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Original article

The effect of a single high velocity low amplitude hip mobilization on strength in subjects with knee injuries

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ABSTRACT

Background: Manual therapy have been used as a disinhibitory intervention to increase muscle activation before performing functional tasks that are limited by weakness. Knee injuries are commonly associated with weakness in quadriceps and gluteus. Currently, there is no evidence to support anecdotal experience that a hip distraction mobilization improves muscle performance in subjects with knee injuries and lower extremity weakness.
Objectives: To determine if a hip distraction mobilization would result in an immediate change of maximal force output of the quadriceps and gluteus.
Design: Non-controlled observational pre-post design.
Methods: Forty individuals with knee pathology were included. Subjects underwent quadriceps, gluteus maximus, and gluteus medius muscle strength assessment before a single hip distraction of the symptomatic side. An immediate re-assessment of muscle strength of both symptomatic and asymptomatic sides followed the mobilization.
Results: /findings: Comparing pre-to post-mobilization strength on the symptomatic side, a significant increase was found with the gluteus maximus (average change = 2.0 kg [95%CI 0.6–3.4]; $p < 0.01$) but not gluteus medius (0.2 kg [-0.7-1.0]; $p = 0.71$) or quadriceps (0.1 kg [-1.4-1.7]; $p = 0.86$). When comparing the strength on the symptomatic side in subjects with weakness greater than the MDD_{95} (0.7–2.9 kg), a significant increase was again found for gluteus maximus (4.7 kg [2.6–6.8]; $p < 0.01$) but not for gluteus medius (0.2 kg [-1.0-1.4]; $p = 0.71$) or quadriceps (1.6 kg [-0.7-3.9]; $p = 0.15$).
Conclusion: A single hip distraction resulted in a significant increase in gluteus maximus strength but did not produce a change in gluteus medius or quadriceps strength in subjects with knee injuries.

1. Introduction

Lower extremity weakness associated with musculoskeletal pathology can cause activity limitations and participation restrictions. Physical therapy intervention in the form of exercise is commonly directed at improving muscular performance. However, neuromuscular adaptations may limit the effectiveness of traditional strengthening exercises (Fransen and McConnell, 2008; Hurley et al., 1994; Mikesky et al., 2006; Pietrosimone et al., 2015). Manual therapy techniques have been used as a disinhibitory intervention to increase muscle activation and strength before performing strengthening exercises or functional tasks that are limited by weakness (Harkey et al., 2014; Kivlan et al., 2015; Pietrosimone et al., 2015). While there is evidence to support joint mobilization as a valuable disinhibitory intervention (Fisher et al., 2016; Motealleh et al., 2016), the potential benefit of high velocity low amplitude (HVLA) hip distraction mobilization on improving an individual's ability to generate muscular force in those with lower extremity pathology and weakness has not been studied.

Muscle weakness may result from muscle inhibition secondary to changes in reflexive and/or cortico-motor pathways (Heroux and Tremblay, 2006; Palmieri et al., 2004, 2005; Pietrosimone et al., 2011). Axial and appendicular joint mobilizations have been shown to positively affect the excitability of motor pathways (Dishman et al., 2008; Fisher et al., 2016; Herzog et al., 1999; Suter et al., 1999; Taylor and Murphy, 2008). Studies have found hip mobilization can produce and increase hip strength in asymptomatic subjects (Makofsky et al., 2007;

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Yerys et al., 2002). Specifically, a grade IV inferior hip joint mobilization was found to increase hip abductor strength (Makofsky et al., 2007) and a grade IV posterior to anterior hip joint mobilization was found to increase gluteus maximus strength (Yerys et al., 2002). While there are a variety of mobilization techniques, a grade V or HVLA hip mobilization may have a benefit over lower-velocity techniques with regards to improving the excitability of motor pathways (Fisher et al., 2016). Therefore, if clinicians are specifically looking to effect neurophysiological mechanisms as a means to improve an individual's ability to generate force, selection of a HVLA mobilization may be justified.

Knee injuries are commonly associated with weakness in quadriceps, gluteus maximus, and gluteus medius. Currently, there is limited empirical evidence to support anecdotal experience that a HVLA hip distraction mobilization improves muscle performance in subjects with knee pathology and lower extremity weakness. Therefore, the purpose of this study was to determine if a single HVLA hip distraction mobilization would result in an immediate change of maximal force output of the quadriceps, gluteus maximus and gluteus medius in those with knee pathology.

