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Research Article

A STUDY ON GLUTEUS MEDIUS DYSFUNCTION IN CHRONIC LOW BACK PAIN

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A R T I C L E I N F O

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A B S T R A C T

Low back pain is a common but severe health problem. Chronic low back painaccounts as a heterogeneous entity seeking to match specific interventions to subpopulations. The present study seek to describe the prevalence of gluteus medius weakness in people with chronic low back pain and test the effectiveness of a gluteusmedius strengthening exercise intervention in people with chronic low back pain. Although gluteus medius weakness is common in people with low back pain and treating this weakness with a targeted exercise intervention is effective, it is not better than a standard stabilization exercise intervention. Doing exercise is likely more important than what exercise is done.

INTRODUCTION

Low back pain (LBP) is a common complaint with the lifetime prevalence estimated to be as high as 84%.It has been defined as pain reported anywhere for the lower margin of the rib cage to the lower gluteal fold, with or without referral into the lower extremity. Chronic low back pain is most commonly defined as low back pain that persists for more than three months, although this is widely recognized to be a problematic definition. Despite exercise being an intervention of choice for chronic non-specific LBP, there is little information on what exercise interventions are the optimal for any specific patient. Systematic reviews demonstrate effectiveness for exercise interventions in general, but do not clearly support any specific exercise intervention. Characteristics of more successful exercise interventions include individual exercise prescription, supervision, stretching exercises, and strengthening exercises. Given the lack of any one broadly effective exercise intervention, identifying subpopulations for specific interventions that may lead to better outcomes has become a research priority.

Review of Literature

The most current Cochrane review of exercise interventions for chronic low back pain supports exercise interventions for chronic low back pain. The meta-analysis conducted as part of this review concluded that exercise interventions had superior outcomes compared to no treatment or other treatments at short (less than 12 weeks), intermediate (six months), and long-term (12 or more months) follow-ups.[11]

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However, these pooled exercise interventions are widely variable, using a variety of strengthening, stretching, aerobic, coordination, and mobilizing interventions. They also treat chronic low back pain as a homogenous entity, although it is widely acknowledged to be heterogeneous. Another more recent systematic review summarized the comparisons of exercise interventions against other interventions in the literature in chronic low back pain[24] The authors conclude that exercise is superior to usual care.[24] However they did not find significant differences between exercise interventions compared to wait list or no treatment controls, back schools, behavioural interventions, passive modalities, manipulation, psychotherapy or upon comparison to other exercise interventions.[24] This is followed by the caveat that the vast majority of the evidence is low quality.

McKenzie's Mechanical Diagnosis & Treatment (MDT) has a relatively large body of literature supporting its use for low back pain in general. A 2006 review of MDT interventions for low back pain suggested its efficacy, but noted its limited effects in chronic low back pain.

The other three more widespread classification systems have much more limited evidence to support their use on people with chronic low back pain. Pathoanatomic Based Classification (PBC) supports the idea of tailored interventions for differing presentations. However there have yet to be reported any interventional studies based on these grouping criteria. Movement System Impairment (MSI) classifies low back pain into one of five movement categories. Use of this classification system has been demonstrated reliable in chronic low back pain. [41]However, it has been shown to be no more effective than a standard intervention in chronic low back pain. The O'Sullivan Classification System (OCS) has proposed

dividing chronic low back pain broadly into either movement impairments or control impairments.[20]They advocate a cognitive-functional therapeutic approach to challenge these movement or control dysfunctions. One study has demonstrated this approach to be more effective than an exercise and manual therapy intervention. Further work will better clarify the utility of these systems for classifying and managing patients with low back pain.

