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Comparison of general exercise, motor control exercise and spinal manipulative therapy for chronic low back pain: A randomized trial

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Abstract

Practice guidelines recommend various types of exercise and manipulative therapy for chronic back pain but there have been few head-to-head comparisons of these interventions. We conducted a randomized controlled trial to compare effects of general exercise, motor control exercise and manipulative therapy on function and perceived effect of intervention in patients with chronic back pain. Two hundred and forty adults with non-specific low back pain $\geqslant$3 months were allocated to groups that received 8 weeks of general exercise, motor control exercise or spinal manipulative therapy. General exercise included strengthening, stretching and aerobic exercises. Motor control exercise involved retraining specific trunk muscles using ultrasound feedback. Spinal manipulative therapy included joint mobilization and manipulation. Primary outcomes were patient-specific function (PSFS, 3–30) and global perceived effect (GPE, −5 to 5) at 8 weeks. These outcomes were also measured at 6 and 12 months. Follow-up was 93% at 8 weeks and 88% at 6 and 12 months. The motor control exercise group had slightly better outcomes than the general exercise group at 8 weeks (between-group difference: PSFS 2.9, 95% CI: 0.9–4.8; GPE 1.7, 95% CI: 0.9–2.4), as did the spinal manipulative therapy group (PSFS 2.3, 95% CI: 0.4–4.2; GPE 1.2, 95% CI: 0.4–2.0). The groups had similar outcomes at 6 and 12 months. Motor control exercise and spinal manipulative therapy produce slightly better short-term function and perceptions of effect than general exercise, but not better medium or long-term effects, in patients with chronic non-specific back pain.
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1. Introduction

Low back pain remains the primary cause of absenteeism and disability in every industrialized society (Waddell, 1998). Patients who develop chronic low back pain (pain and disability persisting for more than 3 months) use more than 80% of all health care for back pain (Waddell, 1998).

Chronic low back pain is commonly treated with exercise or spinal manipulative therapy (Ferreira et al., 2002). The European Guidelines for Management of Chronic Non-Specific Low Back Pain (Airaksinen et al., 2006) recommend supervised exercise therapy as a first-line treatment. The same guidelines recommend that a short course of spinal manipulative therapy should be considered as a treatment option. There have

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been no randomized head-to-head comparisons of the effects of general exercise and spinal manipulative therapy specifically for management of chronic low back pain so it is not clear which treatment is most effective for this group.

Exercise programs for chronic low back pain may be designed to reverse de-conditioning or the fear of movement associated with pain, or both. Such exercise programs are often conducted in groups and typically include aerobic exercise such as walking or stationary cycling, as well as strengthening and stretching exercises (Hayden et al., 2005). Recently a distinctly different approach to exercise has been developed (Richardson et al., 1999). This approach, referred to as motor control exercise, aims to retrain optimal control of spinal motion. Motor control exercises are usually practised under one-to-one supervision, sometimes using ultrasound imaging to provide feedback of muscle contraction (Hides et al., 1995; Teyhen et al., 2005).

A recent systematic review of the effects of motor control exercise for spinal pain showed that motor control exercises are more effective than medical management and education in the management of chronic non-specific low back pain. However, the review did not identify any randomized head-to-head comparisons of the effects of general and motor control exercise in patients with chronic low back pain, so it is not clear which of these interventions is more effective for this patient group (Ferreira et al., 2006).

The available evidence provides little guidance to clinicians who need to decide which interventions to implement for chronic low back pain. There is little basis on which to prefer manipulative therapy or exercise therapy. Also, there is currently little basis on which to prefer general or motor control exercise. Consequently we conducted a pragmatic randomized clinical trial to compare the effects of general exercise, spinal manipulative therapy and motor control exercise for chronic low back pain.

2. Methods

The study protocol was registered with the Australian Clinical trials Registry (ACTRN012605000053628) and approved by the Ethics Committees of the University of Sydney and the South Western and Western Sydney Area Health Services.

