



Virtual McKenzie extension exercises for low back and leg pain: a prospective pilot exploratory case series

Adriaan Louw^a, Kevin Farrell^b, Anthony Nielsen^c, Max O'Malley^d, Terry Cox^e and Emilio J. Puentedura^f

^aDepartment of Physical Therapy, Evidence in Motion, Story City, IA, USA; ^bDepartment of Physical Therapy Education, Residency Program, St. Ambrose University, Health Sciences Center, Davenport, IA, USA; ^cDepartment of Physical Therapy, Rock Valley Physical Therapy, Bettendorf, IA, USA; ^dDepartment of Physical Therapy, AMN Healthcare, Lincolnwood, IL, USA; ^eDepartment of Physical Therapy, Southwest Baptist University, Bolivar, MO, USA; ^fDoctor of Physical Therapy Program, Baylor University, Robbins College of Health and Human Sciences, Waco, TX, USA

ABSTRACT

Introduction: Current evidence supports the inclusion of directional preference exercises for a subgroup of patients with low back (LBP) and leg pain. Recent pain neuroscience strategies have suggested that cortical restructuring associated with movement activating the body map representation in the brain might account for the observed improvement with the directional preference approach.

Objectives: To explore whether or not a motor imagery directional preference approach would result in any changes in patients with LBP and leg pain.

Methods: A consecutive convenience sample of patients with LBP and leg pain were recruited at two outpatient physical therapy clinics. Measurements of LBP, leg pain, fear-avoidance beliefs (FABQ), pain catastrophizing (PCS), active lumbar flexion, and straight leg raise (SLR) were compared before and immediately after a virtual (motor imagery) directional preference exercise.

Results: Statistically significant differences for LBP, FABQ, PCS, active lumbar flexion, and SLR were observed, but only SLR changes met or exceeded the minimally clinically important difference (MCID).

Conclusions: A brief virtual motor imagery extension treatment yielded some immediate positive shifts in patients presenting to physical therapy with LBP and leg pain. Our results indicate that randomized comparison trials are needed to determine the effect of this intervention on the short- and longer-term outcomes in patients with LBP and leg pain.

KEYWORDS

Graded motor imagery; directional preference; low back pain; case series

Introduction

Low back pain (LBP) is the most common musculoskeletal condition treated in physical therapy, accounting for an estimated 25–40% of outpatient physical therapy visits [1,2]. One strategy commonly used by physical therapists for treating LBP with referral into the leg is directional preference [3–5]. Directional preference is the process of examining the response of a patient with LBP and associated leg pain to a repeated movement direction, i.e. extension or flexion, and if it coincides with improvement, the test becomes part of the treatment [3,6–8]. Current evidence supports the inclusion of directional preference in the treatment of LBP in physical therapy [2,9–12]. Specifically for LBP with leg pain, directional preference usually involves either an extension-bias or flexion-bias, with various studies indicating an extension protocol being the most common (estimated >80% of patients) [3,6,13]. With extension exercises, a favorable therapeutic effect results in centralization of symptoms (leg pain migrates proximally), improved range of motion, decreased pain, and decreased fear of movement [2,3,6,9–13].

In recent years, there has been an increased interest in various pain neuroscience strategies to help people in pain, including LBP [14,15]. It is well established that the physical body of a person is represented in the brain by a network of neurons, often referred to as a representation of that particular body part in the brain or body schema [16–20]. This representation refers to the pattern of activity that is evoked when a particular body part is stimulated. The most famous area of the brain associated with representation is the primary somatosensory cortex (S1) [16–19]. These neuronal representations of body parts are dynamically maintained [21–26], and it has been shown that patients with pain, including chronic LBP, display different S1 representations than people with no pain [21–26]. An interesting phenomenon associated with cortical restructuring is the fact that the body maps expand or contract, in essence increasing or decreasing the body map representation in the brain. Furthermore, these changes in shape and size of body maps seem to correlate to increased pain and disability [21,27]. Various studies have shown that physical

movement is associated with restoring the cortical maps, which in turn may be associated with a decreased pain experience [6,16,21].

