serious spinal pathologies (fractures, tumors, or inflammatory pathologies), nerve root compromise (diagnosed by clinical examination of sensibility, power, and reflexes), major depression (measured by the Depression, Anxiety, and Stress scale[45,46]), pregnancy, or if they could not be classified into 1 of the 5 categories of the MSI model[31–33] at the first visit. The physical examination was performed by the first author, who has 13 years of experience with use of the MSI model in clinical practice. The examination included (1) assessment of signs and symptoms associated with clinical tests of different movements and positions, and (2) tests assessing the effects of correcting movements and postures during the clinical tests on the participant's LBP symptoms (Tab. 1). A detailed description of the procedures and rules used to classify have been published elsewhere.[36] All participants received information about the study and signed the informed consent form. The study was approved by the Ethics Committee of the Pontificia Universidade Catolica de Minas Gerais, Brazil, and was prospectively registered at www.clinicaltrials.gov (NCT02221609).

Randomization and Interventions

A researcher (L.C.) who was not involved in the participants' recruitment, assessment, and treatment was responsible for generating a randomization schedule in Excel for Windows. Allocations were concealed using sealed, opaque, and sequentially numbered envelopes.

After the initial assessment, the participants were allocated into 1 of the 2 treatment groups (treatment consisting of strengthening and stretching exercises or treatment based on the MSI model) by opening the next available envelope. Both treatment programs consisted of 12 physical therapy sessions over an 8-week period (2 sessions per week for the first 4 weeks and 1 session per week for the second 4 weeks). Each treatment session duration was 45 to 60 minutes and was supervised by trained physical therapists. Specific details of the exercise protocol and progression of exercises are provided in eAppendixes 1 and 2 (available at https://academic.

Table 1.
Physical Examination Used for MSI Model Classification[34,36]

Position	Symptom Behavior With Movement[a]	Judgment of Alignment or Movement[b]
Standing	Standing	Shape of the lumbar curve Asymmetry and regularity of the lumbar spine Swayback
	Posterior pelvic tilt against wall	
	Forward bending	Lumbar flexion Lumbar extension Relative flexibility[c]
	Corrected forward bending	
	Return from forward bending	Hip extension Lumbar extension Pelvic and shoulder sway
	Corrected return from forward bending	
	Side bending	Asymmetrical lumbar region movement
Sitting	Sitting with lumbar flat	
	Sitting with lumbar region flexed	
	Sitting with lumbar region extended	
	Knee extension	Lumbar or pelvic rotation
	Corrected active knee extension	
Supine	Hips and knees flexed	
	Hips and knees extended	
Hook lying	Hip abduction with lateral rotation	Relative flexibility
	Corrected hip abduction with lateral rotation	
Prone	Prone	
	Corrected prone	
	Knee flexion	Relative flexibility Asymmetrical pelvic rotation
	Hip rotation	Relative flexibility Asymmetrical pelvic rotation
	Hip extension	
Quadruped	Natural alignment	Lumbar region alignment Asymmetry of the lumbar region Alignment of hip joint
	Corrected alignment	
	Arm lifting	Asymmetrical lumbar region rotation
	Rocking backward	Relative flexibility Pelvic rotation or tilt
	Corrected rocking backward	
	Rocking forward	

[a] For each of the items, the participant assumes a position or performs a movement and reports the status of their LBP symptoms (symptoms increased, symptoms decreased, or symptoms remained the same). Positions or movements associated with increased symptoms are followed by corrected alignment or movement involving minimizing lumbar movement that occurs in the early part of the range of motion or that is excessive, while increasing movement in other joints (ie, hip joint). An improvement in the symptoms indicates that the movement or alignment impairment in a specific direction (ie, extension) is associated with the patient's symptoms and helps to decide on the participant's MSI classification.
[b] For each of the items, the examiner judges the alignment of the lumbar region in different positions and/or looks for incorrect timing and/or magnitude of lumbar movement during trunk and limb movements. Alignment of lumbar region in a specific direction (ie, extension) in different positions and incorrect timing and/or magnitude of lumbar movement in a specific direction help to decide on the participant's MSI classification.
[c] Relative flexibility refers to motion of adjoining segments occurring more readily in 1 of the joints (lumbar region in this case) even if the motion should be occurring in the other joint. In general, a patient exhibits a relative flexibility impairment if the lumbar region moves in the first 50% of the range of the overall movement or excessively during the overall movement.
During the MSI classification procedure, greater weight is given to symptoms behavior information than alignment and movement judgment.