2.1. Participants

Participants were 240 patients seeking treatment for chronic non-specific low back pain from physical therapy departments at three teaching hospitals in Sydney, Australia, between May 2002 and November 2003. To be eligible for inclusion patients had to have non-specific low back pain for at least 3 months, be aged between 18 and 80 years, and give written informed voluntary consent. Potential participants were screened for evidence of serious low back pathology and for contraindications to exercise or spinal manipulative therapy by a physical therapist. They were excluded prior to randomization if they had neurological signs, specific spinal pathology (e.g. malignancy, or inflammatory joint or bone disease) or if they had undergone back surgery. Patients who reported osteoarthritis or disc lesions (prolapse, protrusion or herniation without neurological compromise) with or without leg pain were eligible to participate in the study.

2.2. Randomization

Baseline measures were taken of the two primary outcomes and two secondary outcomes prior to randomization. Subsequently each participant was randomized to a general exercise group, a spinal manipulative therapy group or a motor control exercise group. Randomization was by a random sequence of randomly permuted blocks of sizes 6, 9 and 15. The randomization schedule was known only to one investigator who was not involved in recruiting participants, and it was concealed from patients and the other investigators using consecutively numbered, sealed, opaque envelopes.

2.3. Interventions

Participants attended for up to 12 treatment sessions over an 8 week period. The treatments were implemented as follows.

2.3.1. General exercise

A physical therapist carried out an initial assessment of each participant allocated to the general exercise group to determine how physically active the participant was, how troublesome the back problem was, and the ability of the participant to perform the exercises. Participants were then taught the exercises and advised of the intensity at which they should exercise. The exercises were performed under supervision of a physical therapist in classes of up to 8 people with each class lasting approximately 1 h. The intensity of the exercises was progressed over the 12 treatments with participants being encouraged to improve their own performance rather than competing with other members of the class.

The main aims of the program were to improve physical function and confidence in using the spine, and to teach participants how to cope with their back problems. The class was modeled on the 'Back to Fitness' program described by Klaber Moffet and Frost (Klaber Moffett and Frost, 2000) and included strengthening and stretching exercises for the main muscle groups of the body as well as exercises for cardiovascular fitness. The classes started with a warm-up session that was followed by 10 exercises performed for 1 min each. After a warm-down session, there was a short relaxation session and then, at the end of the class, a brief educational message was provided as a "tip of the day". From the beginning, participants were encouraged to avoid unaccustomed rest and remain active, incorporate exercise into their daily activity, and take up activities that they would find enjoyable and satisfying. The final class of the program was an individual session where the participant discussed what new activities they had adopted and how they planned to maintain and increase their activity level after discharge.

2.3.2. Motor control exercise

Participants allocated to the motor control exercise group were prescribed exercises aimed at improving function of specific trunk muscles thought to control inter-segmental movement of the spine, including transversus abdominis, multifidus, the diaphragm and pelvic floor muscles (Richardson et al., 1999). Each participant was trained by a physical therapist to recruit the deep muscles of the spine and reduce activity of other muscles. Initially participants were taught how to contract the transversus abdominis and multifidus muscles in isolation from the more superficial trunk muscles, but in conjunction with the pelvic floor muscles. Ultrasonography was used to provide feedback about muscle recruitment (Hodges et al., 2003), except where the therapist judged that ultrasound feedback would not be useful (for example, if the patient was too obese). The difficulty of the tasks was progressed by incorporating more functional positions and training the coordination of all trunk muscles during functional tasks in a manner that was tailored to the individual patient's presentation.

When treating participants in *both exercise groups*, physical therapists applied principles of cognitive-behavioural therapy (Nicholas and Tonkin, 2004). The cognitive-behavioural approach involves encouragement of skill acquisition by modeling, the use of pacing, setting progressive goals, self-monitoring of progress, and positive reinforcement of progress. Self-reliance was fostered by encouraging participants to engage in problem-solving to deal with difficulties rather than seeking reassurance and advice, by encouraging relevant activity goals, and by encouraging self-reinforcement. Participants in *both exercise groups* were encouraged to exercise at home at least once a day and to finish all 12 training sessions regardless of the extent of recovery.