In patients with high levels of pain, sensitization of the nervous system, and fear of movement, physical movement itself may increase a pain experience [28,29]. An alternative approach to help restore these cortical maps is motor imagery or visualization of movement [30,31]. Various studies have shown that motor imagery activates the same areas of the brain as when actually physically moving, thus restoring the altered maps 'without moving' [31,32]. This approach may have some value in patients with increased fear-avoidance, especially for those with a high fear of physical activity – including movement-based treatments such as directional preference. To this point, recent directional preference research has expanded into exploring directional treatment in the face of psychosocial variables such as fear-avoidance and pain catastrophization [8]. In lieu of the emerging motor imagery research, the question arises whether the physical movement of directional preference is needed, or if visualized, motor imagery of direction preference could have some clinical value in patients presenting with LBP and leg pain, especially chronic LBP with higher levels of fear-avoidance. The aim of this case series was to explore if a motor imagery directional preference approach would yield any positive changes in patients presenting with LBP and leg pain. This was planned as a prospective pilot exploratory case series to examine effect sizes to help determine sample size for future randomized controlled trials (RCTs).

Methods

Patients

Two outpatient physical therapy clinics agreed to participate in the study by collecting data and measurements. Institutional review board approval was obtained from Southwest Baptist University, and the case series was registered with clinicaltrials.gov (NCT04394494). A consecutive convenience sample of patients attending outpatient physical therapy with LBP and leg pain, meeting the inclusion criteria and none of the exclusion criteria were asked to participate in the study. Patients were eligible if they: a) presented to physical therapy with LBP that also referred pain into either lower extremity; b) were aged 18–65; c) able to read and understand the English language; d) presented with no red flags for attending physical therapy during review of systems and evaluation; e) no prior spinal surgery; and f) demonstrated a positive response to directional preference for extension during the evaluation. A positive response to directional preference for

extension was defined as a decrease in presenting symptoms and/or proximal migration of leg symptoms. We chose to limit participation to patients that demonstrated a positive response to directional preference for extension during the evaluation because we needed to determine the effect, if any, of *imagined* extension exercises as opposed to *actual* extension movements.

Participation was entirely voluntary and eligible patients agreeing to participate signed a written informed consent. Upon consent, patients completed a demographics questionnaire, which included items regarding their age, gender, duration, and location of their LBP and leg pain.

Intervention

Patients underwent a standard interview process and review of systems by the first physical therapist [33]. Patients with LBP and leg pain were tested, as part of their physical examination to determine if they responded favorably to extension-based movement as used by the McKenzie approach [3,4]. Eligible patients were instructed how cortical map alterations play a role in LBP, based on a previous study using such a neuroscience educational model [34]. This education was no longer than 5 minutes and was not a lengthy pain neuroscience education session. Following education, a series of measures were taken prior to the intervention to determine a baseline. These measurements were taken by a second physical therapist who was to remain blinded to the treatment intervention. Following measurements, the first physical therapist who was to remain blinded to the measurements placed the patients in a prone position, with their hands under their shoulders in a 'pre-press-up' position. However, instead of doing an active press-up, patients were asked to close their eyes and coached via visual imagery through a typical extension experience (Table 1). Each *virtual* extension was repeated ten times, for an estimated 5-minute total *virtual* extension treatment protocol.

Table 1. Extension protocol.