oup.com/ptj). Two physical therapists with the same duration of clinical experience (2 years) were involved in delivering the treatments. One delivered the strengthening and stretching treatment; the other, the treatment based on the MSI model. They participated in a 16-hour course (lecture) involving the principles of MSI classification and treatment or reviewing the principles of strength and stretching exercises used in patients with LBP. They also practiced their treatment protocols with patients at the university clinic over a month under supervision of the first author. The

first author also periodically audited the interventions through revision of patient home exercise charts and direct oversight during treatment sessions.

Treatment consisting of symptom-guided stretching and strengthening exercises. After walking or pedaling a stationary bicycle for 5 minutes, participants performed stretching exercises addressing the lumbar and abdominal muscles (lumbar flexors, extensors, lateral flexors, and rotators) and lower limb muscles (hip flexors, extensors, rotators, abductors, and adductors). Each static stretching exercise consisted of 1 repetition of 30 seconds. Participants were instructed to perform each stretching movement until a mild stretching sensation was achieved or until normal range of motion was achieved.[47] If there was an increase of LBP, the specific stretch was suspended. During subsequent treatment sessions, the physical therapist attempted to include the previously suspended stretching exercises. If onset or increase of LBP was still observed, the stretching exercise was removed from the treatment program. Participants also performed strengthening exercises involving the abdominal and paraspinal muscles.[10,48] Each strengthening exercise consisted of 3 sets of 10 repetitions with a load high enough to produce fatigue after completion of 10 repetitions.[49] In the case that the participant complained of onset or increased LBP during the exercises, the same decision-making procedure used for prescription and progression of the stretching exercise was used for the strengthening exercises. All participants were told to perform the exercises at least 3 times a week, including the treatment sessions at the clinic. After each treatment session, participants received an exercise chart of instructions and figures displaying the home exercises. A participant's ability to perform his home exercise program was evaluated during each treatment session using an instrument adapted from a previous study.[50] All participants were monitored for any adverse event and for any exacerbation (onset or increase) in LBP due to the home exercises at each of the treatment sessions. Participants were instructed to keep performing the exercises after the 2-month treatment period. For complete description, see eAppendix 1 (available at https://academic.oup.com/ptj).

Treatment based on the MSI model. Treatment based on the MSI model included (1) patient education, (2) analysis and modification of performance of daily activities, and (3) prescription of specific exercises.[51–53] Patient education consisted of teaching the participant which altered movement or posture (eg, flexion, extension, rotation) to modify that also was related to symptoms. Participants received information about the importance of avoiding extremes of those postures and controlling the altered movements as a fundamental part of the treatment. Patient education was included in the first treatment session and could be repeated during the following sessions (eAppendix 2, available at https://academic.oup.com/ptj).

Analysis and modification of performance of daily activities were guided by the participant's MSI classification. Based on the classification, the examiner assessed the performance of activities reported by the participant to be limited due to LBP. Altered postures and movements observed during the assessment were followed by instruction in how to modify the patterns of posture and movement to be less painful or pain free. Participants were instructed to repeat the modified movements and postures throughout their day. Modification of performance of daily activities was initiated during the first treatment session and was revised during the follow-up sessions based on the participant's performance.