2.3.3. Spinal manipulative therapy

Participants allocated to the spinal manipulative therapy group were treated with joint mobilization or manipulation techniques applied to the spine or pelvis (Maitland et al., 2001). The particular dose and techniques were at the discretion of the treating physical therapist, based on each participant's physical examination findings. Participants in this group were not given exercises or a home exercise program, and they were advised to avoid pain-aggravating activities. Manipulative therapy was discontinued if the participant completely recovered before the 12 sessions were completed, as is standard clinical practice.

Although all physical therapists were qualified to apply all three interventions, additional training was provided on administration of general exercise, motor control exercise and spinal manipulative therapy.

Participants in all groups were asked not to seek other treatments and where possible not to change current medications for the 8 week trial period. After 8 weeks, interventions ceased and participants were encouraged to continue their attempts to return to normal activity. Participants were permitted to seek alternate care after the 8 week intervention period.

2.4. Outcomes

Measures of outcome were obtained during follow-up appointments at 8 weeks (i.e. at the end of the intervention period) and at 6 and 12 months. Every attempt within ethical constraints was made to obtain outcome data, regardless of participants' compliance with trial protocols. Participants reported their outcomes to a trial physical therapist who was blinded to allocation.

There were two primary outcome measures, a patient-specific measure of function and global perceived effect of treatment. For the Patient-Specific Functional Scale, participants were required to list three activities they had trouble with as a result of their low back pain on that day and rate the degree of difficulty of each activity from 1 (unable to perform) to 10 (able to perform at pre-injury level) (Westaway et al., 1998). The scores for the three activities were summed, giving a total score that could range from 3 to 30. At follow-ups participants rated the degree of difficulty with the same three tasks. Global perceived effect was measured on an 11-point scale that ranged from -5 (vastly worse) through 0 (no change) to $+5$ (completely recovered) (Ross and LaStayo, 1997). For all measures of global perceived effect (at baseline and all follow-ups), participants were asked "Compared to when this episode first started, how would you describe your back these days?"

Secondary outcomes were pain and disability. Average pain intensity over the last week was measured on a visual analogue scale, where 0 represented no pain and 10 represented the worst pain possible (Ross and LaStayo, 1997). Disability was measured using the Roland Morris Disability Questionnaire which consists of 24 statements related to activities of daily living commonly affected by low back pain. Participants were asked to check the statements that represented their status on that day. Each statement was awarded 1 point if checked, giving a score out of 24 (Roland and Morris, 1983).

2.5. Analysis

The primary measures of effect of treatment were function and global perceived effect at 8 weeks.

Data were analysed according to a protocol specified *a priori*. The statistician was given grouped data, but data were coded so that the statistician was blinded to which group received each intervention. Separate analyses were conducted to determine the effects of treatment at 8 weeks, 6 and 12 months. Analysis was by intention-to-treat in the sense that data were analysed for all randomized subjects for whom follow-up data were available. No attempt was made to impute values for missing data. Consequently cases with missing data at a particular follow-up (8 weeks, 6 or 12 months) were dropped from analyses at that follow-up. The emphasis in the analysis was on estimation of the effects of intervention rather than hypothesis testing. To maximise precision we used analysis of covariance. For each analysis the only covariate, chosen *a priori*, was the baseline value of the outcome.

The sample size of 240 provided an 80% chance of detecting differences between pairs of groups of 1.5 points on an 11-point scale of global perceived effect or 3.5 points on the 28-point measure of function. These calculations assumed a worst-case loss to follow-up of 20%. In sample size calculations we conservatively ignored the extra precision conferred by analysis of covariance.

3. Results

Of 240 participants, 93% were followed up at 8 weeks and 88% were followed up at 6 and 12 months (Fig. 1).

Participants were typically moderately or severely disabled. The groups were similar for most baseline characteristics (Table 1). When compared to the general exercise group, about 10% more participants in the spinal manipulative therapy group were working full time at baseline. The motor control exercise group had shorter duration of pain than the other two groups (median of 36 vs 60 months).

