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Effect of a muscle stretching program using the global postural reeducation method for patients with chronic low back pain: A randomized controlled trial

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ABSTRACT

Objectives: To assess the effect of a muscle stretching program using the global postural reeducation (GPR) method for patients with chronic low back pain.
Methods: A randomized, controlled, clinical trial with a single blinded examiner and intention-to-treat analysis was conducted. Sixty-one patients with chronic low back pain were randomly allocated to either the GPR group or a control group. Patients in the GPR group underwent one weekly 60-minute session of GPR for a period of 12 weeks. The control group remained on the waiting list under drug treatment, with no physical intervention. The following parameters were evaluated: pain (VAS), function capacity (Roland-Morris Questionnaire [RMQ]), quality of life (SF-36) and depressive symptoms (Beck Inventory). The evaluations were performed by a single blinded examiner at baseline, three and six months after the initial evaluation.
Results: The GPR group demonstrated statistical improvements ($P < 0.05$) in the VAS and RMQ as well as the pain, emotional aspects, limitation in physical functioning, vitality and mental health subscales of the SF-36 immediately after the intervention (three months), which were maintained through to the six-month evaluation.
Discussions: Based on the findings, a stretching program using the GPR method showed effective at improving pain, function, some quality of life aspects (emotional, limitations in physical functioning, vitality and mental health) and had no effect on depressive symptoms in patients with chronic low back pain.

1. Introduction

Low back pain is defined as pain between the 12th rib and the inferior gluteal folds [1]. Acute low back pain lasts up to three weeks, whereas subacute low back pain lasts three to 12 weeks and chronic low back pain lasts more than 12 weeks [2]. Low back pain has a multifactor etiology [3] and is denominated *specific* when the cause is known and *nonspecific* when the cause is unknown [1]. The causal factors of low back pain are identified in 5 to 15% of cases, whereas more than 85% of patients exhibit nonspecific low back pain [3].

Low back pain is a leading cause of physical limitations and absenteeism at work throughout the world [4]. This condition can lead to a significant reduction in quality of life, with negative economic consequences for affected individuals, their families, the general community and public healthcare systems. Low back pain has epidemic proportions and constitutes a public health and welfare problem [5].

The diagnosis of low back pain is regarded as clinical. As low back pain is generally diagnosed as nonspecific, a number of treatments, techniques and multidisciplinary interventions have emerged aimed at improving the symptoms until the resolution of the pain [6]. Systematic reviews of the literature offer some evidence of the effectiveness of rehabilitation techniques on reducing pain symptoms and improving function in patients with chronic low back pain [6–11]. However, no one of this reviews include postural exercises.

'Global postural reeducation' (GPR) is a physical therapy method developed by Philippe-Emmanuel Souchard in France. This

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technique is based on the idea of the muscular system as formed by muscle chains, which can face shortening resulting from many factors as constitutional, behavioral and psychological. The aim of the technique is to stretch the shortened muscles using the viscoelastic tissue properties and to enhance contraction of the antagonist muscles avoiding postural asymmetry. The technique involves six postures divided into two groups:

- hip flexion postures that emphasize the posterior chain (lying on back with the legs flexed, sitting with legs extended, standing with the body leaning forward);
- neutral hip postures that emphasize the anterior chain (lying on back with the legs extended, standing with the back against the wall and standing in the center) [12].

The aim of these postures is to correct retractions in the different chains of muscles and re-establish the balance between these muscles, minimizing the loads placed on the joints and thereby reducing pain symptoms.

GPR has been applied in cases of ankylosing spondylitis [13–15], temporomandibular disorder [16], female stress urinary incontinence [17,18], chronic neck pain [19] and chronic low back pain [20]. All these trials have methodological problems not being capable of offering scientific evidence of the effectiveness of this technique on different conditions.

