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The patient signed an informed consent allowing the use of medical information and photographs and received information on the institution's policies regarding the Health Insurance Portability and Accountability Act (HIPAA).

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Key words: Graded motor imagery, chronic pain, low back pain, chronic low back pain

Abstract

Background and Purpose: Chronic low back pain (LBP), defined as pain that persists for three or more months, is widely considered the leading cause of physical activity limitation and work-related disability in the world. The purpose of this case report was to describe the rehabilitation for a middle-aged male with chronic LBP, emphasizing pain neuroscience education (PNE) and cortical remapping of the brain through Graded Motor Imagery (GMI), with movement being a secondary consideration.

Case Description: The patient was a 51-year-old Caucasian male who suffered a low back injury at work. This was a work-related injury covered under Worker's Compensation. The patient's goals were to reduce LBP, regain the ability to perform activities of daily living (ADLs) and work-related duties, and learn better pain management. The plan of care (POC) included aerobic exercise, strengthening exercises, PNE, and cortical remapping through GMI, localization, and graphesthesia training.

Outcomes: The patient's discrimination between left and right sided movements improved from a baseline of 3.1 seconds and 2.7 seconds respectively, with 88% accuracy to 1.5 seconds for both sides with 100% accuracy. His Oswestry Disability Index (ODI) improved, 42/100 to 38/100, and his Fear Avoidance Behavior Questionnaire (FABQ) increased from initial Physical:19 and Work:41 to Physical:23 and Work:43 as did pain values with baseline of 3-4/10 to end of care 4-5/10.

Discussion: The POC produced inconsistent outcomes as the patient's cortical abilities, strength, and perception of function improved with no meaningful improvement in pain, ODI, or FABQ values. Further research is needed to determine if this POC can be successful in a healthcare continuum that utilizes a biopsychosocial approach to chronic pain treatment.

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Introduction/Background and Purpose

Nonspecific LBP is defined as a pathoanatomical cause of pain that does not have a clear root cause.[1] LBP is widely considered the leading cause of activity limitation and disability in working people worldwide, resulting in significant economic impacts.[2,3] Chronic LBP has a reported annual prevalence between 15-45%, with a point prevalence of 30%.[3] People who are susceptible to LBP include individuals who are over thirty years old, have a body mass index of $\geq$30 kg/m^2, engage in minimal exercise, are employed, have psychosocial factors such as stress and anxiety, and women.[4] LBP that persists for greater than three months is categorized as "chronic" or "persistent." Traditional strategies to treat chronic LBP often emphasize pathoanatomical models, including pharmacological intervention, surgical correction, and manual therapy techniques, which have been found to only be moderately successful.[5]

Movement alone may not be the optimal physical therapy (PT) intervention for treating LBP. Current research on chronic pain has looked at influencing pain through the brain via cortical remapping, which has been defined by Daffada et al, as "neuronal reorganization within the higher centers of the brain."[5(p26)] There is physiological evidence (disorganization of the somatosensory cortex) and behavioral evidence (disrupted processing of stimuli to healthy body parts, abnormality of size to painful body areas, and poor movement and imagery performance) that impact the individual's ability to perceive their internal and external environments.[6] Another chronic pain research focus is pain neuroscience education (PNE). According to Louw et al,[7] PNE is defined as the interplay between biologic and physiologic processes in pain that lessens the importance of pathoanatomic dysfunction.[8] Strong evidence supports patient education with exercise to help reduce pain ratings, catastrophizing, fear-avoidant behaviors, and negative attitudes pertaining to pain.[1,8]

Considering interventions that match the above criteria, GMI has been helpful in reducing chronic pain. GMI is a three-stage process that includes discriminating between left and right movements of photographs that depict areas of the body that are painful, visually imagining the movement of the affected area, and using a mirror to give the impression that an affected area of the body is moving when it is not.[6] In a case report conducted by Louw et al,[8] the authors expanded upon the idea of GMI by incorporating graphesthesia and localization training using a nine-block grid to improve tactile acuity of the low back in a patient who had undergone lumbar surgery.

While most LBP interventions focus on increasing the patient's range of motion, strength, endurance, motor control (MC), and tolerance to load through resistance exercise, there has been a lack of literature investigating the combination of PNE and GMI in patients with chronic LBP. The purpose of this case report was to describe rehabilitation for a middle-aged patient with chronic LBP that emphasized PNE and cortical remapping of the brain by means of GMI, with movement being a secondary consideration.