There was a high degree of adherence to all three interventions. Of the possible 12 sessions, participants in the general exercise group attended 9.1 ± 3.9 (mean $\pm$ SD) sessions, participants in the motor control exercise group attended 9.2 ± 3.4 sessions, and participants in the spinal manipulative therapy group attended 9.8 ± 2.7 sessions.

The outcomes of all three groups improved, on average, over the 12 months following randomization (Table 2 and Fig. 2). Mean improvements at 12 months were between 3.8 and 5.0 points on the 28-point function scale and between 3.8 and 4.4 points on the 11-point scale of global perceived effect.

3.1. Treatment effects

In the short term the groups receiving motor control exercises or spinal manipulative therapy improved more than the group receiving general exercise: at 8 weeks the motor control exercise group had better function (adjusted mean difference in function 2.9, 95% CI: 0.9–4.8; $p = 0.004$) and perceived there was a better effect of therapy (adjusted mean difference in global perceived effect 1.7, 95% CI: 0.9–2.4; $p < 0.001$) than did the general exercise group. Likewise the spinal manipulative therapy group had better function (adjusted mean difference 2.3, 95% CI: 0.4–4.2; $p = 0.016$) and perceived there was a better effect of therapy (adjusted mean difference 1.2, 95% CI: 0.4–2.0; $p = 0.004$) than did the general exercise group. There was little difference between the motor control exercise and spinal manipulative therapy groups (for function: 0.4, 95% CI −1.5 to 2.4, $p = 0.643$; for perceived effect of therapy: 0.5, 95% CI −0.2 to 1.1, $p = 0.151$). Similar but slightly smaller and statistically non-significant effects were seen in the secondary outcomes at 8 weeks.

There were no apparent differences between groups in either primary or secondary variables at 6 or 12 months. No adverse events were reported.

4. Discussion

This randomized trial has shown that motor control exercise and spinal manipulative therapy produce slightly better short-term function and short-term perceptions of global effect of treatment, but not better medium or long-term effects, in patients with chronic non-specific low back pain.

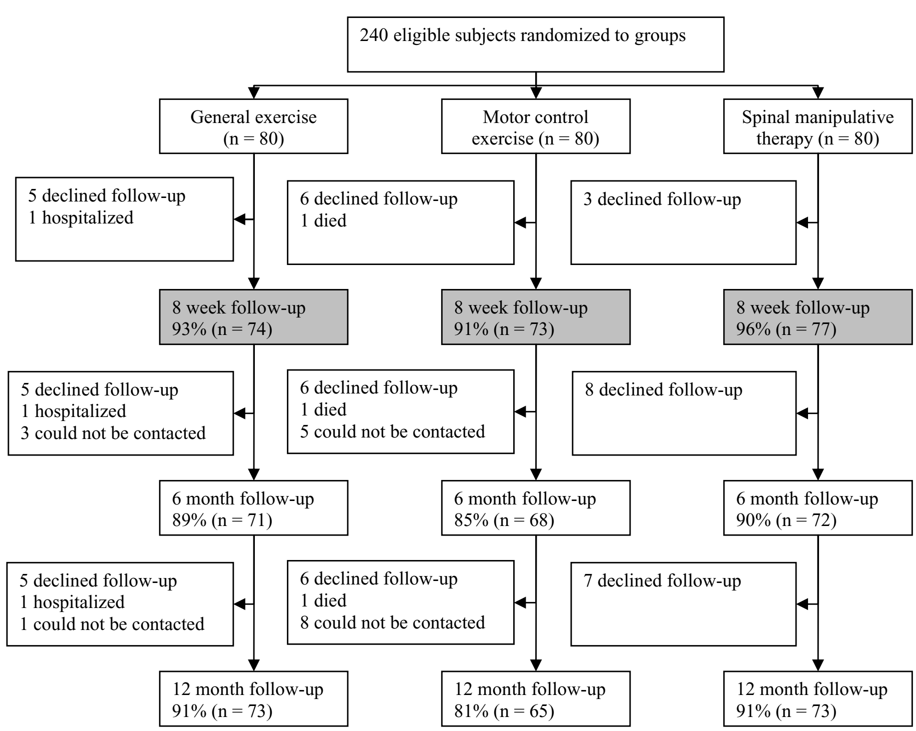

Fig. 1. Flow of participants through the trial. Primary outcomes were measured at 8 weeks (grey boxes).