The prescription of specific exercises included performing modifications of the movement tests from the initial assessment per the participant's LBP classification. Painful movement tests or movement tests in which the person displayed an altered pattern were included in the specific exercise prescription. During treatment sessions, participants were taught to perform the movements pain free or with lower pain levels by reducing or changing the timing of the lumbar spine movement and increasing or changing the timing of movement of the adjacent joints.

A home exercise chart including pictures of the exercises and performance of daily activities with written instructions was given to each participant. Participants were advised to perform the home program at least once a day on the days in which no treatment sessions were scheduled. The participant's ability to perform the home exercises was also assessed as described in the strengthening and stretching exercises treatment.[50] Participants were monitored for any adverse event and any onset or increase in symptoms with the home program in each treatment session and were instructed to keep performing the exercises and daily activities after the 2-month treatment period. For complete description, see eAppendix 2 (available at https://academic.oup.com/ptj).

Outcomes and Follow-Up

Participant characteristics (age, gender, location, and duration of symptoms), clinical outcome prognosis using the STarT Back Screening Tool classification,[54] pain intensity, disability, and the participant's global impression of recovery were assessed at baseline. Pain intensity, disability, and global impression of recovery assessments were also measured at 2 (ie, immediately after treatment), 4, and 6 months after randomization. The primary outcomes were mean pain intensity and disability at 2 months after randomization. Secondary outcomes were mean pain intensity and disability at 4 and 6 months after randomization and global impression of recovery at 2, 4, and 6 months after randomization.

Treatment adherence was assessed by recording the number of treatment sessions at the clinic and the number of days performing the home program for each participant. The number of days performing the home program were documented by each participant in an exercise diary.

Mean pain intensity was assessed using the Numeric Pain Rating Scale

Table 2.
Outcome Measures

Outcome Measure	Description
Verbal Numeric Pain Rating Scale[42,43]	The Numeric Pain Rating Scale assesses the pain intensity levels perceived by the participant in the last 7 days using an 11-point scale (ranging from 0 to 10), with 0 representing "no pain" and 10 representing "the worst possible pain."
Roland Morris Disability Questionnaire[42,43,55,56]	The Roland Morris Disability Questionnaire assesses disability associated with LBP. It has 24 questions that describe daily tasks that the participants have difficulty performing due to their LBP. The total score ranges from 0 to 24 points and is the sum of the points obtained. Higher scores indicate higher disability.
Global Perceived Effect scale[42]	The Global Perceived Effect scale assesses participants' global impression of recovery comparing the onset of symptoms to the last few days. It is an 11-point numerical scale ranging from –5 (vastly worse) to 0 (unchanged) to +5 (completely recovered). Participants will respond to the following question: "Compared to when this episode first started, how would you describe your back these days?" Higher scores indicate better recovery.

(NPRS).[42,43] Disability was assessed using the Roland Morris Disability Questionnaire.[42,43,55,56] Participant's global impression of recovery was assessed by the Global Perceived Effect scale[42] (Tab. 2). All outcomes used in this clinical trial were translated and cross-culturally adapted into Brazilian Portuguese.[42,43,55] A blinded assessor performed the assessment of outcome measures at baseline and follow-ups. Due to the nature of the treatments, blinding of treatment providers and participants was not possible.

Sample Size Calculation

The study was designed to detect a 1-point between-group difference for the primary outcomes of the NPRS outcome with an estimated standard deviation of 1.84 points[42] and a 4-point between-group difference for the disability (Roland Morris Disability Questionnaire) outcome with an estimated standard deviation of 4.9 points[42,43,55] immediately after treatment. Considering a statistical power of 80%, an alpha of 5%, and a 15% dropout rate, 74 participants were needed in each treatment group.

Statistical Analysis

All data were double entered to check for possible data entry errors. The statistical analyses were performed by an assessor blinded to the treatment groups using a numerical code for each treatment group. Descriptive statistics were calculated for participant characteristics and to verify normality of the outcome measures data. Possible between-group differences for the primary and secondary outcomes were tested using linear mixed models. The analysis adjusts the treatment groups' mean differences considering all time points (including baseline) and missing data. The statistical analyses were conducted using an intention-to-treat approach.[57] The IBM SPSS 19 statistical package for Windows (IBM Corp, Armonk, New York) was used for the analyses.