Patient History and Systems Review

The patient provided written informed consent to participate in this case report. He was a 51-year-old Caucasian male who worked as a supervisor and instructor of assessing and delivering propane needs to private residences for two years prior to his injury. He was married with children and enjoyed sports, gardening, and coaching softball.

The patient presented to the medical facility following an injury at work. The patient and three co-workers were lifting a 300-pound oil tank when the patient's right (R) foot slipped on ice, stumbled, and caught his foot on snow, in which he recovered his balance. His injury occurred at work and was therefore covered by Worker's Compensation. The findings of the initial evaluation (IE) can be found in Table 1. The patient's medical history included hypertension and gastroesophageal reflux disease, both treated with medication (refer to Table 2) with no significant family history. His ICD-10 was determined to be unspecified radiculopathy (M54.10).

The patient experienced a complicated course of treatment including pharmacologic interventions (Appendix 1), PT, osteopathic manipulation, and massage therapy. All of these interventions were marginally effective, with LBP persisting. A magnetic resonance image was conducted and was negative for a disc herniation.

When this author met the patient eighteen weeks after IE, he was attempting to work with restrictions with little success and had no perceivable improvement in function. He was limited to lifting less than 30 pounds, no twisting at the low back, and instructed to move every hour. The results of the systems review can be seen in Table 3. The patient's primary goals were to mitigate his LBP, regain ADLs and work-related duties, and have a better understanding of pain management. Prior to this incident, the patient was fully independent in all aspects of his life.

During his revised plan of care (POC) developed by this author, the patient was assessed using the Numeric Pain Rating Scale (NPRS), ODI, FABQ, Subgrouping for Targeting Treatment (STarT Back Tool), and data collected from interventions such as laterality accuracy and speed, localization accuracy, and graphesthesia accuracy. This patient was a good candidate for a case report for several reasons. First, the patient experienced a long course of care, with little change in status, suggesting that prior interventions were only mildly successful. Secondly, since these treatments were unsuccessful, the patient was willing to try a therapy that was atypical from his previous experiences. Lastly, despite best efforts to improve the patient's status, the patient remained optimistic that therapeutic services would be beneficial.

Examination-Tests and Measures

Refer to Table 1 to view the results of the examination performed at IE by the initial therapist and the reassessment by this author. Gross range of motion (ROM) was assessed using the therapist's expertise as indication of the number of degrees the patient was able to attain in each position.

Pain was assessed using the NPRS. The NPRS has been found to be a reliable method of determining pain metrics in patients with chronic spinal pain.[9] The minimal detectable change for the NPRS was 2.1 points.[9]

Strength testing was measured using manual muscle testing (MMT) techniques described by Kendall, et al.[10] MMTs have been found to be a reliable and valid tool for measuring strength.[10] The findings of the reassessment strength test were similar to the IE, with all strength testing being within normal limits (WNL), except dorsiflexion of the R foot, which was graded 4-/5.

Palpation was conducted throughout the lumbar spine with significant findings that can be found in Table 1. Palpation of the lumbar spine is useful to discern where pain is manifesting and what muscles or joints influence the patient's pain experience.[11]

The patient was assessed for radicular symptoms using the slump test and supine straight leg raise (SLR). The slump test and SLR are neural tension tests that assess the mobility of the nerves of the lower extremities (LE).[12] The use of these tests was efficacious in studies finding that the slump was more sensitive (0.84) and the SLR was more specific (0.89) in patients with disc herniations.[12]

Assessment of the joint mobility of the lumbar spine occurred with the patient lying prone while the therapist provided central posterior-to-anterior forces through the spinous processes. Joint play mobility tests have been found to have moderate to good agreement (k=0.38-0.48) in detecting hypomobile or hypermobile lumbar segments along with good validity in correlation to radiographs.[13] This assessment found remarkable findings of hypomobility occurring at the L3-4 segment.

Sensation testing was conducted with the patient in a supine position with his eyes closed. The therapist established a baseline of sensation using the uninvolved L LE. The findings of R LE were similar to the findings of the L LE.