Several authors have reported direct interactions between gluteus medius dysfunction and low back pain. One of the earlier works implicating gluteus medius as a source of low back pain was Simons and Travell's description of gluteus medius myofascial pain. Myofascial pain from the gluteus medius muscle has been reported to be a common component of low back pain. They describe pain referred from gluteus medius as presenting medial toward the sacrum, superiorly along the iliac crest as well as throughout the buttock. Later Njoo and van der Does reported finding gluteus mediusmy of ascial trigger points in 32% of a sample of patients seeking care for low back pain. Nelson-Wong and colleagues assessed muscle activation of the lumbar and thoracic paraspinals, oblique and rectus abdominals, and gluteus medius with surface EMG during an experimental standing task in people without low back pain. They found that people who developed LBP during the standing task had a different recruitment pattern of gluteus medius compared to those who did not develop LBP. People who developed LBP demonstrated a co-contraction pattern of gluteus medius during standing, while those who did not develop LBP utilized a reciprocal activation pattern. They subsequently proposed a clinical screening test, the Active Hip Abduction test, to identify people who would develop pain during the same experimental standing task. This screening tool was demonstrated to be predictive of development of pain during the experimental standing task. Bewyer & Bewyer suggest that there may be a sizeable proportion of patients seeking care for low back pain with gluteus medius dysfunction and associated pain and tenderness. They suggest a treatment of exercises focused on gluteus medius strengthening. They later reported a significantly greater likelihood that pregnant women had low back pain if they had gluteus medius weakness on examination. Together, all of these studies imply that gluteus medius dysfunction plays a role in low back pain and is worthy of further investigation. In order to better understand the role of gluteus medius function we next need to review how to best assess its function.

Despite the sizeable body of literature supporting exercise interventions as effective and an intervention of choice in chronic low back pain the choice of precisely what exercises to select remains uncertain. Classification schemes developed over the past two decades have begun to aid clinicians in the process of matching effective exercise to some patients. These systems generally do not integrate dysfunction across the hip as a part of the clinical entity of low back pain. This is in spite of the evidence to support interactions of low back and hip complaints as well as more direct evidence to 487847support the idea of gluteus medius dysfunction playing a direct role in low back pain. Assessment of gluteus medius function has been reported with multiple functional 186706assessments as well as more direct strength assessments. These assessments allow for the
evaluation of exercise interventions that have been demonstrated to be effective treatments for gluteus medius strength deficits. Exercise choice is informed by both EMG studies and prior interventional studies. Additionally in the context of chronic low back pain psychological factors play a role and should be monitored. Outcomes in chronic low back pain are widely recognized to include both pain and disability reporting. Direct functional assessment also is important to include as an outcome.

Aims and Objectives

1. To determine the effectiveness of a gluteus medius strengthening program compared to a standard exercise program in participants with chronic low back pain.
2. To determine if the gluteus medius strengthening program improves gluteus medius muscle strength.

METHODOLOGY

This study used a randomized controlled comparative effectiveness trial to assess the effect of gluteus medius muscle strengthening to a standard exercise protocol in people with chronic low back pain who have gluteus medius muscle weakness with associated tenderness.

Inclusion Criteria & Exclusion Criteria

	Inclusion Criteria	**Exclusion Criteria**
Demographics	Age 18+ CLBP At least 4/10 pain	Ages <18 <3 months of LBP Specific etiology of LBP
Target Subgroup of CLBP	<4/5 gluteus medius MMT TTP over gluteal bellies Reproduction of pain complaint with gluteus medius MMT or palpation	≥4/5 gluteus medius MMT No gluteal TTP No pain with both gluteus mediusMMT or palpation
Signs of Serious Spinal Pathology	Negative SLR Intact sensory and motor function	Positive SLR Dermatomalparesthesia Myotomal weakness Bowel or bladder incontinence Saddle paresthesia
History	No fractures of thoracic or lumbarvertebra, pelvis, or LE No abdominal, thoracolumbar,pelvis, or LE surgery Unimpaired LE function	Fracture: thoracic or lumbar vertebra, pelvis, or LE Surgery: Abdominal,thoracolumbar, pelvis, or LE LE function: injury or disease withsequelae impacting LE function

Population

Participants were initially attempted to be recruited from the OPD of Tantia University, Physiotherapy department.