2. Methods

2.1. Subjects

Forty subjects with knee injuries recruited from a private rehabilitation clinic volunteered for this study (January 2015 to December 2017). All subjects were referred to the Rehabilitation Sector (Santa Casa of São Paulo, Brazil) with a knee related disorder that was medically diagnosed based on clinical history, physical examination, palpation of peri-articular structures, special knee tests, as well as imaging exams (radiograph and/or magnetic resonance imaging when necessary). None of the subjects had prior commenced physical therapy treatment. Each subject was independently examined by 2 examiners (TYF, DGF) to confirm the diagnosis clinically and exclude other causes of their symptoms. Inclusion criteria included having a unilateral knee musculoskeletal injury, being at least 18 years old, a minimum difference in strength between the symptomatic and asymptomatic sides of at least 10%, and absence of medical precautions that preclude performance of a maximal effort strength test. Exclusion criteria included individuals with a history of knee or hip replacement, recent muscle or tendon ruptures (within the past 6 months), unhealed fractures, neurological diseases, malignant cancer, osteoporosis, active infections processes, and early postoperative knee and hip surgery with range of motion and weight bearing restrictions. Additionally, patients who would be unable to tolerate described strength testing positions or mobilization techniques were also excluded. All volunteers were informed about the study procedures and signed informed consent forms. This clinical trial was approved by the Research Ethics Committee and registered at clinical trials (NCT03115879). Once subjects consented to participate in the study demographic data, including diagnosis from referring physician were collected. All subjects completed the Lower extremity function scale (LEFS) (Binkley et al., 1998). The LEFS is a 20-item functional assessment questionnaire that rates the level of difficulty of functional tasks from 0 (extreme difficulty) to 4 (no difficulty, yielding a maximum score of 80 points, with higher scores indicating better function.

2.2. Muscle strength evaluation

A single evaluator blinded to the involved extremity was responsible for muscle strength assessment pre- and post-mobilization of both symptomatic and asymptomatic sides. A hand-held dynamometer (Lafayette Company Instrument, model 01160) with a stabilizing inelastic band was used to assess strength of the quadriceps, gluteus maximus and gluteus medius (Figs. 1–3). The average of three maximal voluntary isometric contractions held for 5 s was used for strength

Fig. 1. Position for quadriceps strength assessment.

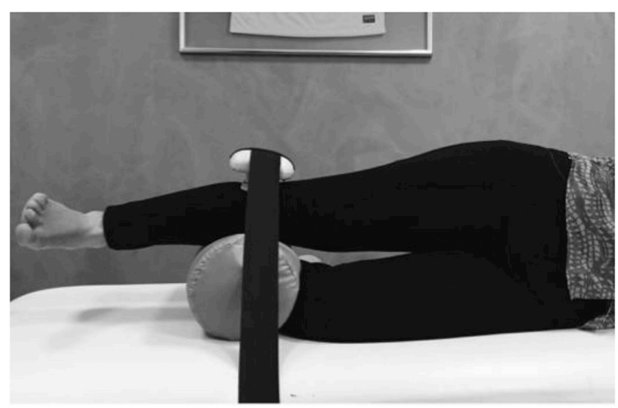

Fig. 2. Position for gluteus strength assessmen.

Fig. 3. Position for gluteus maximus strength assessmen.

assessment. After a 10-min rest, the subject underwent the HVLA hip distraction mobilization of the symptomatic side. An immediate (within 5 min) re-assessment of strength of both symptomatic and asymptomatic sides followed the mobilization (Magalhães et al., 2010, 2013).

2.3. Quadriceps strength

Each participant was seated on a surface high enough that the foot would not touch the ground when the knee was allowed to flex. The subject's trunk and pelvis was stabilized with straps that crossed the trunk and pelvis. The subject's knee was then place in 60° of flexion. In this position an inelastic band and dynamometer was secured to the distal 1/3rd of the leg.

2.4. Gluteus medius strength

Each subject was positioned side-lying with the involved up and supported by a cushion in a neutral hip, knee, and ankle position. The uninvolved lower extremity was positioned with the hip in neutral and the knee flexed to 90°. An inelastic band and dynamometer was secured to the fibular head.

2.5. Gluteus maximus strength

Each subject was positioned prone with the knee on the involved side flexed to 90°. An inelastic band with dynamometer was placed over distal thigh and secured to allow enough hip extension so that thigh could just elevate off the table.