The ODI was used as a patient-reported outcome measure and was recorded weekly to gain better insight to the patient's perception of his injury and ability to perform ADLs. This measure was further used to direct POC. The scoring of this outcome measure was the sum of the items on the measure multiplied by two.[14] The ODI per Lee et al,[14] demonstrated that this outcome was both a valid and reliable outcome measure for patients with persistent, chronic LBP. The patient was in a chronic stage of injury, indicating the ODI was an appropriate measure to use.

The FABQ was a second patient-reported measure aimed to gauge fear and avoidance related to work and physical activity in patients with LBP.[15] Each item of the measure was scored from zero to six and summed for a subscale. The physical activity subscale (FABQ-PA) contains four items and the work subscale (FABQ-W) contains seven items. Scores can range from zero to 28 and zero to 42, respectively.[15] The FABQ has strong evidence supporting its reliability and validity in patients with LBP who fear returning to work.[15] This measure was recorded at baseline and end of care.

The STarT Back Tool was a patient-reported outcome used for two purposes: to predict the risk of chronic, back-related, functional limitation (low, medium, or high) and to find a treatment approach for patients based on subgrouping. The outcome measure was found to be a valid and reliable way to assess poor prognostic factors in patients and aid in targeting appropriate interventions.[16] The STarT Back Tool was recorded at the baseline and end of care.

The assessments of laterality, localization, and graphesthesia of the low back were performed as written in the case report written by Louw et al.[8] Laterality is when the patient is able to correctly identify movements of the area causing pain, in this case, the lumbar spine. The Recognise application, created by the Neuro Orthopedic Institute (NOI) Group (NOI Group, Adelaide, Australia), is an evidence-based multimedia resource that treats pain and was used to assess this. The patient viewed 50 images of low backs and reported whether the images were moving toward the left or right. Localization assessment utilized the same nine-block grid used by Louw et al.[8] The patient was instructed where each blocked was placed in relation to the lumbar spine and was assessed in his ability to discriminate between the blocks in 20 trials.[8] Graphesthesia testing occurred with the patient prone. The patient was instructed that the therapist would use a pen to write numbers that ranged from zero to ten on his lumbar spine, in which he had to discriminate between the available eleven options. Localization trials and graphesthesia trials were completed 20 trials for each, with successful attempts converted to percentages. All were assessed on a visit basis. Refer to Table 4 for baseline intervention values.

Clinical Impression: Evaluation, Diagnosis, Prognosis

When comparing the IE to the reassessment, it was the opinion of this author that diagnosis of unspecified lumbar radiculopathy may have not been consistent with the patient's most recent presentation. The patient had experienced this pain for three months and had psychosocial components to his injury, which significantly factored into care, warranting a chronic LBP diagnosis (M54.5). The patient's primary symptoms were constant stiffness and transient spasm in the thoracic and lumbar regions of the spine. The results of these symptoms included mild pain that was exacerbated with activity with occasional symptoms in the R LE, decreased strength of core musculature, and anxiety/avoidance with functional movements related to his line of work.

The patient continued to be appropriate for this case report due to his inability to perform tasks, pain levels, willingness to partake in therapeutic interventions, and motivation to improve functioning. The prognosis for this case was complicated due to the incorporation of the psychosocial aspects of the patient's care along with the pathoanatomical impairments.

According to Maher et al,[1] patients with chronic LBP have poor prognoses, with complete symptom resolution unlikely. Consulting the literature for prognoses using PNE and GMI as interventions for LBP, no estimated timelines were provided. Despite no such timelines, evidence favorably supports these interventions in patients with chronic pain.[5,17,18] Factors that supported this patient's ability to recover were a supportive family, being moderately physically active prior to injury, and motivation to adhere to PT. Potential barriers to recovery included the chronicity of the injury and comorbidities such as hypertension and obesity that may have impaired the healing process and the patient's perseveration of the situation in which the injury occurred.[1]

There were no referrals made to other medical professionals aside from the medical staff he had already been working with, which included a medical doctor, a physician's assistant, a doctor of osteopathic medicine (DO), and a massage therapist. The patient was reassessed at the six-week mark, which included a re-examination of AROM and gross strength of the LE along with an ODI outcome measure. PT interventions for this patient included PNE, neuromuscular re-education which included laterality training and tactile acuity training (graphesthesia and localization training), mobilizations of the spine, aerobic exercise, strength training, and functional task simulation. Short and long-term goals were established at the reassessment visit two weeks after the initiation of treatment by this author. (Table 5).