Randomization

Participants were randomized to treatment immediately before the intervention was begun and randomization was stratified by sex. An allocation concealment method with permuted block randomization (4 per block) was used to randomize participants to one of the two treatments.

Demographic data

Participant's age, sex, height and weight were assessed at the initial visit.

Intervention

Exercise Program Both groups performed standardized exercise protocols. The stabilization exercise protocol was based on the protocols utilized by Hicks and colleagues and Rabin and colleagues. They used a series of four exercises designed to improve the stabilizing function of the abdominal musculature using the abdominal drawing in manoeuvre (ADIM) in various activities. They used explicit criteria to advance participants through progressively more challenging exercises for each muscle group. This exercise intervention was selected because it is the most common matched intervention for people with chronic non-specific low back pain within the Treatment Based Classification system that is currently recommended as standard of practice within the physical therapy profession.21The gluteus medius strengthening group performed exercises targeting the gluteus medius muscle. These are based on the EMG literature and previously reported gluteus medius strengthening programs. These also used a criterion-based progression to standardize treatment. At each visit the participant performed an exercise from each progression, starting with the first exercise on the first visit or the exercise that was previously prescribed at their prior visit. If they met the criterion for progression, they performed the next exercise, if they did not meet the criterion for progression that exercise is prescribed. Thiswas repeated for each exercise progression until the participant failed to meet the criteria for progression.

Table 1 Stabilization Exercise Protocol

Exercise	Progression Criterion
Quadruped Progression	
ADIM in quadruped	30 reps with 8 sec hold
ADIM in quadruped, UE lifts	30 reps with 8 sec hold, both sides
ADIM in quadruped, LE lifts	30 reps with 8 sec hold, both sides
ADIM in quadruped, UE & LE lifts	30 reps with 8 sec hold, both sides
ADIM in quadruped, dynamic UE & LE lifts	
Supine Progression	
ADIM in supine	30 reps with 8 sec hold
ADIM in supine, heel slides	20 reps with 4 sec hold, both sides
ADIM in supine, LE lift	20 reps with 4 sec hold, both sides
ADIM in supine, bridge	30 reps with 8 sec hold
ADIM in supine, SLS bridge	30 reps with 8 sec hold, both sides
ADIM in supine, curl up, elbows at sides	30 reps with 8 sec hold
ADIM in supine, curl up, elbows elevated	30 reps with 8 sec hold
ADIM in supine, curl up, hands at head	
Sidelying Progression	
ADIM in sidelying	30 reps with 8 sec hold
ADIM in sidelying, side plank, knees bent	30 reps with 8 sec hold, both sides
ADIM in sidelying, side plank, knees extended	30 reps with 8 sec hold, both sides
ADIM in sidelying, side plank with hip tilts	30 reps with 4 tilts A/P, both sides
ADIM in sidelying, side plank with roll	
Standing Progression	
ADIM in standing	30 reps with 8 sec hold
ADIM in standing, row	30 reps with 8 sec hold
ADIM in standing, walking	

Table 2 Gluteus Medius Strengthening Protocol

Exercise	Progression Criterion
Supine Progression	
Bridge	30 reps with 8 sec hold
Bridge with Arms Crossed	30 reps with 8 sec hold
Bridge with Arms Crossed & Feet Together	30 reps with 8 sec hold
SLS Bridge	
Sidelying Progression	
Clam at 45 degrees	30 reps with 8 sec hold
Sidelying hip abduction, knees extended	30 reps with 8 sec hold
Side plank, knees bent	30 reps with 8 sec hold
Side plank, knees extended	30 reps with 8 sec hold
Squat Progression	
Squat	30 reps
SLS mini squat	30 reps
SLS squat	
Standing Progression 1	
Standing abduction	30 reps
Standing abduction, yellow band	30 reps
Standing abduction, red band	30 reps
Standing abduction, green band	30 reps
Standing abduction, blue band	30 reps
Standing abduction, black band	
Standing Progression 2	
Standing abduction with extension	30 reps
Standing abduction with extension, yellow band	30 reps
Standing abduction with extension, red band	30 reps
Standing abduction with extension, green band	30 reps
Standing abduction with extension, blue band	30 reps
Standing abduction with extension, black band	