One systematic review assessed the use of GPR for different conditions of the musculoskeletal system [21] and found only one randomized, controlled study that demonstrated a statistical improvement in functional capacity in patients with ankylosing spondylitis [14,15]. The authors concluded that further randomized, controlled trials with adequate methodological quality are needed to assess the effects of GPR on patients with chronic low back pain.

The aim of the present study was to assess to assess the effect of a muscle stretching program using the GPR method on pain, function, quality of life and depressive symptoms in patients with chronic low back pain.

2. Methods

A randomized, controlled, clinical trial was carried out with a single blinded examiner and intention-to-treat analysis. This study received approval from the Research Ethics Committee of the Federal University of São Paulo and is registered in ClinicalTrials.gov under the number NCT01557049.

All patients were previously evaluated and diagnosed by a rheumatologist and were instructed to use up to 3.0 g of acetaminophen per day as the first choice for back pain or up to 150 mg of diclofenac as the secondary choice, if needed, and to keep of record of the intake. All patients originated from rheumatology ambulatory of Federal University of São Paulo.

The following were the inclusion criteria: either gender; age between 18 and 65 years; diagnosis of chronic low back pain, characterized by mechanical pain (pain that worsens with movement and improves with rest), for a period of more than three months between the last rib and gluteal sulcus [1]; and a score of 3.0 to 8.0 cm on a 0–10 cm visual analog scale for pain. This range of score was chosen to permit analyses the changes that could occur in this parameter.

The following were the exclusion criteria: nerve root pain; motor impairment; inflammatory spondyloarthropathy; spondylolisthesis, fibromyalgia, previous back surgery, vertebral fracture, current pregnancy, current physiotherapy (or in previous three months); body mass index (BMI) greater than 30 kg/m^2; change in pain drugs in previous 30 days, because the benefit caused by the drugs could influence the results or current involvement in litigation.

Opaque, sealed envelopes numbered in increasing order were used for the randomized allocation of the patients based on an electronic randomization table. Sixty-one individuals were randomly allocated to one of two groups: GPR group or control group.

The individuals in the GPR group individually underwent one weekly 60-minute session of GPR by the same physiotherapist with 12 years of experience in technical, for a period of 12 weeks and after these weeks, they remained without intervention over 12 weeks, completing 24 weeks in total. All six GPR postures described by Souchard et al. [12] were used in a standardized fashion. Each stretching posture lasted about 20 minutes. In the first three sessions, “lying on back with the legs extended” and “lying on back with the legs flexed” were performed with arms folded. In sessions 4, 5 and 6, “lying on back with the legs extended” and “lying on back with the legs flexed” were performed with arms open, ending with “standing with the body leaning forward”. In sessions 7, 8 and 9, “lying on back with the legs extended” with arms open, “lying on back with the legs flexed” with arms open and “sitting with legs extended” were performed. In the last three sessions, “lying on back with the legs extended” with arms folded, “lying on back with the legs flexed” with arms open, “standing with the back against the wall and standing in the center” were performed (Fig. 1). All these 6 different stretch positions were performed by patient under the therapist supervision.

The individuals in the control group remained only under drug treatment, if necessary, with no physical intervention, during 24 weeks of study, but were offered GPR after the end of the study (after 24 weeks from started study).

Evaluations were performed at baseline (T0) as well as three (T1) and six months after the baseline (T2). An examiner blinded to the allocation of the patients performed all evaluations. All patients were followed up in person. Pain in the day of the evaluation, function capacity, quality of life and depressive symptoms were assessed using a visual analog scale of pain (VAS) that ranged 0 cm (painless) to 10 cm (severe pain), the Roland-Morris Questionnaire [22], the Medical Outcomes Study Short-Form 36-Item Health Survey (SF-36) [23] and the Beck Inventory [24], respectively.

