Seeing It Helps

Movement-related Back Pain is Reduced by Visualization of the Back During Movement

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Objectives: The aim of this study was to determine whether visualization of the back influenced parameters of movement-related pain in people with chronic nonspecific low back pain.

Methods: We used a randomized cross-over experiment in which 25 participants performed repeated lumbar spine movements under 2 conditions. In the visual feedback condition, patients were able to visualize their back as it moved by the use of mirrors. In the control condition, the mirror was covered so no visualization of the back was possible.

Results: The average postmovement pain intensity after participants had moved with visual feedback was less (35.5 ± 22.8 mm) than when they moved without visual feedback (44.7 ± 26.0 mm). This difference was statistically significant (mean difference = 9.3, 95% confidence interval: 2.8-15.7 $F_{(1,22)} = 8.82$, $P = 0.007$). The average time to ease after participants had moved with visual feedback was shorter (44.5 s ± 53.8) than when they moved without visual feedback (94.4 s ± 80.7). This difference was also statistically significantly (mean difference = 49.9, 95% confidence interval: 19.3-80.6, $F_{(1,22)} = 8.82$, $P = 0.003$).

Discussion: Patients with chronic nonspecific low back pain reported less increase in pain and faster resolution of pain when moving in an environment that enabled them to visualize their back. This is consistent with emerging research on the use of mirror visual feedback in other long-standing pain problems and suggests that similar lines of inquiry may be worth pursuing in the chronic nonspecific low back pain population.

Key Words: low back pain, visual feedback, cortical reorganization, physical therapy

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Low back pain (LBP) is a common health problem[1] and a major reason for accessing primary healthcare.[2] The majority of LBP patients presenting to primary care are diagnosed as having nonspecific LBP,[3] indicating an absence of identifiable peripheral pathology.[4] Numerous models have been proposed to explain the mechanisms of symptom production in the nonspecific population.[5–9] These and similar approaches largely focus on aberrant spinal mechanics and suggest that symptoms are primarily a response to abnormal loading of the tissues of the back. Other possibilities have been suggested, particularly in those with chronic conditions. Recent publications have speculated that maladaptive changes within the central nervous system may be one mechanism by which symptoms are produced and maintained in chronic nonspecific LBP.[10–12]

That the central nervous system changes when pain persists has been known for some time.[13] Recently, attention has turned toward maladaptive changes in the functional organization of the brain in people with chronic painful conditions, particularly complex regional pain syndrome (CRPS)[14,15] and phantom limb pain.[16] As a result, new treatment approaches that aim to explicitly target these maladaptive changes have been developed. One approach involves the use of mirrors as a therapeutic device. Termed mirror visual feedback (MVF) therapy, patients undertake exercises while viewing a reflection of the unaffected limb. Favorable outcomes have been reported when this technique is used on patients with phantom limb pain[17] and CRPS[18,19]; however, we are unaware of any similar evidence for patients with chronic LBP. Furthermore, unlike mirror therapy for peripheral pain syndromes, using mirror feedback for spinal movements does not seek to normalize perception through an illusion. Rather, mirror feedback offers a genuine view of the affected body part. We were interested in whether MVF performed in this way has an effect on pain.

The aim of this study was to determine whether visualization of the back modulates movement-related pain in people with chronic nonspecific LBP. We hypothesized that pain would increase less, and settle more quickly, when movements were performed with visual feedback than when movements were performed without visual feedback.

MATERIALS AND METHODS

Design

This randomized controlled cross-over experiment was approved by the Human Research Committees' of the

University of Notre Dame Australia and The Sir Charles Gairdner Hospital, Perth, Western Australia. Participants provided informed consent and all procedures conformed to the Declaration of Helsinki.

Participants

A convenience sample of 25 chronic nonspecific LBP patients was recruited from the Department of Pain Management at The Sir Charles Gairdner Hospital, and from community physiotherapy practices. This sample size provides 95% power for a 2 treatment cross-over study to detect a treatment effect of 15 mm on a 100-mm pain intensity visual analog scale (VAS)[20] using $\alpha = 0.05$, with an estimated standard deviation of 20 mm and a within-subject correlation of outcome scores of 0.4 or greater.[21] Participants were eligible if they were aged between 18 and 60 years; were proficient in written and spoken English; reported back pain as their main symptom; had experienced nonspecific LBP for a minimum of 6 months; rated their back pain as at least moderate on a modified version of item 7 of the Short-Form 36[22]; and were able to provide informed consent. Patients were excluded if they presented with nerve root pain (as determined by the referring clinician's assessment) or evidence of specific spinal pathology (such as malignancy, infection, fracture, inflammatory disease); were pregnant or less than 6 months postpartum; had undergone any lumbar surgery or invasive procedure within the previous 12 months; were involved in litigation in relation to their back pain; were judged by their treating clinician to be unsuitable for performance of a repeated movement assessment; had significant medical or psychological illness; or had significant visual impairment. All participants were screened for eligibility by their referring clinician.

