

CLINICAL SCIENCE

Segmental stabilization and muscular strengthening in chronic low back pain - a comparative study

Fábio Renovato França, Thomaz Nogueira Burke, Erica Sato Hanada, Amélia Pasqual Marques

Department of Physical Therapy, Communication Science & Disorders, Occupational Therapy, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

OBJECTIVE: To contrast the efficacy of two exercise programs, segmental stabilization and strengthening of abdominal and trunk muscles, on pain, functional disability, and activation of the transversus abdominis muscle (TrA), in individuals with chronic low back pain.

DESIGN: Our sample consisted of 30 individuals, randomly assigned to one of two treatment groups: segmental stabilization, where exercises focused on the TrA and lumbar multifidus muscles, and superficial strengthening, where exercises focused on the rectus abdominis, abdominus obliquus internus, abdominus obliquus externus, and erector spinae. Groups were examined to discover whether the exercises created contrasts regarding pain (visual analogical scale and McGill pain questionnaire), functional disability (Oswestry disability questionnaire), and TrA muscle activation capacity (Pressure Biofeedback Unit = PBU). The program lasted 6 weeks, and 30-minute sessions occurred twice a week. Analysis of variance was used for inter- and intra-group comparisons. The significance level was established at 5%.

RESULTS: As compared to baseline, both treatments were effective in relieving pain and improving disability ($p < 0.001$). Those in the segmental stabilization group had significant gains for all variables when compared to the ST group ($p < 0.001$), including TrA activation, where relative gains were 48.3% and -5.1%, respectively.

CONCLUSION: Both techniques lessened pain and reduced disability. Segmental stabilization is superior to superficial strengthening for all variables. Superficial strengthening does not improve TrA activation capacity.

KEYWORDS: Chronic Low Back Pain; Pressure Biofeedback Unit; Segmental Stabilization; Muscle Strength; Transversus Abdominis.

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E-mail: fabiojrf@usp.br

Tel.: 55 11 3091 8423

INTRODUCTION

Chronic low back pain (CLBP) is defined as back pain lasting more than 12 weeks,¹ and it affects more than 50% of the general population. It is estimated that over 70% of adults have at least one episode of low back pain during their lifetimes.² Prevalence is higher in young, economically active adults in South American populations;³ indeed, low back pain is the second most common reason for absenteeism from work, and one of the most common reasons for medical consultation.⁴

One important risk factor for low back pain is weakness of superficial trunk and abdominal muscles,⁵⁻⁹ and strengthening of these muscles is often associated with significant improvements of CLBP, as well as with decreased functional disability.¹⁰⁻¹⁵ Another independent risk factor for CLBP is the weakness and lack of motor control of deep trunk muscles,

such as the lumbar multifidus (LM) and transversus abdominis (TrA) muscles.^{16,17} Ferreira et al.¹⁸ and Hodges et al.¹⁹ demonstrated that the TrA had insufficient control and speed of muscle contraction delayed in individuals with CLBP.

Kinesiotherapeutic protocols addressing both the superficial and the deep muscles seem to be effective in the treatment of CLBP.²⁰⁻²² Most clinical protocols combine different exercises and techniques, making it difficult to isolate the efficacy of specific strategies.^{10,11} This is of great clinical importance and needs to be further clarified through research. Therefore, in this study, we compared the efficacy of SS exercises with strengthening of abdominal and trunk muscles (ST) on pain, functional capacity, and TrA activation capacity in individuals with CLBP.

Our hypothesis was that the lumbar stabilization would be more efficient than the muscle strength in the improvement of chronic low back pain.

METHODS

Subjects

Our sample was selected from a list of patients being seen at the Department of Orthopedics, University Hospital, Sao

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Figure 1 - The test of the abdominal drawing in action in a prone position, monitoring the contraction of TrA with pressure biofeedback unit.

Paulo University. We made 162 calls, and performed 35 evaluations. Four patients were excluded for rheumatologic disorders and one for surgical reasons. Therefore, the sample consisted of 30 patients (four men and 11 women in each group) with non-specific CLBP. They were randomized by means of opaque envelopes to one of two treatment groups: SS and ST. Inclusion criteria were: low back pain for more than 3 months (pain felt between T12 and the gluteal fold), patients willing and able to participate in an exercise program safely and without cognitive impairments that would limit their participation. Exclusion criteria were history of back surgery, rheumatologic disorders, spine infections and spine exercise training in the 3 months before the onset of the study. This study was approved by the Ethics Committee of the University Hospital (Protocol 700/06) and of the School of Medicine (Protocol 1249/06), University of São Paulo. Participants signed informed consent forms.