2.1. Statistical analysis

A minimal sample of 60 individuals was required to detect a difference of up to 20% on the VAS, with a standard deviation of 2 cm α of 5 and 90% test power. The Chi-squared test was used of the categorical variables. The Mann-Whitney test was used for continuous variables with non-normal distribution. Either ANOVA with a post hoc correction or the Student’s t-test was used for continuous variables with normal distribution. The statistical analysis was performed using the SPSS 17.0 program, with the level of significance set to 5% ($P < 0.05$).

3. Results

From January 2008 to September 2011, among the 108 patients contacted, 61 fulfilled the eligibility criteria and were randomly allocated to the two groups (31 in the GPR group and 30 in the control group). One participant in the GPR group interrupted treatment due to a humerus fracture occurred outside the study, but attended the evaluations (Fig. 2). Another participant did not show up for the final evaluation due to personal reasons and the data from the previous evaluation were repeated for this patient (intention-to-treat analysis).

Table 1
Socio-demographic data of sample.

Variables	GPR group ($n = 31$)	Control group ($n = 30$)	P
Age (years)[a]	49.4 (12.0)	47.5 (11.9)	0.547
BMI[a]	26.17 (2.95)	26.22 (3.18)	0.784
Gender (female)[b]	25 (80.6%)	22 (73.3%)	0.497
Duration of pain (years)[a]	2.9 (1.2)	3.1 (1.5)	0.755
Smoking status[b]			0.559
Non-smoker	24 (77.4%)	22 (73.3%)	
Ex-smoker	1 (3.2%)	3 (10.0%)	
Smoker	6 (19.4%)	5 (16.7%)	
Schooling[b]			0.335
Incomplete elementary	19 (61.3%)	11 (36.7%)	
Complete elementary	3 (9.7%)	6 (20.0%)	
Incomplete high school	2 (6.5%)	3 (10.0%)	
Complete high school	4 (12.9%)	5 (16.7%)	
Incomplete university	1 (3.2%)	0 (0%)	
Complete university	2 (6.5%)	5 (16.7%)	

GPR: global postural reeducation; BMI: body mass index.
[a] Mean (standard deviation).
[b] Frequency (percentage).

At baseline, the individuals in both groups were homogeneous with regard to age, BMI, duration of chronic low back pain in years, gender, smoking status and schooling (Table 1).

Repeated-measure ANOVA revealed statistically significant differences between the baseline and three-month evaluation in the GPR group with regard to VAS ($P < 0.001$) and the Roland-Morris Questionnaire ($P < 0.001$), with the gains maintained through to the six-month evaluation. No differences between groups were found regarding depressive symptoms (Beck Inventory) at any evaluation time. No statistical differences between groups were found regarding the use of paracetamol (acetaminophen) and diclofenac (Table 2).

Regarding VAS for pain, an improvement of more than 1.5 cm were found in 27 (87%) patients in the GPR group and 7 (23%) in the CG at T1 ($P < 0,05$) and 18 (58%) patients in the GPR group and 5 (17%) in the CG at T2 ($P < 0,05$). In the Roland-Morris Questionnaire score an improvement of more than 5 points were observed in 19 (61%) patient in the GPR group and 3 (10%) in the CG at T1 ($P = 0,031$) and 15 (48%) in the GPR group and 3 (10%) in the CG at T2 ($P < 0,05$).

No statistically significant differences between groups were found regarding the functional capacity, general health or social aspects subscales of the SF-36, whereas statistically significant differences favoring the GPR group were found regarding the limitations due to physical aspects, vitality and mental health subscales ($P < 0,05$; $P < 0,01$ and $P < 0,05$, respectively); however,