- Close your eyes and take a deep breath.
- Focus on your back and leg pain at the moment so you can be aware of it and feel it.
- Now imagine yourself straightening your arms slowly as you do a press-up.
- Feel yourself pushing up more and more ultimately toward fully locking your arms.
- As you push up, feel your back arching backward – sore, but safe.
- As your arms lock completely, you're arched as far back as you can; feel your back compressing and breathe out and hold 1, 2 and 3 seconds.
- Now, after compressing the back, slowly feel yourself coming back down; bending your arms and coming down to your starting position.
- Deep breath. One done; nine to go ... (Repeat coaching through all ten extensions)

Immediately following the experimental intervention, post-measures were completed by the second physical therapist who had been blinded to the treatment intervention. Upon completion of post-intervention measures, the formal study was completed, and the treating physical therapists would then continue their individual plan of care for each patient.

Measurements

To determine a baseline disability score, each patient completed an Oswestry Disability Index (ODI). The ODI is a 10-item questionnaire used to assess different aspects of physical function. Each item is scored from 0 to 5, with higher values representing greater disability. The total score is multiplied by 2 and expressed as a percentage. The ODI has been shown to be a valid and reliable measure of disability related to LBP [35–37].

Prior to and immediately following the experimental intervention, a series of self-reported measures and physical tests were performed:

- Self-reported pain (Low back and leg) (Numeric Pain Rating Scale – NPRS): Low back and leg pain were measured with the NPRS, as has been used in various studies [38–41]. The minimal clinically important difference (MCID) for the NPRS for acute/subacute LBP is reported to be 2.0 [42] and for chronic pain 1.7 [43].
- Fear avoidance beliefs (Fear Avoidance Beliefs Questionnaire – FABQ): The FABQ is a 16-item questionnaire that was designed to quantify fear and avoidance beliefs in individuals with LBP. The FABQ has two subscales: 1) a 4-item scale to measure fear avoidance beliefs about physical activity (PA) and 2) a 7-item scale to measure fear-avoidance beliefs about work (W). Each item is scored from 0 to 6 with possible scores ranging between 0 and 24 and 0 and 42 for the physical activity and work subscales, respectively. Higher scores represent an increase in fear-avoidance beliefs. The FABQ has demonstrated acceptable levels of reliability and validity in previous studies [44–46]. The presence of avoidance behavior is associated with an increased risk of prolonged disability and work loss. It is proposed that FABQ-PA >14 and FABQ-W scores >34 and are associated with a higher likelihood of not returning to work [47,48]. The MCID for the FABQ has been reported as 13.0 [49].
- Pain catastrophizing: Pain catastrophizing was measured using the pain catastrophizing scale (PCS). The PCS is a self-report questionnaire that assesses inappropriate coping strategies and catastrophic thinking about pain and injury. The PCS has been used in previous studies [50,51] and

demonstrated strong construct validity, reliability, and stability [52]. The PCS utilizes a 13-item, 5-point Likert scale with higher scores indicating elevated levels of catastrophization. Previous studies utilizing the PCS have shown a median score of 18 in healthy individuals and a score over 30 reported as a high level of pain catastrophizing [52]. In patients with musculoskeletal pain, the minimal detectable change (MDC) for the PCS is reported to be 9.1 [53], but the MCID has not been established.

The physical tests were performed by a single physical therapist educator with more than 30 years of clinical experience. Active lumbar flexion range of motion and passive straight leg raise have been found to have high intra-rater reliability with intraclass correlation coefficients (ICCs) reported to be between 0.81 and 0.97 [54–56]

- Active lumbar flexion: Active trunk forward flexion, measured from the longest finger on the dominant hand to the floor in centimeters (cm) [57–59]. The MDC for active trunk forward flexion has been reported to be 4.5 cm [60].
- Straight Leg Raise (SLR): SLR was used as a neurodynamic measurement rather than a test of hamstring length. SLR was measured with an inclinometer placed on the tibial crest 5 cm distal to the inferior border of the patella on the most affected leg [57–59]. SLR for this study kept the ankle in neutral (90 degrees) with no added dorsiflexion or plantar flexion, per previous studies [57–59]. MDC for SLR has been reported as a 5.7 degree difference [60].