Assessments

Participants were assessed at baseline and at the end of the treatment by an investigator (physiotherapist) who was blinded to the randomization, the severity of pain, functional disability, and TrA activation capacity.

Pain

Pain was assessed using a visual analogical scale (VAS) and the McGill pain questionnaire.²³ The VAS consists of a 10-cm line, with the left extremity indicating “no pain” and the right extremity indicating “unbearable pain.” Participants were asked to use the scale to indicate their current level of pain. Higher values suggest more intense pain. The McGill pain questionnaire consists of a list of 78 pain descriptors organized into 4 major classes (sensory, affective, evaluative, and miscellaneous) and 20 subclasses, each made up of at least 2 and at most 6 words, to which are assigned intensity values.

Functional Disability

Functional disability was estimated by the Oswestry disability questionnaire,²⁴ a functional scale assessing the impact of low back pain on daily activities. Other

questionnaires are available for the measurement of the evaluation of low-back pain, but McGill and Oswestry were considered the most appropriate in the context of this project.^{26,27} The score is calculated by the addition of the values assigned for each of the 10 individual questions and is used to categorize disability as: mild or no disability (0-20%); moderate disability (21%-40%); severe disability (41% to 60%); incapacity (61% to 80%); restricted to bed (81% to 100%).

Transversus Abdominis Activation Capacity

TrA activation capacity was assessed by using the Stabilizer Pressure Biofeedback Unit (PBU, Chattanooga Group, Australia). The PBU consists of a combined gauge/inflation bulb connected to a pressure cell. It is a simple device that registers changing pressure in an air-filled pressure cell allowing body movement, especially spinal movement, to be detected during exercise. The gauge contains 16.7 × 24 cm of inelastic material. The pressure cell measures from 0-200 mmHg, with a precision of 2 mmHg. Changes in body position modify the pressure, and they are registered by the sphygmomanometer.²⁵ The device was placed on the TrA (above the anterior superior iliac spines) while participants were in ventral decubitus over a rigid surface. The depression of the abdominal muscles over the spinal cord typically decreases the pressure by 4-10 mmHg.²⁰ Before individuals were asked to contract the muscle, the device was inflated to a pressure of 70 mmHg. The participants were instructed to draw the lower stomach gently off the pressure sensor without moving the back or the hips and to sustain it for 10 seconds, measured by a stop watch.

Interventions

Interventions were conducted over 6 weeks, twice per week, each session lasting 30 minutes. Sessions were supervised by the investigator, and participants were instructed to report any adverse event, whether it was related to the exercises or not. Groups were instructed not to participate in any other physical program during the study and not to exercise while at home. In the segmental stabilization (SS) group, exercises focused on the TrA and LM muscles according to the protocol proposed by Richardson et al.^{17,28} In the superficial strengthening (ST) group, exercises focused on the rectus abdominis (RA), abdominus obliquus internus (OI), abdominus obliquus externus (OE), and erector spinae (ES).²⁹

Three series of 15 repetitions were done for each exercise (Table 1).

Statistical Analysis

Sample size was calculated assuming a power of 80% to detect a 30% improvement in pain (VAS), with a standard deviation of 2 points and a significance level of 5%. The required sample would be 10 patients per group.

The relative gain with treatment was calculated with the following equation: $RG_i = \frac{(Baseline_i - End_i)}{End_i - Min(variable)} \times 100$

ANOVA One Way was used for inter-group and intra-group comparisons. For TrA activation, the binomial test was used.

Analyses were done using Minitab 14 and 15 for Windows. The significance level was established at 5%.

Table 1 - Treatment protocol in the segmental stabilization and superficial strengthening groups.

Segmental Stabilization ^{17,26}	
Strengthening of the Transversus abdominis (TrA) and lumbar multifidus (LM)	<ul style="list-style-type: none"> • Exercises for the TrA in 4 point kneeling; • Exercises for the TrA in dorsal decubitus with flexed knees; • Exercises for the LM in ventral decubitus; • Co-contraction of the TrA and LM in upright position.
Superficial strengthening ²⁷	
Strengthening of the rectus abdominis (RA), external and internal obliquus (EO and IO) and erector spinae (ES)	<ul style="list-style-type: none"> • Exercises for the RA in dorsal decubitus with flexed knees: trunk flexion; • Exercises for the RA, IO and EO in dorsal decubitus and flexed knees: trunk flexion and rotation; • Exercises for the RA in dorsal decubitus and semi-flexed knees: hip flexion; • Exercises for the ES in ventral decubitus: trunk extension.