Patient Profile

Eligible patients were first seen by a research assistant who clarified inclusion and exclusion criteria, obtained informed consent, collected basic demographic data, and assigned each patient a research number. Participants then completed a questionnaire that solicited information about the length of the current episode, pain distribution, work status, and current pain medications. In addition, patients completed a set of standardized questionnaires that assessed disability, pain, and psychological functioning. LBP-related disability was measured using the Roland Morris Disability Questionnaire.[23] Back pain intensity was measured using a VAS for average pain over the last week, anchored with 0 = "no pain" and 100 = "pain as bad as you can imagine." Kinesophobia was estimated using the Tampa Scale of Kinesiophobia. The level of pain-related catastrophization was measured using the Pain Catastrophizing Scale.[24] Depression and anxiety were assessed with The Hospital Anxiety and Depression Scale (HADS).[25]

Outcome Measures

The primary outcomes were the intensity of back pain after movement ("Pain") and the time for movement provoked pain to ease ("Time to Ease"). To assess back pain intensity, a VAS for present back pain was completed immediately on conclusion of each set of repeated movements. The VAS was anchored with 0 = "no pain" and 100 = "pain as bad as you can imagine." Participants were asked to "rate their back pain by placing a vertical line at the point that best corresponds to their pain right now." Participant responses were converted to a number by measuring the distance from their mark to the left anchor. To assess Time to Ease, patients were positioned comfortably in supported crook lying on an examination table directly after completing the postmovement VAS and asked to indicate when the pain had returned to baseline level. The time in seconds for pain to ease was measured using a stopwatch by a research assistant who was not blind to condition. If the participants' pain had not eased to baseline levels by 5 minutes, Time to Ease was recorded as 300 seconds.

Procedure

A random number sequence was computer generated by an individual not involved with the study. Each number was placed in consecutively numbered, sealed, opaque envelopes. After completion of the baseline assessment questionnaires, the research assistant opened the envelope that corresponded to the participant's research number and participants were randomized by odd/even allocation into either movement with visual feedback or movement without visual feedback. After the first condition, participants rested for 5 minutes before undertaking the alternate condition. Participants were blinded to the study hypotheses.

Participants first removed their shirt and lay prone on an examination table. To augment visual feedback, the position of each lumbar spinous process, the iliac crests and the 12th ribs were marked with a washable pen. They then stood in a 50×50 cm square marked on the floor and were asked to move as far as they comfortably could while performing lumbar forward flexion, extension, left and right side flexion, and left and right side glide[5] without bending their knees. The distance down the leg that the fingertips reached for flexion, extension, and side flexion was marked with a washable pen. An external marker on the floor denoted how far the patient's pelvis moved to the left and to the right during the side glide movement. Two large mobile mirrors were then placed in front and behind the participant. The mirrors were positioned so that the patient had a clear view of the reflection of their back in the mirror in front of them. This mirror was then covered with a sheet and the patient was asked to record their current level of LBP on a VAS.

In the visual feedback condition, the sheet was removed and participants were instructed to perform 10 repetitions each of forward flexion, extension, right and left side flexion. and right and left side glide while attending to the reflection of their back in the mirror. Participants were informed that they may cease performance of the repeated movements at any time and may withdraw from the study at any time. The research assistant counted out the number of repetitions, and the timing of the movement was kept constant by use of a metronome. The research assistant also placed their hand at the endpoint of range that had been marked previously and participants were instructed to touch their fingertips or pelvis (for side glide) to the research assistant's hand, this ensured that they moved to the same point in range throughout the experiment while still maintaining attention on the reflection of their back. Immediately after the repeated movements, patients again recorded their level of current back pain on a VAS. Participants were then positioned in supported crook lying on an examination table for 5 minutes. In the no visual feedback condition, the protocol, including all instructions, was identical except that the sheet was kept over the mirror throughout the procedure and participants were instructed to look at the sheet over the mirror, this was to ensure a standardized body position between the 2 conditions.