Intervention and Plan of Care

Documentation, communication, and coordination of the patient's care occurred in AllScripts (Allscripts Health Solution, Chicago, IL), an electronic health care record technology system. All healthcare providers within the facility were able to view documentation of each discipline to ensure understanding of the patient's POC. Documentation was recorded at each visit.

Refer to Table 6 for specific interventions details. The patient had two, one-hour visits per week during the six-week intervention. Treatment sessions began with the patient on a VigorFit (Appendix 1) where he performed gravity-lessened squats to produce aerobic exercise effects for eight to ten minutes. In a meta-analysis conducted by Wewege et al,[19] pain and psychological wellbeing improved with aerobic and resistance training. Simultaneously, the patient would either engage in a discussion with the therapist about his home exercise program (HEP) and PNE or watch various videos that explained chronic pain. Louw et al,[7] found PNE increased patient knowledge and understanding, decreased pain, fear-avoidance, and catastrophizing in patients with chronic pain.

Cortical remapping and cognitive training included laterality training, graphesthesia, and localization. Refer to Examination and Test Measures section and Table 6. for descriptions of the assessments which then became the treatments provided. Similar to the assessment, laterality training (Appendix 2) used 50 low back images to identify movements of the low back throughout the duration of intervention.[8] Graphesthesia training (Appendix 3) started with numbers zero to ten for weeks one to three and then progressed weekly to also include capital letters if >75% accuracy was maintained. Localization training (Appendix 4) remained the same throughout, with less verbal and tactile feedback given as the patient progressed. These cognitive interventions occurred each session to improve skewed body schema and tactile acuity.[1,20]

Secondary considerations for the intervention started with an emphasis on MC and shifted toward strengthening exercises over a six-week period. MC exercises followed a progression of supine to quadruped exercises. Progress was determined by the therapist when improved coordination and efficiency were visualized and patient feedback of the exercises matched the description of therapist's expectation. MC exercises were used to coordinate voluntary muscle contraction of the core and increase efficiency of energy use. In a Cochrane review conducted by Saragiotto et al,[21] MC exercises for nonspecific LBP had a slight effect on pain reduction.

Resistance training focused on strengthening the core and surrounding musculature. Exercises were added and progressed based on patient report of ease and capacity to tolerate more movement with consideration of task demands at work. Resistance training was used to increase the patient's confidence in movement and increase tolerance to load and movement. Kumar et al,[22] found efficacy in strengthening the core and gluteal muscles in conjunction with lumbar flexibility training. Functional task simulation started at week four to emphasize proper lifting mechanics through a hip hinge progression. Graded exposure to exercise and functional task training were supported by a study conducted by Ogston et al,[23] where patients experienced ODI changes above a minimal clinically important difference (MCID) and improvements in functional lifting tasks ($P < 0.001$).

The patient was compliant with attendance of most scheduled visits (excluding two cancelled visits due to personal matters) and was able to discuss progression of his HEP at the beginning of each session. HEP consisted of the techniques to help manage pain as well as preform MC and strengthening exercises. One particular technique that was emphasized throughout the intervention was mental imagery. The patient was instructed to consider three of the most provocative movements in his daily life. He then would find a relaxed position and imagine himself sitting in the car, picking an object up from the ground, and working in the garden on his knees with no pain for two minutes each. Mental imagery has been used as an effective intervention to reduce perceived threat and to increase efficacy in movements.[6] At the initiation of the POC, the patient was given MC-based exercises to work on as part of his HEP. As he became more coordinated, efficient, and comfortable with movements, he was progressed to strengthening exercises.

Timeline

Outcomes

During the six-week POC conducted by this author, the patient made moderate improvements. Refer to Table 1 for results of the final reassessment. In the last visit, eradication of lumbar paraspinal guarding was observed, all MMTs were found to be WNL with no pain, and a negative slump test was evident.