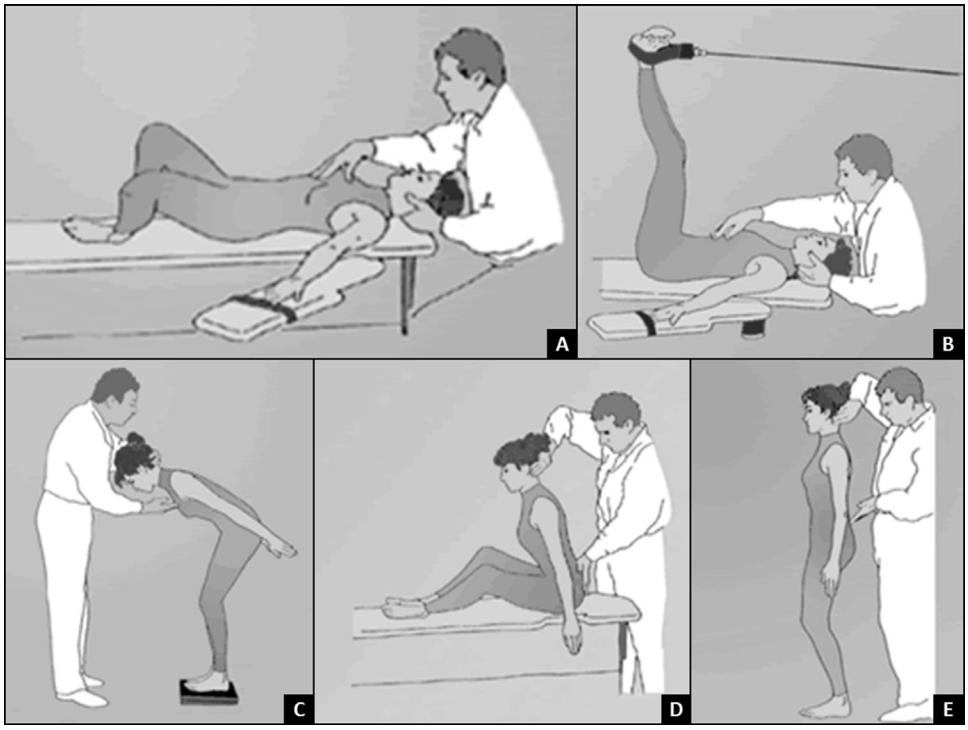

Fig. 1. Global postural reeducation postures described by Souchard et al. A. Lying on back with the legs extended. B. Lying on back with the legs flexed. C. Standing with the body leaning forward'. D. Sitting with legs extended. E. Standing in the center [12].

Table 2
Between-groups and intragroup comparisons for pain, function, depression, analgesic and anti-inflammatory consumption and general health scores on three evaluations.

	GPR group ($n = 30$)				Control group ($n = 30$)				
	T0	T1	T2	*P* intragroup	T0	T1	T2	*P* intragroup	*P* intergroup
VAS for pain (cm)	6.4 (1.6)	3.1 (2.3)	4.4 (2.5)	p < 0.001	6.3 (1.6)	6.1 (2.2)	5.8 (1.7)	p = 0.340	p < 0.001
Roland-Morris	12.6 (4.8)	7.2 (5.2)	8.1 (6.3)	p < 0.001	11.9 (5.0)	10.9 (5.5)	11.4 (5.5)	p = 0.264	p < 0.001
Beck Inventory	11.8 (8.1)	8.5 (6.8)	8.7 (7.8)		12.0 (8.2)	9.4 (6.1)	10.7 (8.2)		p = 0.558
Paracetamol consumption		7.6 (10.6)	7.9 (10.3)			8.1 (9.7)	6.9 (10.2)		p = 0.925
Diclofenac consumption		9 (2.6)	5 (2.5)			4 (1.2)	5 (1.4)		
SF-36									
Functional capacity	50,8 (20,3)	52,7 (24,2)	63,1 (20,1)		52,7 (24,2)	53,8 (24,7)	57,7 (25,1)		p = 0.396
Limitation in physical aspects	45,2 (40,5)	67,8 (37,2)	67,1 (39,5)	p = 0,007	37,5 (35,8)	45,8 (40,5)	44,7 (35,5)	p = 0,007	p = 0,040
Pain	41,3 (14,3)	52,4 (21,6)	51,0 (17,8)	p = 0,005	40,9 (12,3)	40,9 (14,2)	42,5 (15,5)	p = 0,676	p = 0.047
General health	59,5 (25,1)	67,8 (23,7)	64,4 (23,0)		58 (23,1)	60,9 (17,0)	59,2 (19,4)		p = 0.363
Vitality	48,7 (21,0)	64,1 (19,4)	64,2 (20,3)	p < 0,001	39,8 (17,0)	48,5 (17,1)	50,2 (17,6)	p < 0,001	p = 0.003
Social aspects	66,1 (22,2)	79,0 (17,2)	74,6 (22,2)		62,1 (29,6)	64,6 (25,9)	66,5 (27,5)		p = 0.103
Emotional aspects	51,9 (41,3)	75,7 (35,4)	78,9 (30,4)	p = 0,007	54,4 (41,5)	56,7 (42,1)	51,6 (39,2)	p = 0,571	p = 0.008
Mental health	63,6 (19,8)	72,7 (18,9)	72,1 (20,7)	p = 0,004	57,3 (24,8)	58,8 (17,5)	61,8 (19,9)	p = 0,004	p = 0,034