Data analysis

Frequency counts for demographic data were examined for normality of distribution and the means of pre- and post-intervention measures were compared within the group using the paired-samples Student's t-test. Statistically significant findings were further evaluated by repeating the analysis using the more conservative non-parametric Wilcoxon Signed rank tests. Data analysis was performed using PASW Statistics 21 (© 2012, SPSS Inc., IBM, Chicago, IL, 60606).

Results

Ten patients met the inclusion criteria for the case series (Table 2).

Self-reported pain

Immediately after the virtual directional preference exercises, there was a statistically significant difference for mean LBP, which decreased from 4.5 to 3.6

Table 2. Demographics.

Characteristics	Patients (n = 10)
Mean age (years) (Standard deviation – SD)	41.5 (15.3)
Female (%)	4 (40%)
Race:	10 (100%)
- White/Caucasian (%)	
Mean duration of pain in days (range) (SD)	72.3 (67.2)
Mean disability (Oswestry Disability Index) (SD)	11.4 (7.1)
Mean LBP (NPRS) (SD)	4.5 (1.7)
Mean leg pain (NPRS) (SD)	3.7 (1.8)
Mean FABQ-PA (SD)	11.7 (5.6)
Mean FABQ-W (SD)	15.6 (9.3)
Mean PCS (SD)	21 (7.3)

(p = 0.029) (Table 3). Overall, LBP failed to improve beyond MCID for chronic LBP, but three patients met/exceeded the MCID for LBP improvements. There was no statistically significant difference for mean leg pain, from 3.7 to 2.8 (p = 0.067). Mean leg pain differences for the case series failed to meet MCID for leg pain, but six individual patients met or exceeded MCID for leg pain improvement.

Psychosocial

Immediately after the virtual directional preference treatment, there was a statistically significant improvement in all psychosocial measures – FABQ-PA

Table 3. Before and immediately after intervention measures.

Measurement	Before motor imagery	After motor imagery	Difference
LBP	4.5	3.6	p = 0.029*
Leg Pain	3.7	2.8	p = 0.067
FABQ-PA	11.7	9.8	p = 0.06
FABQ-W	15.6	13.5	p = 0.003*
PCS	21	19.2	p = 0.001*
Active trunk flexion (cm)	38.45	36.2	p < 0.001*
SLR (degrees)	59	66.5**	p < 0.001*

*Significant improvement
**Exceed MCID

(p = 0.06), FABQ-W (p = 0.003), and PCS (p = 0.0014). However, none of these measures met or exceeded MCID.

Physical movements

Immediately after the virtual directional preference, there was a statistically significant improvement in active spinal flexion of 2.25 cm (p < 0.001), but it did not meet or exceed MCID for active trunk flexion. Immediately after the virtual extension exercises, there was a statistically significant improvement in mean SLR of 7.5 degrees (p < 0.001), which did exceed the MCID (Figure 1).

Discussion

To date, this is the first study to explore any potential benefit of a *virtual*, motor imagery directional preference treatment approach. Immediately after a *virtual*, motor imagery extension protocol, patients with LBP and leg pain experienced positive changes in LBP, fear-avoidance, pain catastrophizing, active trunk flexion, and SLR, with only SLR meeting/exceeding MCID.

Various motor imagery studies have shown positive changes in pain ratings and movement [31,61,62]. The result of this study concurs with those findings, albeit aimed at a specific commonly proposed treatment approach of directional preference. Even though most post-intervention measures improved, only SLR exceeded MCID. This result of significantly increased SLR concurs with previous studies aiming to restore cortical body maps [34,63]. Even though this study did not measure the sensitivity of the nervous system via pressure pain thresholds (PPT), previous studies have shown a correlation between improved SLR and increased PPT in techniques aimed at body maps in the brain [63–65]. It is proposed from those studies, and perhaps supported by the results of this study, that motor imagery may in fact lead to a calming of the central and peripheral nervous system, which in