Refer to Table 4 for results of the final outcome measures. The patient's score on the ODI and NPRS fluctuated with baselines of 42/100 and 3-4/10 respectively with final outcomes of 38/100 and 4-5/10. FABQ at baseline found a physical score of 19 and work score of 41 compared to a physical score of 23 and work score of 43 at end of care. Laterality training was improved from a baseline average of 3.1 seconds (sec) and 2.7 sec in response to L/R movement images respectively with 88% accuracy to a final average of 1.5 sec for both L/R images with 100% accuracy. The patient demonstrated varied abilities in localization and graphesthesia training.

The goals met by the patient can be seen Table 5. The patient met goals related to cortical remapping/GMI training and functional activities but did not achieve goals related to ODI, FABQ, and localization measures.

HEP compliance was conducted by regular check-ins with the patient at the start of each visit. The patient verbalized compliance with his HEP approximately 80% of the time, which was documented.

Discussion

This case report described the use of GMI and cortical remapping as a primary means of treating chronic LBP in a middle-aged patient as its intended purpose. The POC consisted of aerobic exercise, PNE education, cortical remapping/GMI training, and movement through MC and strengthening exercises. The patient demonstrated improvements in muscle guarding, strength, measures in cortical training, and increased perceived ability to perform functional activities. Laterality improved significantly, correlating positively with research that had found improved functioning in patients who averaged <2.4 sec and >85% accuracy.[20] The patient's scores on the ODI, FABQ, and the NPRS did not improve in a clinically meaningful way. The ODI in this case fluctuated with a three-point improvement from baseline failing to reach the MCID of 9.5 points for patients with chronic low back pain.[24] The FABQ values increased from baseline, unable to reach an MCID of a 13-point decrease suggesting the patient may have increase fear avoidance.[25] Pain ratings from the NPRS scale did not change during the intervention, unable to reach a 2.1-point MCD for patients with chronic musculoskeletal pain.[9] There were no defined normative values for localization and graphesthesia training.

Contrary to the outcome measures, the patient reported increased knowledge concerning his pain, implications of his pain classification to function, and improved confidence in his rehabilitation.

The strengths of this case report included the use of evidence-based research to guide clinical decision making and expertise. Limitations include the discrepancy of the patient's healthcare team to act under a single diagnosis and lack of psychosocial considerations, which may have impacted the intervention directed toward PNE and cortical remapping. At the end of care, the patient was still hopeful that diagnostic testing would provide meaning to his pain, despite inconclusive previous findings.

Based on the findings of this report, utilizing PNE and cortical remapping including GMI may not have been beneficial in the treatment of this patient's chronic LBP. However, future research is needed to confirm these findings. Additional research should focus on providing similar types of interventions within a healthcare continuum that practices under the purview of a biopsychosocial lens. Additionally, further exploration of clinically meaningful values to laterality, localization, and graphesthesia training in patients with chronic pain is necessary. The increasing incidence of chronic pain worldwide emphasizes the critical importance of interventions that consider the brain's effect on chronic pain.

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Tables and Figures

Table 1. Tests and Measures

Examination Measure	**Initial Evaluation (previous therapist)**	**Reassessment (this author)**	**Last Recorded Visit (this author)**
Posture	Thoracic-Increase kyphosis Bilateral rounded shoulders Lumbar-PPT	Thoracic-Increase kyphosis Bilateral rounded shoulders Lumbar-PPT	Thoracic-Increase kyphosis Bilateral rounded shoulders
Numeric Pain Rating Scale (NPRS)			
	7/10	4-5/10	4-5/10
Sensory integrity			
Light touch and localization	Decreased sensation of R lateral calf, lateral foot, dorsum of the foot (L4, l5, S1)	WNL, bilaterally	WNL bilaterally
Range of Motion (ROM)			
Gross AROM Lumbar Flexion	60 deg., painful	80 deg.	80 deg.
Lumbar Extension	15 deg., painful	25 deg.	25 deg.
R/L Thoracolumbar Side Bending	35 deg., painful	35 deg., painful to R	35 deg., painful to R
R/L Lumbar Rotation	45 deg., painful	45 deg., painful to R	45 deg., painful to R
Palpation			
	TTP with significant muscle guarding:	Lumbar paraspinals significant guarding	Hypomobility (2/6) L3-4