Table 1
Baseline characteristics of the study sample

	General exercise ($n = 80$)	Motor control exercise ($n = 80$)	SMT ($n = 80$)
Age	54.8 (15.3)	51.9 (15.3)	54.0 (14.4)
Female *n* (%)	56 (70.0)	53 (66.3)	56 (70.0)
Low back pain duration *n* (%)			
3–12 months	17 (21.2)	19 (23.8)	22 (27.5)
13–36 months	11 (13.8)	23 (28.8)	14 (17.5)
>36 months	52 (65.0)	38 (47.5)	44 (55.0)
Low back pain duration (median, IQR, in months)	60 (24–206)	36 (15–120)	60 (12–162)
Height (cm)	164.0 (9.9)	163.8 (9.2)	163.7 (8.4)
Weight (kg)	73.3 (15.4)	81.0 (18.6)	72.8 (14.1)
Work status *n* (%)			
Full time	1 (1.3)	6 (7.5)	11 (13.8)
Part time	5 (6.3)	3 (3.7)	4 (5.1)
Not working	63 (78.8)	58 (72.6)	54 (67.5)
Not reported	11 (13.8)	13 (16.2)	11 (13.8)
Primary outcomes			
Function[a]	10.1 (4.2)	10.7 (4.0)	11.2 (4.6)
Global perceived effect[b]	−2.8 (1.8)	−2.6 (2.2)	−2.6 (2.1)
Secondary outcomes			
Pain intensity[c]	6.5 (2.1)	6.3 (2.0)	6.2 (2.0)
Disability[d]	14.1 (5.5)	14.0 (5.3)	12.4 (5.7)

Data are means and SDs except where indicated.
SMT: spinal manipulative therapy.
[a] Patient-Specific Functional Scale: 3 (unable to perform activities) to 30 (able to perform activities at pre-injury level).
[b] Global Perceived Effect Scale: −5 (vastly worse) to 0 (unchanged) to 5 (completely better).
[c] Pain: 0 (no pain) to 10 (worst pain possible).
[d] Roland Morris Disability Questionnaire: 0 (no disability) to 24 (severe disability).

Table 2
Outcomes (means and SDs) and effects of intervention (mean between-group differences, adjusted for baseline values, with 95% confidence intervals)