Role of Funding Source

The first author of the study is a doctoral candidate funded by Coordenacao de Aperfeicoamento de Pessoal de Nıvel Superior (CAPES). This study was funded by Conselho Nacional de Desenvolvimento Cientifico e Tecnologico/Brazil (CNPQ grant number 470273/2013-5). The funder played no role in the conduct of this study.

Results

A total of 231 participants volunteered to take part in the study. After the first assessment, 83 participants were excluded and 148 participants were assessed at baseline and enrolled in the trial. A total of 145 participants completed the 2-, 4-, and 6-month follow-up assessment (Fig. 1). All data was self-reported, including all outcomes that were collected at baseline and in all follow-up time points. Missing data information is provided in the flow diagram. Participants' characteristics at baseline are presented in Table 3. There were no differences between participants in the 2 treatment groups with regard to baseline characteristics.

There was no significant difference between treatment groups for the primary outcome measures of mean NPRS at 2 months (mean difference = 0.05, 95% CI = –0.90 to 0.80) and disability at 2 months (mean difference = 0.00, 95% CI = –1.55 to 1.56). There were also no statistically significant differences between treatment groups for any of the secondary outcome measures (Tab. 4). No adverse effects were observed for both groups.

Treatment Adherence

Treatment adherence data, including number of treatment sessions performed at the clinic and number of days performing the home program, is presented in Table 5. Considering the total expected number of treatment days (treatment session days plus number of days performing the home program), the strengthening and stretching group adhered more to the treatment when compared to the MSI model group (mean difference = 17.8%, 95% CI = 8.4% to 27.1%). The strengthening and stretching group performed 16.1 days of exercise (total number of days expected = 24 days, mean adherence = 67.0%, SD = 24.6%), while the MSI model group performed 27.6 days of treatment (total number of days expected = 56, mean adherence = 49.3%, SD = 32.3%) ($P<.001$).

Discussion

The purpose of this study was to compare the efficacy of a treatment based on the MSI model with a treatment consisting of symptom-guided stretching and strengthening exercises for patients with chronic LBP. No significant differences in mean pain, disability, or global impression of recovery were observed between groups at any of the follow-up