	R lumbosacral region Thoracic paraspinals R calf medial and lateral	Right PSIS TTP Hypomobility (2/6) L3-4	
Muscle Performance			
Manual Muscle Tests	L LE: WNL R LE: WNL PF: 5/5, painful	L LE: WNL R LE: 5/5 DF: 4-/5	All WNL with 0/10 pain
Special Tests			
SLR	Positive at 45	Negative	Negative
Slump	N/A	Positive, increase with DF	Negative

PPT= posterior pelvic tilt, R= right, WNL= within normal limits deg.= degree, PF= plantarflexion, DF = dorsiflexion, PSIS =posterior superior iliac spine TTP= tender to palpation SLR = straight leg raise

Table 2: Medication List

Medications Prior to Injury	**Name**	**When Prescribed**	**Justification**
	Nexium	Unknown	Gastroesophageal reflux disease
	ACE Inhibitor	Unknown	Stabilize/decrease blood pressure values
Medications Post Injury	**Name**	**When Prescribed**	**Justification**
	Naproxen, 500 mg	Day of injury	Decrease inflammation
	Cyclobenzaprine	Approximately one week after injury	Muscle relaxant
	Methylpredisone	Approximately 1.5 weeks post injury	To replace inflammatory support of ibuprofen

Table 3: Systems Review

Cardiovascular/Pulmonary	Impaired, Hypertension
Musculoskeletal	Impaired, decreased gross (ROM): AROM of lumbar spine Impaired height/weight: BMI >25
Neuromuscular	Impaired, decreased sensation of dermatomes and myotomes in right lower extremity (L4, L5, S1)
Integumentary	Not impaired
Communication	Not impaired
Affect, Cognition, Language, Learning Style	Not impaired Preferred language: English Learning Style: Verbal, visual, and mental

BMI=body mass index, AROM=active range of motion

Table 4. Baseline Measures and Intervention

	Pain (NPRS)	**Laterality**	**Graphesthesia Localization**	**ODI**	**STarT Back**	**FABQ**
Baseline	3-4/10	Left: 3.1 sec Right: 2.7 sec	10/20 trials (50%)	41/100	Total – 4 Sub Score (Q5-9): 1	P-19 (Q 2-5 = 13) W-41

		Accuracy: 88%				
Week Two	3-410	Left: 2.8 sec Right: 2.1 sec Accuracy: 96%	15/20 trials (75%) 12/20 trials (60%)	32/100		
Week Three	4-5/10	Left: 2.1 sec Right: 1.9 sec Accuracy Left: 96% Accuracy Right: 100%	17/20 trials (85%) 8/20 trials (40%)	32/100		
Week Four	4/10	Left: 1.5 sec Right 1.3 sec Accuracy: Left: 84% Accuracy Right: 80%	15/20 (75%) 12/20 (60%)	42/100		
Week Five	4/10	Left: 1.4 sec Right: 1.7 sec Accuracy: 100%	16/20 (80%) 13/20 (65%)	40/100		
Week Six	4-5/10	Left: 1.5 sec Right: 1.5 sec Accuracy: 100%	13/20 (65%) 10/20 (50%)	38/100	Total-5 Sub Score (Q5-9):3	P-23 (Q 2-5 = 17) W-43

ODI=Oswestry Disability Index, FABQ= Fear Avoidance Belief Questionnaire, sec= seconds, P= physical, W=work

Table 5: Short & Long-Term Goals

Short-Term Goals (2-4 weeks)	**Long-Term Goals (6-8 weeks)**

1. The patient will be able to consistently obtain a score of >75% (>15/20) on graphesthesia training within two weeks. **(Met)** 2. The patient will decrease average time to detect R/L discrimination on Recognise application to < 2.0 seconds within two weeks. **(Met)** 3. The patient will decrease ODI score by > 9.5 points in four weeks to display a minimum clinically significant difference (MCID) in functional status within four weeks. **(Not met)** 4. The patient will be able to decrease overall FABQ score by > 6.5 points in four weeks. **(Not met)**	1. The patient will be able to consistently obtain score of >75% (>15/20 trials) on localization training within six weeks. **(Not Met)** 2. The patient will decrease ODI score to the "minimal disability" category (<20%) within eight weeks. **(Not met)** 3. The patient will be able to decrease overall FABQ score by > 13 points in eight weeks. **(Not Met)** 4. The patient will be able to complete continuous functional activity for two hours without increasing pain >2/10 from baseline pain measures in eight weeks. **(Met)**