Dosage

Both programs were performed over an eight-week period with six clinic visits; an initial visit with follow up visits at one, two, four, and six weeks, and a final visit at eight weeks. This length of intervention and visit scheme was selected to be similar to other interventional studies and to mimic the clinical course of decreasing visit frequency typical of clinical practice. All participants were prescribed a home exercise program to be performed daily. Home exercise logs were used to monitor adherence with prescribed home exercises and were reviewed at each clinic visit. At the end of the intervention participants were recommended to continue their exercise program. Both of the protocols used criterion-based progression of exercises, thus the exercise programwas customized to each individual participant based on their response and physical capacity as is done clinically.

Assessments

Demographics were assessed at the initial visit. Outcome measures were assessed at the initial visit and at the end of exercise intervention. A researcher blinded to treatment assessed functional outcome measures since the treating physical therapist could not be blinded, as they needed to progress the exercise intervention. Participants were blinded to intervention. Exercise logs were used during the intervention period to monitor adherence. Adherence was determined as the

percentage of days during the intervention period that at least some of the prescribed exercises were performed.

Primary Outcome Measure

Average low back pain over the past week was rated using a 0-10 numerical rating scale with anchors of no pain and worst pain imaginable. This has been found to be a valid and responsive outcome measure for pain.

Secondary Outcome Measures

Perceived change was assessed with an 11-point Global Rating of Change (GRC) scale. Global Rating of Change has established validity in people with low back pain and has been reported reliable. The minimum clinically important difference is two points on the 11-pont scale. Disability was assessed with the Oswestry Disability Index, a widely used low back pain disease-specific disability questionnaire. The Oswestry Disability Index is valid and reliable in the chronic low back pain population. Quality of life was assessed using the Medical Outcomes Study 36-item short-form health survey. It has well-developed validity and population norms. Function was assessed with the five-times sit-to-stand and six-minute walk tests. The five-times sit-to-stand test is a standard function test that measures the time it takes to move from sitting to standing five times from a chair without arms. It is widely used and is reliable in people with chronic low back pain. In the six-minute walk test participants are asked to walk as far as they can over a period of six minutes and the distance walked is recorded. An analogous, five-minute walk test, has been demonstrated valid and reliable in people with low back pain. These two functional tests were chosensince they appear to assess differing underlying factors: the five-time sit-to-stand test is aspeed & coordination test whereas the walk test is an endurance & strength measure. Fear-avoidance was assessed with the Fear-Avoidance Beliefs Questionnaire (FABQ).

The FABQ is valid and reliable in the chronic low back pain population. Gluteus medius strength was assessed using handheld dynamometry. Testing procedures used the protocol described by Hislop to assess gluteus medius strength. Dynamometry was used to assess strength with greater resolution than manual muscle testing and is a reliable method to assess strength. Gluteus medius muscle dysfunction was assessed with two functional strength tests: the Active Hip Abduction Test and Single Limb Squat Tests. Tenderness throughout the lumbar and hip region was assessed with a physical exam. The greater trochanter, gluteal musculature, lumbar musculature were all assessed for pain to pressure. Pressure was standardized by pressing with the experimenter's thumb until the nail blanched, a commonly used criterion for controlling pressure application clinically, equal to approximately 4kg pressure. Tenderness was considered positive when palpation reproduced symptoms. Sample Size
A sample size of 20 per group was targeted after changing recruitment strategies to pilot the intervention and outcome assessments. An additional 16 participants were added to account for losses to exclusion after consent (estimated 20%) and drop out (estimated 20%). A total of 56 potential participants were screened and 38 randomized.