Outcome	General exercise	Motor control exercise	SMT	Motor control vs general exercise[a]	SMT vs general exercise[b]	Motor control exercise vs SMT[a]
Primary outcome variables						
PSFS (3–30)						
Baseline	10.1 (4.2)	10.7 (4.0)	11.2 (4.6)			
8 weeks	14.4 (6.6)	17.7 (6.2)	17.5 (6.8)	2.9 (0.9 to 4.8)	2.3 (0.4 to 4.2)	0.4 (−1.5 to 2.4)
6 months	15.0 (7.4)	16.4 (6.6)	17.3 (7.0)	1.1 (−1.0 to 3.1)	1.7 (−0.4 to 3.8)	−0.7 (−2.7 to 1.3)
12 months	13.9 (7.2)	15.7 (6.8)	15.2 (6.8)	1.1 (−1.0 to 3.2)	0.3 (−1.7 to 2.3)	0.8 (−1.2 to 2.9)
GPE (−5 to 5)						
Baseline	−2.8 (1.8)	−2.6 (2.2)	−2.6 (2.1)			
8 weeks	1.0 (2.8)	2.8 (1.8)	2.3 (2.2)	1.7 (0.9 to 2.4)	1.2 (0.4 to 2.0)	0.5 (−0.2 to 1.1)
6 months	1.4 (2.4)	1.9 (2.4)	1.7 (2.6)	0.5 (−0.3 to 1.3)	0.3 (−0.5 to 1.1)	0.2 (−0.6 to 1.0)
12 months	1.0 (2.8)	1.8 (2.5)	1.2 (2.9)	0.7 (−0.2 to 1.6)	0.1 (−0.8 to 1.0)	0.6 (−0.3 to 1.5)
Secondary outcome variables						
Pain (1–10)						
Baseline	6.5 (2.1)	6.3 (2.0)	6.2 (2.0)			
8 weeks	4.8 (2.4)	4.0 (2.5)	4.1 (2.6)	−0.8 (−1.6 to −0.1)	−0.6 (−1.4 to 0.1)	−0.2 (−1.0 to 0.6)
6 months	4.8 (2.6)	4.3 (2.6)	4.3 (2.6)	−0.5 (−1.3 to 0.4)	−0.5 (−1.4 to 0.3)	0.0 (−0.8 to 0.9)
12 months	5.2 (2.8)	4.9 (2.9)	4.9 (2.7)	−0.3 (−1.3 to 0.6)	−0.2 (−1.1 to 0.6)	−0.1 (−1.0 to 0.8)
RMDQ (1–24)						
Baseline	14.1 (5.5)	14.0 (5.3)	12.4 (5.7)			
8 weeks	9.7 (6.3)	7.9 (5.7)	7.9 (6.0)	−1.6 (−3.2 to 0.1)	−0.7 (−2.4 to 0.9)	−0.7 (−2.3 to 0.9)
6 months	10.1 (7.0)	8.4 (6.4)	7.7 (6.2)	−1.1 (−2.9 to 0.7)	−0.9 (−2.7 to 0.9)	−0.2 (−1.9 to 1.5)
12 months	9.6 (6.9)	8.8 (6.5)	9.2 (6.6)	−0.6 (−2.5 to 1.2)	1.2 (−0.6 to 3.0)	−1.8 (−3.6 to 0.0)

Cells containing primary end points are in grey.
Primary analyses in grey boxes. SMT, spinal manipulative therapy. RMDQ, Roland Morris Disability Questionnaire. GPE, Global Perceived Effect. PSFS, Patient-Specific Functional Scale.
[a] Positive values favor motor control exercise.
[b] Positive values favor SMT.

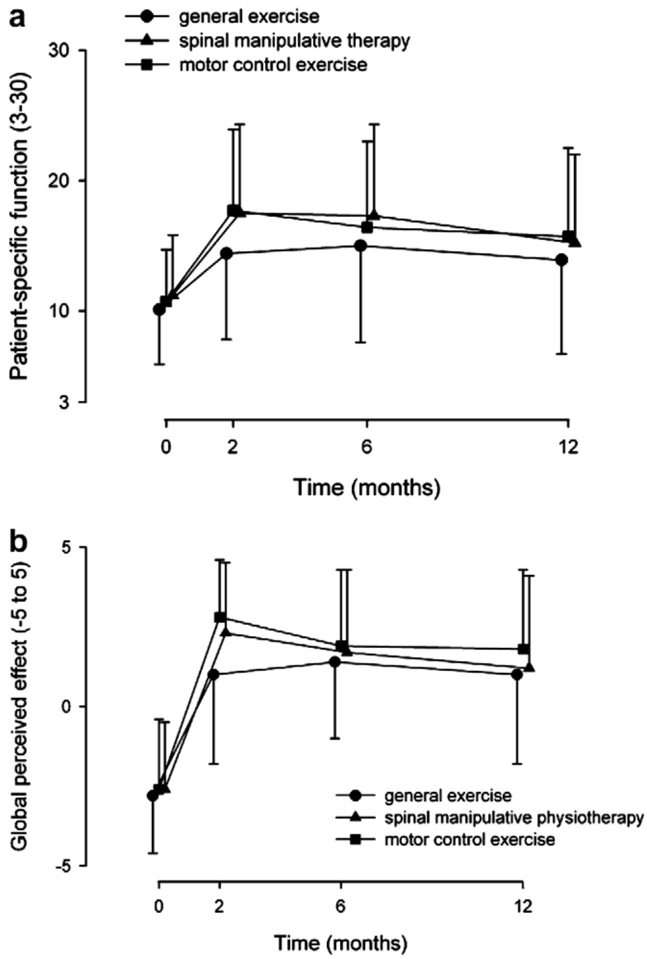

Fig. 2. Primary outcomes. (a) function. (b) Global perceived effect of therapy. Data are means and SDs. Only one side of the SD bars is shown. Higher scores represent better outcomes. The three plots in each panel have been slightly offset in a horizontal direction for clarity.