Data Analysis

Descriptive statistics were used to present demographic information and to describe clinical status. A repeated measures analysis of variance model was used to estimate condition, period, and condition by period interaction effects for the 2 primary outcome measures. Statistical significance for carryover (treatment by period interaction) was set at $P<0.1$. Plots of residuals versus fitted values were examined to check the assumptions of normal distribution of within and between-subject residuals. Significance was set at $P<0.025$ for estimation of treatment effect to adjust for the use of 2 primary outcome measures. In the case of the outcome variable Time to Ease, the nonparametric Wilcoxin matched-pairs test was also performed as the distribution of times was positively skewed. All analyses were undertaken using Stata/IC 10.1 for Windows (Statacorp LP, College Station, TX).

RESULTS

Group Characteristics

The mean age of participants was 41.8 years (± 14.7; range, 19 to 60 y) and were reasonably evenly split between male (n = 14) and female (n = 11). The majority of participants were working (n = 20), 4 participants were off work due to their LBP and 1 patient off work for other reasons. Ten of the participants reported LBP only while 15 participants had both back and leg pain and the average duration of LBP was 9.9 years (± 9.5). Mean back pain intensity was 46.8/100 (± 20.6), disability 10.4/24 (± 6.0), kinesiophobia 40.4/68 (± 6.4), pain-related catastrophization 18.8/52 (± 12.3), HADS depression score 4.9/21 (± 3.2), and HADS anxiety score 7.1/21 (± 4.6). Ten participants reported that they were using opioid medications for their LBP. Two participants withdrew after the completion of the first condition, 1 participant from the visual feedback condition and 1 participant from the no vision condition.

Effect of Visualization of the Back During Back Movements on Pain Intensity

There was no evidence for period ($F_{(1,21)}=0.04$, $P=0.848$) or period by treatment interaction ($F_{(1,21)}=0.27$, $P=0.611$) and therefore treatment effects were estimated unadjusted for period effects. The average postmovement pain intensity after participants had moved with visual feedback was less (35.5 ± 22.8 mm) than when they moved without visual feedback (44.7 ± 26.0 mm). This difference was statistically significant (MD = 9.3, 95% confidence interval: 2.8-15.7 $F_{(1,22)}=8.82$, $P=0.007$).

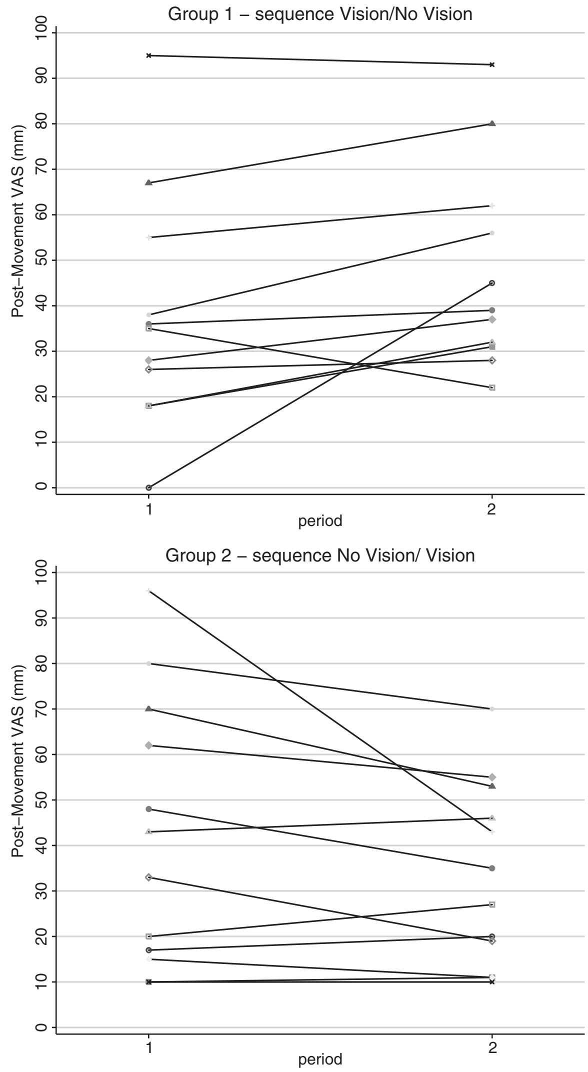

FIGURE 1. Individual measures of postmovement pain intensity visual analog scale (VAS; mm) by treatment sequence and period.