Statistical Analysis

Participant demographics were compared with t-tests for continuous data and a Mann-Whitney U for ordinal data. The primary outcome of self-reported pain was assessed between groups with a generalized linear mixed model to account for all of the participant data. Effect size between groups was calculated based on outcome assessments. The secondary outcomes of GRC, ODI, SF-36, FABQ, five-times sit-to-stand, six-minute walk test, and torque assessed with dynamometry were also compared with a generalized linear mixed model to account for all participant data. Effect size between groups was calculated based on outcome assessments. The Active Hip Abduction test and Single Limb Squat test were compared between treatment groups with a Mann-Whitney U. klFinally, correlation coefficients were calculated between adherence and change in each of the outcome assessments on an intention to treat basis using the last value carried forward to assess the impacts of adherence on outcome.

RESULTS

Participants

Recruitment was performed using email to the University of Iowa community. Participant recruitment is detailed in Figure 4. Of those who were interested, 55% were lost and 30% were excluded. Of those who were consented, 68% met our inclusion criteria. Of those randomized to treatment, 24% dropped out. The participants who dropped out all cited not being able to keep up with the burden of a daily exercise program as their rationale for leaving the study. Those who dropped out were not significantly different from those who completed the interventions in any of the demographic or baseline assessments (Tables 9, 10, & 11).

Table 3 Participant Demographics and Baseline Assessments. There were no differences between participants who completed the intervention and those who dropped out. Data are mean ± standard deviation (range).

	Completed (n=29)	**Dropped Out (n=9)**	**t-test**
Age (years)	51.0±14.1 (22-74)	50.2±13.7 (23-65)	t=0.138 p=0.891
Height (cm)	166.8±7.5 (154.0-181.5)	168.7±13.6 (151.5-188.5)	t=-0.373 p=0.718
Weight (kg)	73.3±14.2 (52.4-112.2)	86.4±23.4 (57.1-116.5)	t=-1.516 p=0.166
BMI	26.4±5.3 (18.8-46.1)	30.1±6.5 (22.2-41.8)	t=-1.662 p=0.106
Duration of LBP (mo)	83.7±92.5 (6-348)	185.9±180.8 (5-480)	t=-1.530 p=0.163
Pain (0-10 NRS)	5.2±1.1 (4-7)	5.8±0.8 (5-7)	t=-1.511 p=0.140
ODI	19.3±9.7 (0-38)	20.2±9.0 (8-30)	t=-0.250 p=0.804
FABQ-PA	11.2±4.6 (1-20)	10.0±5.1 (3-19)	t=0.686 p=0.497
FABQ-W	10.0±7.7 (0-23)	9.3±10.8 (1-28)	t=0.195 p=0.847
SF-36 PCS	48.0±5.3 (35.7-56.2)	49.0±4.9 (42.3-55.2)	t=-0.507 p=0.615
SF-36 MCS	50.8±5.8 (38.3-58.0)	51.3±5.4 (42.0-58.5)	t=-0.258 p=0.798
5TSTS (s)	9.1±2.9 (4.58-14.68)	10.6±2.2 (8.13-14.68)	t=-1.495 p=0.144
6MWT (m)	571.9±66.0 (430-661)	544.6±63.2 (438-665)	t=1.096 p=0.280

Table 4 Strength Assessments. There were no strength differences between participants who completed the intervention and those who dropped out. Data are mean ± standard deviation (range).