2.6. Intervention

A single physiotherapist performed each HVLA hip distraction mobilization with the subject positioned supine on the table with the asymptomatic lower extremity in a comfortably flexed position. The clinician grasped the subject's involved lower extremity just above the malleolus and positioned in approximately 25° of hip flexion, 25° abduction and slight external rotation. After positioning, the therapist performed a single HVLA hip distraction mobilization (Fig. 4).

2.7. Statistical analysis

Three pre-mobilization hand-held dynamometer strength measures from the 40 subjects' involved and uninvolved sides (80 measures for each muscle) were used to assess test re-test reliability of the strength assessment. Intra-class correlation coefficients ($ICC_{2,1}$), standard error of measures (SEM), and minimal detectable difference (MDD_{95}) were determined for the gluteus medius, gluteus maximus, and quadriceps. Paired t-tests were done comparing average strength pre-to post-mobilization for the gluteus medius, gluteus maximus and quadriceps in the symptomatic and asymptomatic sides.

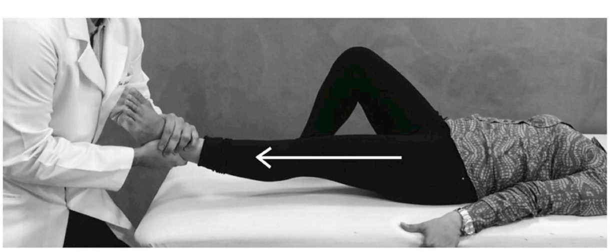

Fig. 4. Subject position for hip distraction mobilization.

Table 1
Represented diagnoses, number of patients and demographics per diagnostic category.

Diagnosis	Total	Age (years)	Gender		Funcionality (LEFS)[a]
			Female	Male	
Patellofemoral Pain Syndrome	18 (45%)	29 (± 12.2)	15	3	58 (± 18.4)
Knee Osteoarthritis	14 (35%)	51 (± 6.4)	12	2	46 (± 22.7)
Meniscus Tear	5 (12.5%)	36 (± 9.7)	3	2	67 (± 15.5)
Patellar Tendonitis	3 (7.5%)	28 (± 13.7)	3	0	52 (± 9.7)

[a] LEFS (Low Extremity Functional Scale), where "0" represents worst function and "80" represents better function.

3. Results

3.1. Subjects

The 40 subjects had a mean age of 34.7 years old (± 11.1) with 33 being female and 7 male. The average LEFS score was 53.4 points (± 18.7). Diagnoses and related demographic information are presented in Table 1.

3.2. Test Re-test reliability

Test re-test reliability was excellent, with $ICC_{2,1}$ values > 0.97 and minimal detectable differences $MDD_{95} < 3.0$ kg (Table 2).

3.3. Pre-mobilization and post-mobilization strength assessment

Comparing pre-to post-mobilization strength on the symptomatic side, a significant increase was found with the gluteus maximus (average change = 2.0 kg [95%CI 0.6–3.4] $p < 0.01$) but not gluteus medius (average change = 0.2 kg [95%CI -0.7-1.0]; p = 0.71) or quadriceps (average change = 0.1 [95%CI -1.4-1.7]; p = 0.86) (Table 3). Pre- and post-mobilization strength was not significantly different (average change −1 to −0.75 kg; $p > 0.05$) on the asymptomatic side.

A separate analysis was done on subjects with pre-mobilization strength differences, between symptomatic and asymptomatic sides, greater than the MDD_{95} identified for each muscle group. This analysis included 25, 18, and 22 subjects with weakness of the gluteus medius (> 0.7 kg difference), gluteus maximus (> 2.9 kg difference), and quadriceps (> 1.6 kg difference), respectively. When comparing pre-to post-mobilization strength on the symptomatic side in these subjects, a significant increase in strength was again found for gluteus maximus (average change = 4.7 kg [95%CI 2.6–6.8]; $p < 0.01$) but not for gluteus medius (average change = 0.2 kg [95%CI -1.0-1.4]; p = 0.71) or quadriceps (average change = 1.6 kg [95%CI -0.7-3.9]; p = 0.15) (Table 4).