ODI =Oswestry Disability Index, FABQ = Fear-Avoidance Belief Questionnaire

Table 6: Weekly Interventions

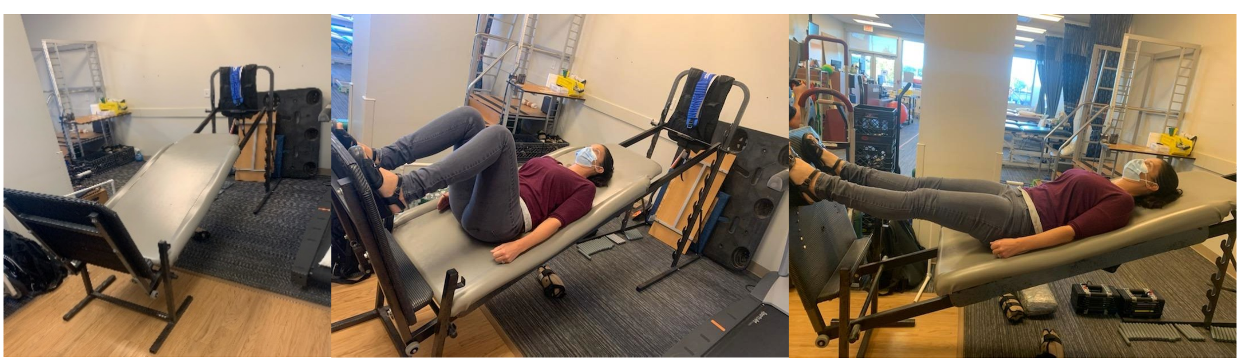
	Rx Weeks 1-3	**Rx Week 4**	**Rx Week 5**	**Rx Week 6**
Interventions	Sessions were held 1-2x/week based on patient availability			
PNE	Discussions about chronic pain,	"Tame the Beast" (video)	"Professor Lorimer Mosley discusses his	"Recovery Strategies" pain guide book

	interplay between pain and brain "Understanding Pain Rebrand" (video) Discussion and review of prior week's PNE	Discussion and review of prior week's PNE	experience with pain" (video) Discussion and review of prior week's PNE	Discussion and review of prior week's PNE
Aerobic Warm-Up	VigorFit Squats x 8-10 minutes			
Laterality	Images of low back sidebending, rotation, or combination x 50 images			
Graphesthesia	0-10 x 20 trials	0-10, A-E x 20 trials	0-10, A-H x 20 trials	0-10, A-Z x 20 trials
Localization	Nine Block Grid on low back x 20 trials			
Motor Control	-Supine PPT 3x20 -Supine HL OH Flies 3x15 -Supine Flyes Alternating Flyes 3x15	-Bird Dog 3x10 -Quadruped Rock Backs 2x20	Bird Dog 3x10 -Quadruped Rock Backs 2x20	
Strengthening	-Hip Bridges 3x15 -Lat Pulldown 3x15 GTB - Rows GTB 3x15	-Lat Pulldown 3x15 BTB - Rows BTB 3x15	-Lat Pulldown 3x15 BTB - Rows BTB 3x15 -Hands Elevated Plank Shoulder Taps 3x10	-Plank 3x30 seconds -Hands Elevated Side Plank 3x20 seconds -Anti-Rotation Push/Pull 3x20 BTB
Functional Task Simulation		Dowel Hip Hinge 3x10	Hip Hinge simulating work duties (elevated surface) 30# 3x6	Hip Hinge simulating work duties (ground) 30# 3x6

Rx=treatment, GTB=green theraband, BTB= blue theraband, PPT= posterior pelvic tilt, HL =hook lying, OH = overhead