RESULTS

Sample Characterization

Demographic data are presented in Table 2. No significant differences were seen for age, weight, height, and body mass index.

Pre-and Post-Treatment Results

Table 3 displays results found in those randomized to SS training. All variables significantly improved with treatment (p<0.001). The highest relative gain was for pain (99%). Contraction of the TrA improved by 48.3%.

Table 4 displays the results for the ST group. All variables significantly improved with treatment (p<0.001), with the exception of TrA contraction (p=0.99). The highest relative

gain was for pain (61%). Functional disability improved by 52% to no or mild disability. However, TrA contraction had negative gains (worsening -5.1%).

Intragroup Comparisons

Table 5 contrasts the results seen in each group. The SS group yielded significantly higher gains in all variables when compared to the ST group (p<0.001).

DISCUSSION

The aim of this study was to compare the efficacy of SS and ST exercises in the relief of CLBP symptoms. Both treatments were effective in relieving pain and in decreasing functional impairment, but only the SS treatment improved TrA muscle activation.

The PBU test has been validated by imaging¹⁹ and electromyography,¹⁷ tests that are considered to be the gold-standard measurements of TrA performance. These tests demonstrated that individuals with low back pain have an impaired ability to depress the abdominal wall. Hides et al.³⁰ suggested that the TrA is important in sustaining the spinal cord and that its conditioning is accompanied by functional improvement.

The SS group exercised the TrA and LM muscles. On average, participants had optimal depression of the abdominal wall, as measured by the PBU, with a gain of 48.3% with the program, findings that are similar to those obtained by Cairns et al.³¹

Table 2 - Patient's clinical and demographic data, according to group.

Features	SS group (n = 15)	ST group (n = 15)	p
Mean age (yrs)	42.07 (8.15)	41.73 (6.42)	0.902*
Weight (Kg)	74.61 (16.26)	73.60 (12.26)	0.849*
Height (cm)	1.67 (0.11)	1.65 (0.08)	0.542*
BMI (cm/Kg ²)	26.40 (4.47)	26.92 (3.64)	0.725*
Pain			
12 to 24 months	4 (26.66%)	6 (40%)	
More than 24 months	11 (73.44%)	9 (60%)	

*p value for t Test

Table 3 - Pain, functional disability and contraction of TrA mean values of SS group at pre- and post-treatment evaluations, and p values.

	Segmental Stabilization (n = 15)		Relative gain	P
	Pre-treat	Post-treat		
Pain-VAS (0-10 cm)#				
Mean(SD)	5.94 (1.56)	0.06 (0.16)	99%	<0.001*
Pain-McGill (0-67)#				
Mean(SD)	35.00 (7.76)	3.20 (4.00)	92%	<0.001*
Sensory (0-34)#				
Mean(SD)	18.20 (4.43)	1.73 (2.99)	93%	<0.001*
Affective (0-17)#				
Mean(SD)	8.07 (2.43)	0.33 (0.62)	97%	<0.001*
Functional disability (0-45)#				
Mean(SD)	17.07 (3.99)	1.80 (1.26)	90%	<0.001*
Contraction of TrA-UBP (4 to-10mmHg)#				
Mean(SD)	-0.67 (1.95)	-5.33 (1.23)	48.32%	<0,001*

*statistically significant difference; pre-treat = before treatment; post-treat = immediately after treatment

#Normal range

Table 4 - Pain, functional disability and contraction of TrA mean values of ST group at pre- and post-treatment evaluations, and p values.

	Superficial Strengthening (n = 15)		Relative gain	p
	Pre-treat	Post-treat		
Pain-VAS (0-10 cm)#				
Mean(SD)	6.49 (1.48)	2.89 (1.45)	55%	<0.000*
Pain-McGill (0-67)#				
Mean(SD)	37.67 (7.33)	19.8 (7.93)	48%	<0.000*
Sensory (0-34)#				
Mean(SD)	20.20 (3.55)	11.27 (4.58)	43%	<0.000*
Affective (0-17)#				
Mean(SD)	9.40 (3.29)	3.60 (1.99)	61%	<0.000*
Functional disability- Oswestry (0-45)#				
Mean(SD)	17.27 (3,84)	8.40 (3,13)	52%	<0,000*
Contraction of TrA- UBP (4 to -10mmHg)#				
Mean(SD)	-0.40 (1,35)	0.00 (1,57)	-5.11%	0,99

*statistically significant difference; pre-treat = before treatment; post-treat = immediately after treatment
 #Normal range

Ferreira et al.¹⁸ and Teyhen et al.³² also suggested that TrA exercising improves muscle activation in individuals with low back pain. According to Jull and Richardson³⁰ and Richardson et al.,³¹ normal PBU responses range from -4 to -10 mmHg; for Hodges et al.,¹⁹ mean normal values were around -5,82 mmHg.