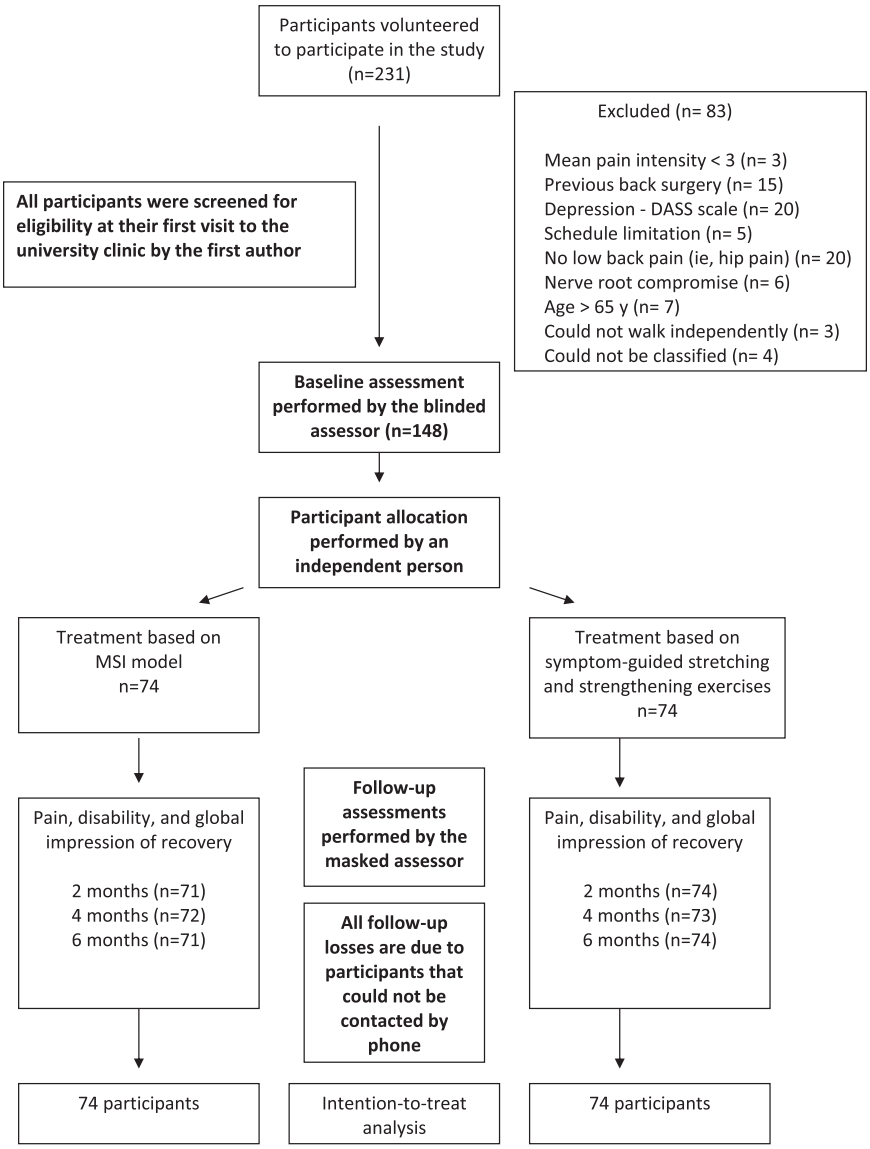

Figure 1.
Study flow diagram. DASS = Depression Anxiety Stress Scale.

time points. The strengthening and stretching group adhered more to the treatment when compared to the MSI model group.

A previous study showed similar efficacy of a classification-specific treatment based on the MSI model when compared to a nonclassification-specific treatment in patients with chronic nonspecific LBP.[40] The non–classification-specific treatment was based on strengthening and stretching exercises and teaching the participants to maintain a balanced spinal alignment when performing daily activities. The authors hypothesized that the lack of difference in outcomes between both groups could be related to the similarities found in both treatment programs and the fact that participants in both groups adhered more to that which was similar in both treatments. Both treatment programs had people perform everyday activities in which they decreased the amount of lumbar spine movement, increased the amount of movement of other joints, and avoided end-range positioning of the lumbar spine. The specific direction of lumbar spine movement and alignment to be corrected, however, was only informed to participants in the classification-specific treatment group. The current study compared a treatment based on the MSI model with a treatment consisting of symptom-guided stretching and strengthening exercises. Although the strengthening and stretching group was not given instructions to modify specific lumbar spine movements or alignments, the exercises prescribed were adjusted based on pain behavior. Participants were supposed to perform exercises involving movements in all directions, but decision-making by the clinician allowed for the participant to eliminate an exercise if it was not tolerated due to onset or increased LBP. Thus, participants may have ended up performing only the exercises that were not symptom-provoking. Performing exercises involving spine movements in directions that are not symptom-provoking may be a common element between the 2 treatment groups and may explain the similar improvements found in both groups in the current study.