These data are summarized in Table 1 and individual measures are displayed in Figure 1.

Effect of Visualization of the Back During Back Movements on Time to Ease

There was no evidence for period ($F_{(1,21)}=1.72$, $P=0.204$) or period by treatment interaction ($F_{(1,21)}=1.88$, $P=0.185$), so condition effects were estimated

TABLE 1. Results of Analysis Comparing the 2 Conditions

	With Visual Feedback, Mean (SD)	Without Visual Feedback, Mean (SD)	Mean Difference (SD)	95% CI for Mean Difference	*P*
Postmovement pain intensity	35.5 (22.8)	44.7 (26.0)	9.3 (15.0)	2.8-15.7	0.007
Time to ease (s)	44.5 (53.8)	94.4 (80.6)	49.9 (70.9)	19.3-80.6	0.003

CI indicates confidence interval.

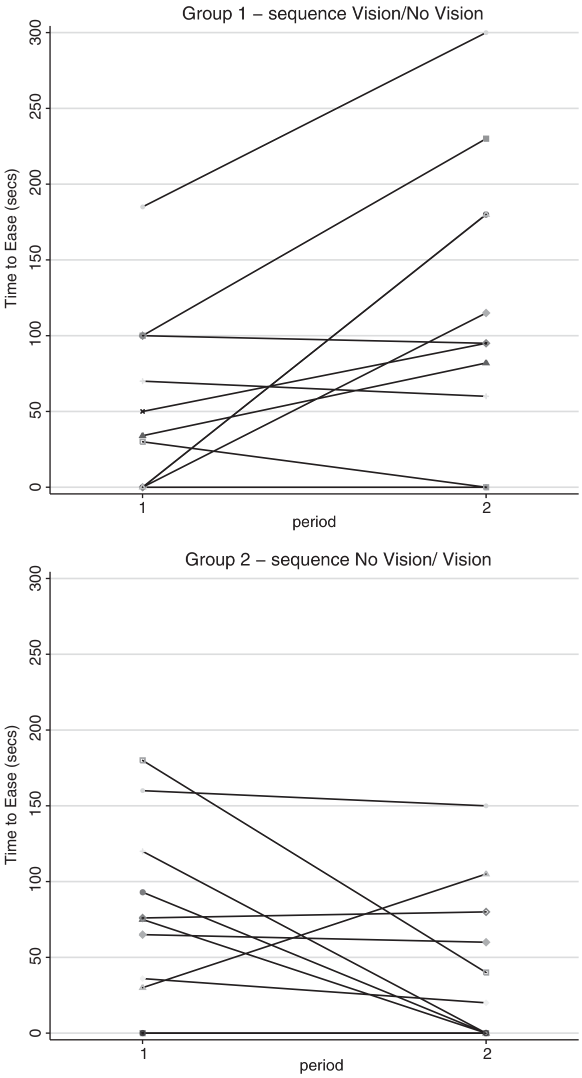

FIGURE 2. Individual measures of Time to Ease (s) by treatment sequence and period.

unadjusted for period effects. The average time to ease after participants had moved with visual feedback was shorter (44.5 s ± 53.8) than when they moved without visual feedback (94.4 s ± 80.7). This difference was also statistically significant (MD = 49.9, 95% confidence interval: 19.3-80.6, $F_{(1,22)} = 8.82$, $P = 0.003$). The Wilcoxin matched-pairs test for the difference returned a similar estimate of statistical significance ($P = 0.008$). These data are summarized in Table 1 and individual measures are displayed in Figure 2.

DISCUSSION

The aim of this study was to determine whether visualization of the back-modulated movement-related pain in people with chronic nonspecific LBP. We used a randomized cross-over experiment in which participants performed repeated lumbar spine movements under 2 conditions. In the visual feedback condition, patients were able to visualize their back as it moved by the use of mirrors. In the control condition, the mirror was covered so no visualization of the back was possible. We hypothesized that pain would increase less, and settle more quickly, when movements were performed with visual feedback than when movements were performed without visual feedback. Consistent with our hypotheses, patients reported significantly less increase in pain and recovered significantly faster when they were able to visualize their back during the performance of repeated spinal movements. We controlled for an order effect by randomizing the sequence of testing. Methodologic checks suggest that this was successful. In addition, premovement pain scores for the 2 conditions were nearly identical, which suggests that there was no carry over effect.