Data presented as mean (standard deviation); GPR: global postural reeducation; T0: baseline; T1: three months after the baseline; T2: six months after the baseline; VAS visual analog scale.

these differences were evident beginning at baseline (Table 2). The GPR group demonstrated statistical significant improvements in the pain ($P < 0,05$) and emotional aspects ($P < 0,01$) subscales as well as the VAS in comparison with the control group.

4. Discussion

This is the first randomized, controlled, blind, clinical trial to assess the effect of a muscle stretching program using the GPR method on patients with chronic low back pain. GPR is a non-invasive treatment option with no side effects. In the present study, all six postures were used and none of the patients complained of any adverse effect. The sessions were held once a week over a 12-week period, over which time GPR proved effective at improving pain and function.

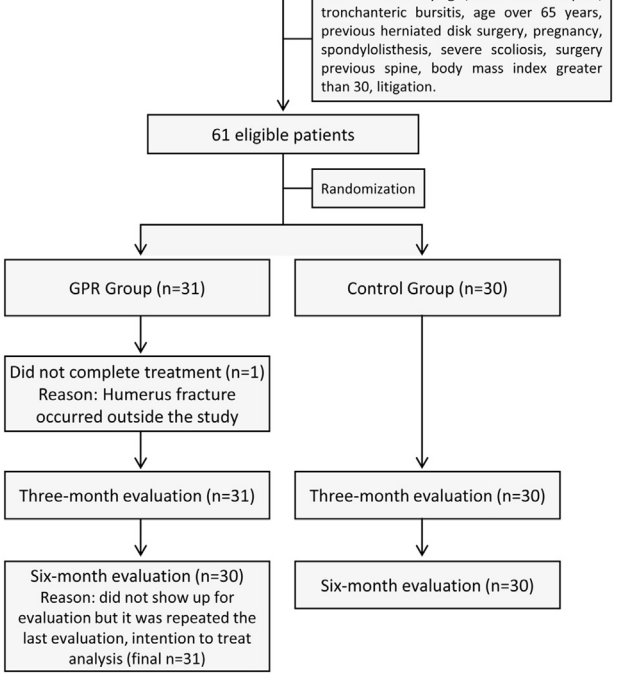

Fig. 2. Flowchart of trial participants.

It is known that simple stretching technique improve pain and reduce disability in patients with chronic low back pain when compared with segmental stabilization [25] or self-care book [26] or multimodal rehabilitation program without stretching maneuver [27] but not superior to yoga [26]. However, no study until now evaluates the effectiveness of a muscle stretching program using the GPR method in chronic low back pain patients.