The participants in this trial were from a population that is considered hard to treat: typically they were moderately or severely disabled by back pain that had lasted for more than three years. Many were from disadvantaged socio-economic backgrounds and most were not working. All sought care for chronic low back through public hospitals. The findings of this trial can most confidently be applied to similar populations.

We showed there are small but significant short-term differences in the average outcomes of people receiving three common treatments for chronic low back pain. Better short-term outcomes were attained with motor control exercise and spinal manipulative therapy than with general exercise. The three groups had similar effects at 6 and 12 months. As the study compared the outcomes of three active treatments the data should not be used to make inferences about the effectiveness, compared to no intervention, of any of the treatments.

The findings can assist care providers, therapists and people with chronic back pain to make rational decisions about treatment. Care providers will need to take into account how the interventions were administered. The general exercise program was administered in groups, whereas motor control exercise was administered on a one-to-one basis. Administration of general exercise required a gym and some gym equipment (exercise bike, weights and exercise mats), whereas administration of motor control exercise involved feedback of muscle contraction with ultrasonography. (Some clinicians provide motor control exercise without feedback from ultrasound imaging (Richardson et al., 1999).) Some patients may prefer one-to-one treatment with motor control exercise or spinal manipulative therapy, whereas others may prefer whole-body general exercise. However general exercise is, on average, slightly less effective than motor control exercise and spinal manipulative therapy.

The trial took a pragmatic perspective. It involved the comparison of "packages" of interventions. Participants in the general exercise and motor control exercise groups received therapy that was administered within a cognitive behavioural therapy framework, and they were encouraged to exercise at home. These co-interventions were not included in the intervention package administered to the spinal manipulative therapy group. This is a natural packaging of interventions: exercise therapy almost always involves home exercise programs, and it would be philosophically inconsistent to provide a passive therapy such as spinal manipulative therapy while adopting the cognitive behavioural emphasis on self-management of symptoms. Nonetheless, we acknowledge that interventions will not always be packaged in the same way and that, in some clinics, home exercise programs may be thought of as part of a spinal manipulative therapy. In so far as it is possible to conceive of home exercise programs as part of spinal manipulative therapy, rather than an as additional therapy, our trial may have underestimated the effects of spinal manipulative therapy.

In this trial, ultrasonography was used to provide feedback of muscle contraction during motor control exercises. Ultrasonography has been recommended to assist training of motor control (Richardson et al., 1999) because it can be used to provide real-time non-invasive feedback of the activity of deep spinal muscles (Hodges et al., 2003). However there is inconsistent evidence that feedback with ultrasonography improves patients' ability to recruit stabilizing muscles within a single session, and there is no evidence that feedback with ultrasonography produces better recruitment in the longer term (Henry and Westervelt, 2005; Teyhen et al., 2005). No study has evaluated whether motor control exercise with ultrasonography produces better clinical outcomes than motor control exercise without ultrasonography, so it is not clear that clinicians should routinely provide ultrasound feedback when training motor control.

Differences in outcomes of the three treatments were apparent at eight weeks but not at 6 or 12 months. This could be because the treatments differ only in their short-term effects. Alternatively, because we did not control treatment after the first eight weeks, it could be that participants in the general exercise group subsequently sought effective co-interventions that equalized subsequent outcomes.

Many practitioners will be interested in whether particular subgroups of participants respond better to one intervention than to another. This is plausible in the current trial because the trial compared three interventions with very different presumed mechanisms. A recent study has provided some evidence that certain subgroups respond better to spinal manipulative therapy than others (Childs et al., 2004). However identification of subgroups is difficult, not least because identification of subgroups cannot yet be guided by a coherent theory of causation of back pain. We are currently conducting secondary analyses to investigate interactions between baseline characteristics of subjects and effects of interventions.

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