For pain, the SS technique yielded impressive improvements (99% when measured by the VAS and 90% by the McGill questionnaire); functional disability improved by 90%. Our findings are supported by other studies,^{21,22} where SS translated into pain and functional capacity improvements. The better results of the SS group may be explained by the fact that this technique addressed two muscles primarily affected by low back pain. Hides¹⁶ identified selective atrophy of the LM after the first episode of back pain; the atrophy was unlikely to revert without specific training, and the lower muscular stability predisposed an individual to further episodes of low back pain. In individuals with low back pain, the TrA has decreased anticipatory capacity, meaning that it has reduced segmental protective function.¹⁹ Richardson et al.¹⁷ suggested that both muscles are primary stabilizers of the lumbar segment, minimizing compressive forces on spinal structures.

The ST group performed exercises that aimed to strengthen the superficial muscles of the abdomen and trunk. The regimen yielded significant pain and functional capacity improvements, which were also demonstrated by other studies.^{10,11} Rodacki et al.³³ suggested that abdominal exercises are associated with low back pain improvement, since during abdominal contraction the pressure on the intervertebral disks was decreased as a consequence of the

increased intra-abdominal pressure. However, no improvements on TrA capacity of activation were observed. Cairns et al.³¹ found that individuals with a history of but no current low back pain had impairments in TrA contraction. Accordingly, pain remission does not necessarily translate into improved muscle activation capacity.

The better improvement in all variables yielded by the SS relative to ST may be explained by the hierarchical structure of the muscular control system. According to Bergmark,³⁴ two systems are important. The local system is formed by the deep muscles directly involved with the joints, and their primary function is stabilizing the segments, avoiding articular micro-movements. These muscles do not normally perform joint movements, which makes contracting them more difficult, and this is exacerbated by pain. The second system is formed by the superficial muscles, which secondarily stabilize the spinal cord, further minimizing compressive forces. The main function of this system is to generate and control axial movements, and it makes little contribution to segmental stability.

Hides et al.¹⁶ found that even after pain remission in patients with low back pain, proper deep muscle reestablishment often did not happen and that specific physical therapy focusing on those muscles was necessary. Snijders et al.³⁵ postulated that the co-contraction of the TrA and LM muscles is the basis of the lumbo-sacral biomechanical stability and that these muscles act by reducing the compressive overloads, attenuating or eradicating pain perception. According to Norris,³⁶ the rectus abdominis is the most important trunk flexor, while the obliquus muscles support flexion but also rotation, and lateral inclination as well as providing secondary stability during exercise.³⁷

Our findings suggest that both protocols are of clinical utility in the improvement of chronic low back pain.

Table 5 - Mean Gain (difference of before and after in each group), and p value.

Mean(SD)	ST (n = 15)	SS (n = 15)	p
Pain-VAS (cm)	3.6(1.56)	5.8(1.61)	<0.001*
Pain-McGill	17.87(6.73)	31.8(6.06)	<0.001*
Sensory	8.9(5.05)	16.4(2.90)	<0.001*
Affective	5.8(2.59)	7.73(2.18)	<0.001*
Functional disability -Oswestry	8.86(2.82)	15.26(3.43)	<0.001*
Contraction of TrA- UBP (mmHg) #	-0.40(1.60)	4.66(2.22)	<0.001#

*statistically significant difference (Anova one-way)
 #statistically significant difference (Binomial test)

CONCLUSIONS

Segmental stabilization and strengthening exercises effectively reduce pain and functional disability in individuals with chronic low back pain. Segmental stabilization but not strengthening improves TrA muscle activation capacity. Improvement in all variables was superior in the segmental stabilization group opposed to the strengthening group.

LIMITATIONS OF THE STUDY

Limitations of the study were that there were no intermediate and long-term follow up examinations. Moreover, biopsychosocial factors were not observed in this study.

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