According to Warren et al., the time needed to stretch a tissue is inversely proportional to the force applied. Muscle stretching is one of the advantages of GPR. Due to the holding of stretching positions in this technique, less force is required to produce gains in flexibility, thereby minimizing the risk of injury [28]. This lack of injury caused by GPR may also be explained by Hooke's law which postulates that the degree of deformation is equal to the force applied multiplied by the application time [29]. Thus, the low-intensity eccentric isometric force applied during the sessions is compensated by the prolonged holding of the posture, leading to more effective stretching.

According to Ostelo et al., a change of at least 15 mm on a 100 mm VAS scale for pain and a 5-point change on the Roland-Morris Questionnaire denote clinically differences [30]. Thus, the greater than 1.5 cm change on the 10 cm VAS pain scale and the greater than 5-point change on the Roland-Morris Questionnaire in the present study demonstrate statistically and clinically differences as well as an important improvement in function. In this study we found that more patients in the GPR group achieved results that were consider clinically significant and it was statistically different from the CG.

One of the hypotheses for the analgesic effect of GPR is that muscle stretching reduces the viscoelasticity of the tissues and increases range of motion, with a consequent reduction in pain [31]. Another hypothesis states that this analgesic effect is due to the increase in blood flow produced by stretching in capillaries adjacent to the stretched region [32]. In the present study, the

reduction in pain in the GPR group was associated with a functional improvement in the lumbar region, allowing gains in the performance of activities of daily living. Pain alters motor control and leads to functional deficit [33]. A number of authors suggest that this deficit in motor control impairs joint mobility, thereby favoring the emergence of micro-traumas and pain [34]. However, these hypotheses have not been confirmed.

GPR involves global stretching postures and isometric contraction, leading to the inhibition of agonist muscles and stimulation of antagonist muscles [12]. The influence of stretching on muscle spindles, Golgi tendon organs and joint receptors may favor functional improvement [35,36].

Quality of life is generally impaired in patients with chronic low back pain. With the physical restrictions stemming from pain and functional impairment, such patients tend to become functionally dependent with regard to activities of daily living and experience impairments in the emotional and social realms as well. Despite this, few studies have addressed quality of life in patients with this condition. In the present study, the patients in the GPR group experienced improvements in the pain, emotional aspects, limitation in physical functioning, vitality and mental health subscales of the SF-36 in comparison to the control group immediately after the intervention (three months), which were maintained through to the six-month evaluation.

The association between chronic pain and emotional factors has long been recognized. Krishnan et al. demonstrate that signs of anxiety are common among patients with chronic low back pain, especially those who suffer from depression, which consequently alters their perception of pain [37]. Despite the improvements in pain, functional capacity (as determined by the Roland-Morris Questionnaire), emotional aspects and mental health among the individuals in the GPR group, the technique had no impact on depressive symptoms, as demonstrated by the findings of the Beck Inventory. The score on this measure ranges from 0 to 63 points, for which higher scores denote more severe depression. The individuals in the present study had a mean score of 12 points on this scale, with no statistical change over time. Thus, GPR does not appear to exert an influence over mild symptoms of depression.

Mean duration of pain in the present study was three years, with a mean VAS score of 6.4 cm in a population with a mean age of 49 years. Thus, the use of analgesics and anti-inflammatory agents was expected to be greater. However, the population studied appeared to be reluctant to use medications and sought alternative methods for relieving pain, such as the application of a heat pad.

The present study has some limitations. We believe that may be an educational role of the physiotherapist during the GPR section what can influence the results. The lack of a control group doing exercise or other therapy, to compare with the GPR group results however it is not the aim of our study. Another studies comparing GPR with simple stretching technique or another conventional therapies should be done and a cost-benefit study is necessary too.