Different absolute amounts of participation in the home exercise programs were found between the 2 treatment groups. Treatment based on the MSI model group had more home exercise practice prescribed compared to the strengthening and stretching group treatment. This difference was expected because participants in the MSI model group were instructed to perform the home exercises at least 5 or 6 days a week, in addition to treatment session days. Participants in the strengthening and stretching group were instructed to perform the home exercises at least 1 or 2 days a week, in addition to treatment session days. The MSI model is based on movement and alignment education and training, thus it is believed that more practice is needed,[27] while stretching and strengthening programs are performed usually 3 times a week.[49] However, when considering the total expected number of treatment days (treatment session days plus number of days performing the home program), the strengthening and stretching group adhered more to the treatment when compared to the MSI model group. It is not possible to predict if a higher adherence by the MSI model group would

Table 3.
Participants' Characteristics at Baseline[a]

	Strengthening and Stretching Exercise (n = 74)	Movement System Impairment-Based Treatment (n = 74)
Age (y)	40.4 (13.4)	43.4 (12.5)
Sex		
Male	31 (41.9%)	26 (35.1%)
Female	43 (58.1%)	48 (64.9%)
Weight (kg)	72.0 (16.8)	70.8 (16.1)
Height (cm)	167.6 (10)	166.0 (9.4)
Body Mass Index (kg/m^2)	25.5 (5.3)	25.5 (4.4)
Marital status		
Single	27 (36.5%)	21 (28.4%)
Married	38 (51.4%)	38 (51.4%)
Widowed	7 (9.5%)	10 (13.5%)
Divorced	2 (2.7%)	5 (6.8%)
Educational status		
Elementary degree	7 (9.5%)	14 (18.9%)
High school	46 (62.2%)	39 (52.7%)
University	11 (14.9%)	15 (20.3%)
Graduate degree	10 (13.5%)	6 (8.2%)
Income (in USD/hr)	8.6 (6.7)	7.9 (8.2)
Absenteeism[b] (current)		
No	73 (98.6%)	68 (91.9%)
Yes	1 (1.4%)	6 (8.1%)
Smoker		
No	69 (93.2%)	64 (86.5%)
Yes	5 (6.8%)	10 (13.5%)
Physically active[c]		
No	44 (59.5%)	49 (66.2%)
Yes	30 (40.5%)	25 (33.8%)
Physical activity duration[d] (mo)	38.5 (59.9)	32.0 (66.9)
Physical activity frequency[e] (d/wk)	3.3 (1.5)	2.8 (1.4)
Current use of medication		
No	43 (58.1%)	45 (60.8%)
Yes	31 (41.9%)	29 (39.2%)
Pain location		
Lumbar	59 (79.7%)	57 (77.0%)
Lumbar and above knee	10 (13.5%)	7 (9.5%)
Lumbar and below knee	5 (6.8%)	10 (13.5%)
History of LBP (months)	75.2 (74.0)	94.9 (96.7)
STarT Back Screening Tool classification[f]		
Low risk	25 (33.8%)	24 (32.4%)
Medium risk	32 (43.2%)	33 (44.6%)
High risk	17 (23.0%)	17 (23.0%)
MSI classification		
Flexion	10 (13.5%)	12 (16.2%)
Extension	21 (28.4%)	25 (33.8%)

Continued

Table 3.
Continued

	Strengthening and Stretching Exercise (n = 74)	Movement System Impairment-Based Treatment (n = 74)
Rotation	4 (5.4%)	1 (1.4%)
Flexion and rotation	18 (24.3%)	7 (9.5%)
Extension and rotation	21 (28.4%)	29 (39.2%)
Mean pain intensity (0–10)[g]	6.5 (1.9)	6.6 (1.8)
Disability (0–24)[h]	10.2 (5.0)	10.7 (5.1)
Global impression of recovery[i]	–1.8 (2.5)	–1.0 (2.8)

[a]Continuous variables are expressed as mean (SD). Categorical variables are expressed as *n* (%). MSI = Movement System Impairment.
[b]Proportion of participants unable to work due to low back pain (LBP).
[c]Number of participants who consider themselves to be physically active.
[d]If participants considered themselves to be currently physically active, they were asked, "How long have you been practicing (any physical activity)?"
[e]If participants considered themselves to be currently physically active, they were asked, "How many days per week are you practicing (any physical activity)?"
[f]STarT Back Screening Tool classification.[54]
[g]Numeric Pain Rating Scale.[42,43]
[h]Roland Morris Disability Questionnaire for low back pain.[42,43,55,56]
[i]Global Perceived Effect scale.[42]