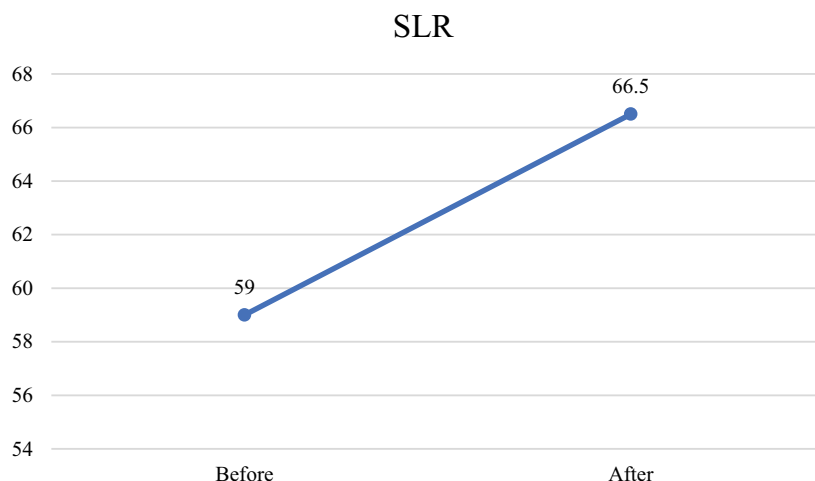


Figure 1. Straight leg raise before and immediately following virtual directional preference treatment.

turn decreases its mechanosensitivity allowing for increased movement. Considering that one of the main objectives of the directional preference model is decreased leg pain (centralization toward the low back), the improvement in SLR may be important as it fits within the McKenzie model of improvement of the extremity [66].

It is important to recognize that the total treatment was approximately only 5 minutes, yet yielded various immediate positive changes, including powerful psychosocial variables often associated with protracted recovery, i.e. high FABQ and PCS scores [49,52]. These results concur with a recent systematic review that showed that directional preference is associated with improvements in various psychometric measures, including fear-avoidance [8]. Even though the case series was not designed as such, it can be argued that patients with extremely high fear-avoidance of physical activity may indeed be appropriate candidates for such a motor imagery approach allowing for ‘movement without movement’ [63]. Furthermore, in line with a true motor imagery approach, imagined extension exercises could be seen as a precursor for actual extension movements, especially for those with higher levels of fear of movement. Future studies will need to explore whether adding motor imagery extension prior to actual extension might yield superior results compared to only active extension.

This study also adds to the body of evidence pointing to sub-grouping of patients. In this small case series, some patient’s pain measurements exceeded MCID, while others did not. These results imply that there may be a subgroup of patients presenting with LBP and leg pain, responsive to extension directional preference that may indeed greatly benefit from this approach. Future studies should further explore potential subgroups more favorable to a virtual motor imagery extension approach.

The case series contains numerous limitations. First, by its design, there were no control subjects to compare these results to. Second, only immediate outcomes were obtained, and no long-term results are reported, thus limiting the interpretation to immediate post-treatment effects. This does not address whether the findings translate or carry-over to medium- or long-term outcomes. Additionally, in lieu of the aforementioned discussions, it can be argued that a cohort of patients specifically with high-fear avoidance may have been a better sample to test this approach and assess its effect on fear-avoidance. Similarly, based on the McKenzie model, a cohort of patients with acute leg pain may have been more representative of this model. The strength of this pilot study was that the physical therapists collecting the data were adequately blinded. One PT who took all the measurements did not know what

the intervention would be, and the other PT who provided the education and virtual extension protocol was blinded to measurements.

Conclusion

A brief virtual motor imagery extension treatment yielded some immediate positive shifts in patients presenting to physical therapy with LBP and leg pain. However, only SLR showed immediate clinically relevant improvement. The results indicate that randomized comparison trials are needed to determine the effect of this intervention on the short- and longer-term outcomes in patients with LBP and leg pain.

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