Based on the findings of the present study, GPR proved effective at improving pain, function and some aspects of quality of life, but had no effect on depressive symptoms in patients with chronic low back pain. This technique can be considered yet another treatment option for chronic low back pain.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

[1] Van Middelkoop M, Rubinstein SM, Verhagen AP, et al. Exercise therapy for chronic nonspecific low back pain. Best Pract Res Clin Rheumatol 2010;24:193–204.
[2] Van Tulder MW, Becker A, Bekkering T, et al. Chapter 3. European guidelines for the management of acute nonspecific low back pain in primary care. Eur Spine J 2006;15(Suppl. 2):S169–91.
[3] Deyo RA, Weinstein JN. Low back pain. N Engl J Med 2001;344:363–70.
[4] Lidgren L. The bone and joint decade 2000–2010. Bull World Health Organ 2003;81:629.
[5] Hoy D, Brooks P, Blyth F, et al. The epidemiology of low back pain. Best Pract Res Clin Rheumatol 2010;24:769–81.
[6] Lewis JS, Hewitt JS, Billington L, et al. A randomized clinical trial comparing two physiotherapy interventions for chronic low back pain. Spine (Phila Pa 1976) 2005;30:711–21.
[7] Hayden J, van Tulder MW, Malmivaara A, et al. Exercise therapy for treatment of non-specific low back pain. Cochrane Database Syst Rev 2005;3:CD00033.
[8] Niemistö L, Lahtinen-Suopanki T, Rissanen P, et al. A randomized trial of combined manipulation stabilizing exercises, and physician consultation compared to physician consultation alone for chronic low back pain. Spine (Phila Pa 1976) 2003;28:2185–91.
[9] Snook SH, Webster BS, McGorry RW, et al. The reduction of chronic nonspecific low back pain through the control of early lumbar flexion. Spine (Phila Pa 1976) 1998;23:2601–7.
[10] Hsieh CY, Adams AH, Tobis J, et al. Effectiveness of four consevative treatments for subacute low back pain. Spine (Phila Pa 1976) 2002;27:1142–8.
[11] Mannion AF, Müntener M, Taimela S, et al. A randomized clinical trial of three active therapies for chronic low back pain. Spine (Phila Pa 1976) 1999;24:2435–48.
[12] Souchard P-E, Meli O, Sgamma D, et al. Rieducazione posturale globale. In: EMC - Medicina Riabilitativa. Paris: Elsevier Masson SAS; 2009 [26-061-A-15].
[13] Durmus D, Alayli G, Uzun O, et al. Effects of two exercises interventions on pulmonary functions in the patients whith ankylosing spondylitis. Joint Bone Spine 2009;76:150–5.
[14] Fernández-de-las-Peñas C, Alonso-Blanco C, Morales-Cabezas M, et al. Two exercise interventions for the management of patients with ankylosing spondylitis: a randomized controlled trial. Am J Phys Med Rehabil 2005;84:407–19.
[15] Fernández-de-las-Peñas C, Alonso-Blanco C, Alguacil-Diego IM, et al. One-year follow-up of two exercise interventions for the management of patients with ankylosing spondylitis: a randomized controlled trial. Am J Phys Med Rehabil 2006;85:559–67.
[16] Maluf SA, Moreno BGD, Crivello O, et al. Global postural reeducation and static stretching exercises in the treatment of myogenic temporomandibular disorders: a randomized study. J Manipulative Physiol Ther 2010;33:500–7.
[17] Fozzatti MCM, Palma P, Herrmann V, et al. Impact of global postural reeducation for treatment of female stress urinary incontinence. Rev Assoc Med Bras 2008;54:17–22.
[18] Fozzatti C, Herrmann V, Palma T, et al. Global postural re-education: an alternative approach for stress urinary incontinence? Eur J Obstet Gynecol Reprod Biol 2010;152:218–22.
[19] Cunha ACV, Burke TN, França RJR, et al. Effect of global posture reeducation and of static stretching on pain, range of motion and quality of life in women with chronic neck pain: a randomized clinical trial. Clinics 2008;63:763–70.
[20] Bonetti F, Curti S, Mattioli S, et al. Effectiveness of global postural reeducation program for persistent low back pain: a non-randomized controlled trial. BMC Musculoskelet Disord 2010;11:285.
[21] Vanti C, Generali A, Ferrari S, et al. La Rieducazione Posturale Globale nell epatologie muscolo-scheletriche: evidenze scientifiche e indicazion icliniche Rééducation Posturale Globale in musculoskeletal diseases: scientific evidence and clinical practice. Reumatismo 2007;59:192–201.
[22] Nusbaum L, Natour J, Ferraz MB, et al. Translation Adaptation and Validation of the Roland Morris Questionnaire – Brazil Roland Morris. Braz J Med Biol Res 2001;34:203–10.
[23] Ciconelli RM, Ferraz MB, Santos W, et al. Tradução para a língua portuguesa e validação do questionário genérico de avaliação de qualidade de vida SF-36 (Brasil SF-36). Brazilian-Portuguese version of the SF-36. A reliable and valid quality of life outcome measure. Rev Bras Reumatol 1999;39:143–50 [article in Portuguese].
[24] Gorenstein C, Andrade L. Validation of a Portuguese version of a Beck Depression Inventory and the State-Trait Anxiety Inventory in Brazilian subjects. Braz J Med Biol Res 1996;29:453–7.
[25] França FR, Burke TN, Caffaro RR, et al. Effects of muscular stretching and segmental stabilization on functional disability and pain in patients with chronic low back pain: a randomized, controlled trial. J Manipulative Physiol Ther 2012;35:279–85.
[26] Sherman KJ, Cherkin DC, Wellman RD, et al. A randomized trial comparing yoga, stretching, and a self-care book for chronic low back pain. Arch Intern Med 2011;171:2019–26.
[27] Khalil TM, Asfour SS, Martinez LM, et al. Stretching in the rehabilitation of low-back pain patients. Spine (Phila Pa 1976) 1992;17:311–7.
[28] Warren CG, Lehamann JF, Koblansk JN. Heat and stretch produces. An evaluation using rat tail tendon. Arch Phys Med Rehabil 1976;57:122–6.