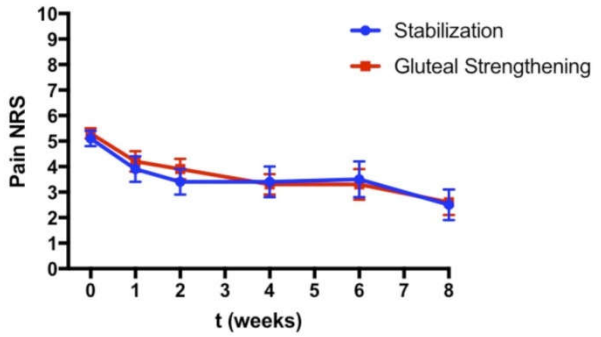
	Completed (n=29)		Dropped Out (n=9)		t-test	
	Right	Left	Right	Left	Right	Left
G Medius (Nm)	136.6±52.8 (51.3-279.4)	140.7±57.8 (58.4-311.7)	142.8±63.5 (51.4-217.6)	145.5±71.2 (40.0-239.7)	t=-0.293 p=0.772	t=-0.207 p=0.837
TFL (Nm)	151.2±63.0 (42.8-293.0)	150.2±58.9 (54.5-306.0)	158.7±68.7 (44.5-238.5)	148.0±69.1 (55.5-267.4)	t=-0.307 p=0.761	t=0.094 p=0.926
G Maximus (Nm)	83.9±26.3 (50.9-155.9)	80.9±27.0 (48.0-175.0)	71.9±29.3 (33.3-111.1)	74.1±31.2 (30.2-123.1)	t=1.166 p=0.251	t=0.637 p=0.528

Table 5 Functional Strength Assessments. There were no functional strength differences between participants who completed the intervention and those who dropped out. Data are number of participants at each score.

	Completed (n=29)		Dropped Out (n=9)		Mann-Whitney U	
	Right	Left	Right	Left	Right	Left
Active Hip Abduction Test	0: 5 1: 9 2: 14 3: 1	0:4 1: 8 2: 16 3: 1	0: 3 1: 2 2: 3 3: 1	0: 0 1: 3 2: 5 3: 1	p=0.686	p=0.457
Single Limb Squat Test	1: 2 2: 1 3: 26	1: 2 2: 1 3: 26	1: 1 2: 0 3: 8	1: 0 2: 1 3: 8	p=0.973	p=1.000

Medication Usage

A total of 22 of the 38 participants enrolled reported using pain medications during the intervention period. Data was missing for six of the participants as they dropped out before returning any of their logs. Participants used over the counter (OTC) medications almost exclusively. OTC non-steroidal anti-inflammatory drugs (NSAIDs) were most commonly used: twelve people reported using ibuprofen, seven reported using naproxen, and two reported using aspirin. Four people reported using acetaminophen. Only four participants reported using prescription drugs. These included one participant using meloxicam, one using tramadol, one using cyclobenzaprine, and one using gabapentin and baclofen. During the first week of the interventions, participants took a mean of 8.8 pills/week. This decreased to 6.8 pills/week during the final week of the interventions. However a few participants who used large amounts of medications skewed these data. Median usage went from 5 pills/week to 3 pills/week of pain medication.



DISCUSSION

This study failed to demonstrate a significant difference between treatments for the primary outcome of self-reported pain with a very small effect size (d<0.05). This study had power to detect an effect size of 1.134 based on the distribution of self-reported pain outcomes. Further pursuit of a large-scale clinical trial to examine differences between these treatments in this sample population is not justified due to the small effect sizes. These small effect sizes suggest equivalence of these two exercise interventions in this population of people with chronic low back pain. Given that clinically significant improvements in pain were seen in both groups suggests that either intervention is effective in managing chronic low back pain. However, the sample recruited in the current study may not be representative of the clinical population ofpeople seeking physical therapy intervention for chronic low back pain. Further, increasing adherence with exercise was significantly correlated with improvement in pain and perceived improvement in overall condition. Future work should focus on interventions to improve adherence rather than focus on choice of exercise intervention for people with chronic low back pain.

CONCLUSION

The first specific aim, that outcomes would be superior in the gluteus medius strengthening group, was not supported. Although the gluteus medius strengthening exercise intervention was effective in treating these participants chronic low back pain, it was no more effective than the lumbar stabilization intervention. The second aim of this hypothesis, that the gluteus medius strengthening program will improve gluteus medius strength as measured with dynamometry and functional strength tests, was only partly supported. Gluteus medius strength was greater after participating in the gluteus medius strengthening intervention. However there was no difference between groups after treatment. Functional strength testing was not different between groups. The study concluded that people experience improvement in their chronic low back pain with a focused gluteus medius strengthening exercise intervention, but this intervention is no more effective than a lumbar stabilization intervention.

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