Appendices

Appendix 1: Gravity lessened Squats for Aerobic Exercise

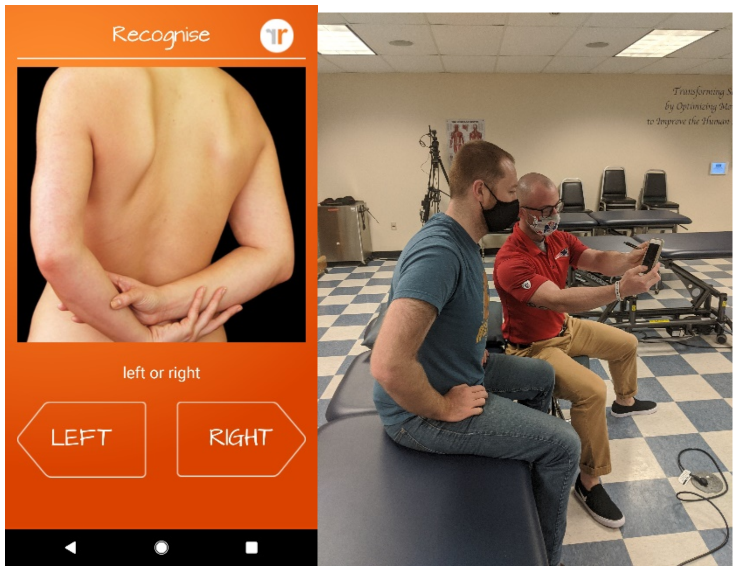


A. **B.** **C.**

A: VigorFit gravity lessened squatter where aerobic activity was performed for 8-10 minutes at the start of each session.

B: Middle phase of squat.
C: Start and end phase of squat
Photos A-C. Courtesy of Miranda Sapier and Wendy Wardell.

Appendix 2: Laterality training



A. **B.**

A: This is an example of a picture seen during training using the Recognise NOI Group application. *
B: The manner that laterality training sessions were conducted where the therapist held the device, the patient responded, and the therapist logged the response.
*A: photo courtesy of Recognise Application (NOI Group, Adelaide, Australia and B. photo courtesy of Devin Bulick and Brandon Drinan

Appendix 3. Graphesthesia Training

The patient laid prone with his shirt lifted to exposed the lumbar spine. The therapist traced on the patient's skin a letter or number with the back of a pen in which the patient responded to the stimuli. Photo courtesy of Devin Bulick and Brandon Drinan

Appendix 4. Localization training

The patient laid prone with a piece of paper in his hands that depicted a nine-block grid on a low back. The therapist placed the same grid over the patient's back, with the center of the grid placed at the area with the most discomfort. The therapist the placed the end of a pen through each block to establish a baseline in which the patient conveyed understanding. This training was conducted at random for 20 trials.

Photo courtesy of Devin Bulick and Brandon Drinan

CARE Checklist

CARE Content Area	Page
1. **Title** – The area of focus and “case report” should appear in the title	1
2. **Key Words** – Two to five key words that identify topics in this case report	1
3. **Abstract** – (structure or unstructured) a. Introduction – What is unique and why is it important? b. The patient’s main concerns and important clinical findings. c. The main diagnoses, interventions, and outcomes. d. Conclusion—What are one or more “take-away” lessons?	2
4. **Introduction** – Briefly summarize why this case is unique with medical literature references.	3
5. **Patient Information** a. De-identified demographic and other patient information. b. Main concerns and symptoms of the patient. c. Medical, family, and psychosocial history including genetic information. d. Relevant past interventions and their outcomes.	4
6. **Clinical Findings** – Relevant physical examination (PE) and other clinical findings	8
7. **Timeline** – Relevant data from this episode of care organized as a timeline (figure or table).	13
8. **Diagnostic Assessment** a. Diagnostic methods (PE, laboratory testing, imaging, surveys). b. Diagnostic challenges. c. Diagnostic reasoning including differential diagnosis. d. Prognostic characteristics when applicable.	8
9. **Therapeutic Intervention** a. Types of intervention (pharmacologic, surgical, preventive). b. Administration of intervention (dosage, strength, duration). c. Changes in the interventions with explanations.	10
10. **Follow-up and Outcomes** a. Clinician and patient-assessed outcomes when appropriate. b. Important follow-up diagnostic and other test results. c. Intervention adherence and tolerability (how was this assessed)? d. Adverse and unanticipated events.	13
11. **Discussion** a. Strengths and limitations in your approach to this case. b. Discussion of the relevant medical literature. c. The rationale for your conclusions. d. The primary “take-away” lessons from this case report.	14
12. **Patient Perspective** – The patient can share their perspective on their case.	5

13. **Informed Consent** – The patient should give informed consent.	4