Table 4.
Unadjusted Mean Values (SD) and Adjusted Between-Group Differences (95% CI) for the Outcomes of Mean Pain Intensity, Disability, and Global Impression of Recovery[a]

Outcomes	Strengthening and Stretching Exercise Mean (SD)	Movement System Impairment-Based Treatment Mean (SD)	Adjusted Between-Group Differences (95% CI)	*p*
Pain intensity (0–10)[b]				
Baseline	6.51 (1.92)	6.61 (1.84)		
2 months	3.86 (3.05)	3.68 (2.59)	–0.05 (–0.90 to 0.80)	*P* = .91
4 months	3.79 (2.94)	4.19 (2.95)	–0.23 (–1.08 to 0.61)	*P* = .59
6 months	3.70 (3.06)	3.81 (2.64)	0.24 (–0.61 to 1.08)	*P* = .58
Disability (0–24)[c]				
Baseline	10.19 (5.04)	10.64 (5.04)		
2 months	5.38 (5.59)	5.49 (5.02)	0.00 (–1.55 to 1.56)	*P* = .99
4 months	4.82 (4.97)	5.33 (4.65)	–0.07 (–1.62 to 1.49)	*P* = .93
6 months	4.79 (5.37)	5.16 (5.05)	0.21 (–1.35 to 1.76)	*P* = .79
Global impression of recovery (–5 to+5)[d]				
Baseline	–1.75 (2.48)	–1.03 (2.76)		
2 months	2.49 (2.42)	2.62 (2.19)	0.48 (–0.43 to 1.39)	*P* = .30
4 months	2.16 (2.53)	2.14 (2.72)	0.80 (–0.14 to 1.68)	*P* = .09
6 months	2.22 (2.61)	2.51 (2.32)	0.66 (–0.25 to 1.57)	*P* = .15

[a]Primary outcomes are highlighted in gray. All treatment estimates were adjusted for baseline data using linear mixed models.
[b]Numeric Pain Rating Scale.[42,43]
[c]Roland Morris Low Back Pain Disability Questionnaire.[42,43,55,56]
[d]Global Perceived Effect scale.[42]

result in an increased treatment effect, although previous studies have associated higher levels of adherence to treatment with better outcomes.[40,58,59] Our study also did not assess adherence of the MSI model group to exercise separate from adherence to performance of daily activities. Thus, it is not possible to know which component the participants adhered to and whether this had an impact on the lack of a difference between the 2 treatment groups. This can be considered a limitation since a previous study showed that people adhered more to performance of daily activities

Table 5.
Treatment Adherence

Treatment Adherence	Strengthening and Stretching Exercise	Movement System Impairment-Based Treatment
Number of treatment sessions at the clinic[a] mean (SD) [expected number]	10.6 (2.6) [12]	9.7 (3.5) [12]
Number of days performing the home program[b] mean (SD) [expected number]	5.5 (4.1) [12]	17.9 (15.9) [44]
Treatment adherence[c] mean (SD)	67.0% (24.6%)	49.3% (32.3%)

[a]Both groups are supposed to receive the same number of treatment sessions at the clinic.
[b]Both groups are supposed to have different number of days performing the home program. Participants from the MSI group were advised to perform the home program at least once a day on the days on which no treatment sessions were scheduled. Participants in the strengthening and stretching group were instructed to perform the home exercises at least 1 or 2 days a week, in addition to treatment session days.
[c]Treatment adherence was calculated by the following formula: number of treatment sessions + number of days performing the home program / expected number of treatment sessions + expected number of days performing the home program.

than exercise, and the more they adhered to daily activity performance the greater improvement in function compared to adherence to exercise.[40]

Different studies have found different proportions of the MSI syndromes identified in people with LBP.[34,53,60,61] While some studies excluded participants who were in an acute flare-up during initial assessment,[34,53] others,[60,61] including the current study, did not exclude people who were in an acute flare-up. This difference in exclusion criteria may have influenced the different proportions of the MSI syndromes found in those studies.