[29] Hintzman DL. Robert Hooke's model of memory. Psychon Bull Rev 2003;10:3–14.
[30] Ostelo RWJG, Deyo RA, Stratford P, et al. Interpreting changes scores for pain and functional status in low back pain. Towards international consensus regarding minimal important change. Spine (Phila Pa 1976) 2008;33:90–4.
[31] Shrier I, Gossal K. Myths and truths of stretching. Phys Sports Med 2000;28:57–63.
[32] Levtov VA, Shustova NI, et al. Topographic and hydrodynamic heterogeneity of the terminal bed of the cat gastrocnemius muscles vessel of cat. Fiziol Zh SSSR Im I M Sechenova 1985;71:1112–23.
[33] Häkkinen A, Salo P, Tarvainen U, et al. Effect of manual therapy and stretching on neck muscle strength and mobility in chronic neck pain. J Rehabil Med 2007;39:575–9.
[34] Panjabi M. The stabilizing system of the spine. Part I. Function, dysfunction adaptation and enhancement. J Spinal Disord 1992;5:383–9.
[35] Cornwell A, Nelson AG, Sidaway B. Acute effects of stretching on the neuromechanical properties of the triceps surae muscle complex. Eur J Appl Physiol 2002;86:428–34.
[36] Weir DE, Tingley J, Elder GCB. Acute passive stretching alters the mechanical properties of human plantar flexors and optimal angle for maximal voluntary contraction. Eur J Appl Physiol 2002;86:428–34.
[37] Krishnan KR, France RD, Pelton S, et al. Chronic pain and depression. II. Symptoms of anxiety in chronic low back pain patients and their relationship to subtypes of depression. Pain 1985;22:289–94.