Several investigators have reported attenuation of pain with the use of MVF. Numerous case studies describe improvement in pain when visual feedback is used for conditions such as phantom limb pain,[26–31] CRPS[32–34] brachial plexus avulsion,[28,30] and fibromyalgia.[35] More robust designs largely support these promising findings. McCabe et al[36] noted reduction of pain on movement using MVF in a small sample of acute CRPS patients, whereas pain did not decrease during the control conditions of normal visualization or while viewing a nonreflective surface; however, they found no effect for those with chronic pain. Two recent high-quality randomized controlled trials have investigated the use of intensive MVF in stroke patients with CRPS. Cacchio et al[18] randomized patients to a 4 week program of either MVF, mental imagery, or exercise with the mirror covered. The MVF group demonstrated large and significant decreases in pain in comparison with the other 2 groups. In a larger study by the same group, a 4-week program of conventional stroke rehabilitation and MVF was compared with conventional rehabilitation and placebo MVF.[19] Significant and clinically important reductions in pain were noted in favor of the MVF group at the end of treatment and at 6-month follow-up. Similar findings were observed by Chan et al[17] in a group of participants with phantom limb pain. Patients with phantom pain after amputation of a leg or foot were randomized to receive 4 weeks of either MVF, mental visualization, or a sham mirror condition. Patients receiving MVF improved significantly more than the other 2 groups. In contrast, Brodie et al[37] found no difference in pain relief between MVF and a covered mirror condition after a single session of exercise in a small sample of patients with phantom limb pain. This discrepancy might be explained by the small sample size, the low intensity of the intervention or possibly that the participants in this study were not specifically recruited for the management of their pain.

A number of physiological responses to viewing oneself in a mirror have been reported, such as changes in the perceived location of the body part, increases in excitability of motor pathways and modification of sensory experiences[38]; however, the exact mechanisms by which MVF relieves pain are uncertain.[38] A commonly offered explanation is that MVF works by restoring congruence between motor output and sensory input. It has been proposed that movement-related pain may arise if there is discordance between motor intent and sensory feedback associated with movement.[39] When a motor command is created, the central nervous system makes predictions of the sensory consequences of the movement and monitors the congruence between predicted and actual sensory feedback.[40] If incongruence is detected, it is hypothesized that pain may arise to warn of an error in information processing.[41] The visual feedback afforded by the mirror may improve sensory acuity of the affected area and help reestablish congruence between sensory feedback and motor intention.[40,42] This proposal is supported by data that suggest that a wide range of sensory disturbances, including pain and discomfort, can be provoked when mirrors are used to artificially induce a state of conflict between motor intent and visual feedback.[43–45]

Disruption of the cortical somatosensory representation of the painful body part and distortion of body perception are considered possible mechanisms underpinning the production of sensorimotor incongruence in clinical populations[39,41,46] and these processes might be occurring in people with chronic nonspecific LBP. There is evidence that patients with chronic nonspecific LBP exhibit significant alterations in the brain structure and function,[47] including degeneration[48] and reorganization[49–51] in cortical areas that are thought to subserve the perception of the back. Furthermore, chronic LBP patients display characteristics that are consistent with a disturbance in lumbar spine perception such as decreased lumbar tactile acuity,[52,53] impaired graphaesthesia performance over the back,[53] deficits in lumbar proprioception,[54–58] slowness of lumbar spine movement,[59,60] disruption of the working body schema specific to the back,[61] and difficulty in delineating the outline and size of the back.[62] This range of deficits is consistent with the recent proposal of a cortical body matrix.[63] In that proposal the cortical body matrix integrates the representation and perception of the body and peripersonal space, homeostatic regulation, and sensorymotor control. There is a growing body of literature to suggest that this cortical body matrix becomes disrupted in various clinical states, including chronic pain disorders. That autonomic and motor disruption can be induced by experimentally disrupting the cortical body matrix[64,65] lends support to the idea that distortion in the way the back is represented centrally, and in how the back feels to the individual, could potentially disrupt the relationship between actual and intended back movement.