Different classification systems are available to guide LBP treatment.[23–28] The idea behind subgrouping patients with LBP is to classify them into more homogeneous subgroups and then match the patients to treatments specific to their classification. The goal of the matching is to increase the treatment effect size.[21,62,63] Promising results related to this approach were previously described.[28,51,53,64–69] However, most of the classification systems failed to show clinically significant differences in outcomes when compared to other therapies not based on subgrouping in randomized controlled trials involving people with chronic, nonspecific LBP.[40,62,70–73] Although the combination of physical and cognitive/behavioral treatments in patients with back pain seems not to result in better outcomes when compared to isolated physical or cognitive/behavioral treatments,[74] the inclusion of cognitive/behavioral factors into movement-based classification described by O'Sullivan[25] has shown greater treatment effects when compared to therapies not based on subgrouping (exercise and manual therapy).[69] Limitations of this study,[69] however, included important follow-up loss and no intention to treat analysis. Thus, replication of the O'Sullivan study results is needed.

The lack of between-group differences in outcomes found in the current study could also be explained by the similar distribution of participants in both groups who may be at high, medium, and low risk for poor prognosis according to the STarT Back Screening Tool classification. The use of prognostic factors to guide physical therapy treatment in LBP has been supported by different studies.[75–77] Those studies raise the possibility that prognostic factors may be more important in determining the treatment success than diagnostic/classification factors.

The current study is the largest prospectively registered randomized controlled trial involving the efficacy of a treatment based on the MSI model in patients with chronic, nonspecific LBP.[41] Loss to follow-up was minimal and statistical analyses were performed according to intention-to-treat principles. The physical therapists responsible for the treatments had similar clinical experience and were trained by a senior physical therapist with experience in the concepts underlying the MSI model and application of the classification system and treatment. However, our trial has some limitations. Due to the nature of the study, it was not possible to blind participants and physical therapists responsible for the treatments to group assignment. The physical therapist responsible for the treatment based on MSI model was not responsible for the MSI classification procedure, which is not common in clinical practice. The MSI classification was done by the first author before the randomization procedure because it was part of the inclusion/exclusion criteria. The treating therapist received the filled forms used for MSI classification before the beginning of treatment. This trial also had only 1 treating therapist per arm, which can limit its external validity. Although the treatment consisting of strengthening and stretching exercises did not include explicit movement and alignment education and training, it is possible that participants may have received this information. For example, the physical therapist may have had to answer participants' questions such as what is the best position to assume to

sleep. The physical therapist responsible for the treatment consisting of strengthening and stretching exercises had no previous information or training in the MSI model. The physical therapist was, however, instructed to give very concise and basic information when asked about correct alignment and movement. This study also did not include a control group receiving no treatment. Therefore, it is possible that the improvements observed in the outcomes were attributed to natural history of back pain.[78]

The results of this study showed that people with chronic nonspecific LBP might have the same improvement in pain, disability, and global impression of recovery by receiving a treatment based on progressive strengthening and stretching exercises that was directed by participant symptom response or by a treatment based on the MSI model after a 6-month follow-up. It is possible that specific participant characteristics may identify people who respond better to treatment based on the MSI model compared to treatment consisting of symptom-guided stretching and strengthening exercises. These secondary analyses are being performed on the data from the current trial. The efficacy and effectiveness of treatment based on the MSI model still need to be tested in people with acute and subacute LBP.

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Ethics Approval

The study was approved by the Ethics Committee of the Pontificia Universidade Catolica de Minas Gerais, Brazil.

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Clinical Trial Registration

This trial was prospectively registered at: www.clinicaltrials.gov (NCT02221609).

Disclosure and Presentations

The authors completed the ICJME Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

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