There is experimental support that some of the perceptual impairments present in patients with chronic LBP are improved by visualizing the area. Both tactile[66] and proprioceptive[67] acuity are enhanced with visual feedback, and it seems plausible that other perceptual impairments including difficulty in delineating the outline of the low back and the perception of the back as having shrunk[62] could be rectified by visualization of the lumbar spine. The visual feedback afforded by the mirror may improve sensory acuity and perception of the back and help reestablish congruence between sensory feedback and motor intention and maybe normalize the relationship between actual and intended movement.

Alternative mechanisms have been proposed. Viewing an image of the painful area that looks normal may cause the individual to reject nociceptive signals as spurious as there is nothing to attribute the nociception to[68] and the perception of a normally moving body part potentially decreases anxiety and fear of movement and the threat value associated with use of the painful area.[42] Relevant to this idea is an interpretation offered by Longo et al,[69] after they noted a significant reduction in laser-evoked hand pain when patients viewed a reflection of the hand. Although they suggest that the analgesic effect of seeing the reflected hand probably relates to integration of multisensory inputs, they also suggest an alternative interpretation—that the effect may be mediated by an increased sense of bodily ownership and control. That these 2 interpretations concern mechanisms on the one hand, and mediating variables on the other, suggests that they are not simply alternatives, that is, perhaps both interpretations are correct. It is important to note that the Longo et al[69] study did not involve movement, which makes normalization of sensorimotor incongruence an unlikely explanation. Furthermore, Moseley et al[70] demonstrated that patients with CRPS experience more pain with movement while viewing their hand through magnifying lenses, which reinforced their incorrect perception that the hand was enlarged.[71] In contrast, pain was less if the hand was viewed through minifying lenses, which conceivably corrected the perception that the hand was enlarged. This mechanism has been suggested for clinical conditions in which the mirror image provides a visual substitute for a missing limb (phantom limb pain) or for a limb that looks abnormal (CRPS). However, this perspective might still be applicable to chronic nonspecific LBP in which the visual appearance of the back is generally unremarkable. As the back is rarely visualized, there is limited opportunity to appraise the visual state of the back, access to the reflection of the back which looks largely normal could allay maladaptive beliefs about structural problems with the lumbar spine and help decrease the threat associated with movement of the low back.

It may be that the 2 mechanisms described above work in tandem in the clinical population. Normalization of how the back feels to the individual and the greater sensory acuity provided by MVF may improve motor control and promote congruence between intended and actual movement. Normalization of how the back looks and the absence of any visually identifiable reason for pain possibly decreases fear and concern about the back and the threat value associated with movement. The analgesic effect may be mediated by simultaneous improvements in both body perception and cognitive perception. Furthermore, as the back is rarely visualized these effects are likely to be particularly strong in LBP, as it is only through the use of MVF that visual information is available to normalize perception.

It is also possible that distraction mediates some of the analgesic effects of MVF.[42] Distraction seems to have a significant analgesic effect for procedural pain[72] and in experimental pain paradigms.[73] In our study, the MVF condition was probably more distracting than the control condition. However, there is evidence suggesting that distraction may not be effective in the chronic nonspecific LBP population.[74,75] It is important to note that although Goubert et al[75] reported no analgesic effect of distraction on a repetitive lifting task in chronic LBP patients, the distraction condition was associated with a significantly larger increase in pain intensity immediately after the lifting task than during the nondistraction control condition, a pattern not observed in this present study.

Finally, interpretation of the current results should consider some methodologic issues. Participants were not blinded to condition and we did not assess to see whether any participants were familiar with the concept MVF for the management of pain. The greater novelty of the MVF condition or greater expectation of benefit from this condition may have introduced some bias, although we attempted to control for this by blinding participants to the hypotheses of the study. In addition, the researcher recording the time to ease was not blinded to condition—the rigor of this study would have been improved by the use of an independent assessor for this outcome measure. Although considerable effort was made to standardize the range, speed, and number of movements that were performed, attending to the reflection in the mirror may have induced different movement characteristics between the 2 conditions. We minimized the impact of this potential problem by asking the patient to attend to the mirror in both conditions, but we cannot exclude the possibility that there were subtle biomechanical differences between the 2 conditions.

In conclusion, patients reported significantly less increase in pain and recovered significantly faster when they were able to visualize their back during the performance of repeated spinal movements, than when they were not able to visualize their back. This is consistent with emerging research on the use of MVF in other chronic pain problems. Recent high-quality trials have reported large and sustained improvements in chronic pain patients' clinical status with intensive MVF training programs. The current results suggest that similar lines of inquiry may be worth pursuing in the chronic nonspecific LBP population.

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