4. Discussion

The most important finding of this study was that a single HVLA hip distraction mobilization resulted in a significant increase in gluteus maximus strength but did not produce a change in gluteus medius or quadriceps strength in subjects with knee injuries and lower extremity weakness. Specifically, a 15.3% increase in gluteus maximus strength was found in all subjects, with a 34.2% increase in those with significant pre-treatment gluteus maximus weakness. The 4.7 kg average increase in gluteus maximus strength in those with significant weakness was not only statistically significant but was also greater than the MDD_{95}. This study therefore supports a HVLA hip distraction mobilization as intervention to improve maximal strength output for those with a knee disorder and gluteus maximus weakness.

Table 2
Test Re-test reliability results.

	Intra-class Correlation Coefficients	Standard Error of Measures	Minimal Detectable Difference$_{95}$
Gluteus Medius	0.97	0.2	0.7
Gluteus Maximus	0.97	1.2	2.9
Quadriceps	0.99	0.7	1.6

Table 3
Pre-mobilization and post-mobilization strength assessments for all muscle groups.

		Mean (kg)	Standard Deviation	t-statistic	df	Significance
Gluteus Medius	Pre-mobilization	12.7	5.3	0.38	39	0.71
	Post-mobilization	12.9	4.9			
Gluteus Maximus	Pre-mobilization	16.9	9.0	2.81	39	0.008
	Post-mobilization	18.9	9.8			
Quadriceps	Pre-mobilization	20.2	9.8	0.18	39	0.86
	Post-mobilization	20.3	10.3			

Table 4
Pre-mobilization and post-mobilization assessments considering only subjects with differences between symptomatic and asymptomatic sides greater than MDD[a].

		Means (kg)	Standard Deviation	t-statistic	df	Significance
Gluteus Medius	Pre-mobilization	13.1	6.0	0.38	24	0.71
	Post-mobilization	13.3	5.5			
Gluteus Maximus	Pre-mobilization	17.0	10.4	4.64	17	< 0.0005
	Post-mobilization	21.7	11.1			
Quadriceps	Pre-mobilization	16.2	7.3	1.48	21	0.15
	Post-mobilization	17.8	8.73			

[a] MDD, Minimal detectable difference.

Joint mobilization is thought to improve neuromuscular activation by allowing excitation of motor neurons innervating inhibited muscle (Fisher et al., 2016; Motealleh et al., 2016). A HVLA mobilization may also prepare the brain to optimally learn and integrate new movement patterns (Fisher et al., 2016). The strongest evidence for joint mobilization improving neuromuscular activation has been in the lumbopelvic region. High velocity low amplitude lumbopelvic mobilizations have been shown to improve quadriceps activation (Grindstaff et al., 2009; Hillermann et al., 2006; Motealleh et al., 2016; Suter et al., 1999). High velocity low amplitude ankle distraction mobilizations were found to increased corticospinal motor excitability in the anterior tibialis for approximately 30 min after mobilization (Fisher et al., 2016). Manual hip distraction has been shown to be effective in improving outcomes for those with hip osteoarthritis (Abbott et al., 2013; Hoeksma et al., 2004; Poulsen et al., 2013) and in subjects with hip pain and hypomobility (Vaarbakken and Ljunggren, 2007). Case studies have suggested that a treatment program that includes hip mobilizations could result in decreased pain, improved functional outcome scores, and improved kinematics in those with non-arthritic hip conditions (Ferreira et al., 2013; LeBeau and Nho, 2014; Wright and Hegedus, 2012). Hip mobilizations have been shown to produce an increase in hip strength in asymptomatic subjects (Makofsky et al., 2007; Yerys et al., 2002). This current study is the first to offer evidence to support the use of HVLA hip mobilization to improve muscle performance in patients with knee injuries and gluteus maximus weakness.

Two other studies have examined the effect of hip mobilization on strength (Makofsky et al., 2007; Yerys et al., 2002). The results of this current study agree with Yerys et al. (2002) with increase gluteus maximus strength but differ from the hip abductor strength gains that Makofskyet al (Makofsky et al., 2007) found. Yerys et al. (2002) reported 14% increase in gluteus maximus strength in 40 asymptomatic subjects. This current study noted a 15.3% increase in gluteus maximus strength in all subjects and a 34.2% increase in gluteus maximus strength in a subgroup of subjects with significant weakness. It should be noted that Yerys at al (Yerys et al., 2002) employed a low velocity mobilization technique while this current study employed a high velocity technique. Despite this difference in technique, strength gains were similar. Makofsky et al. (2007) found a 17.3% increase in hip abductor strength following low velocity hip mobilization technique in asymptomatic subjects. This current study found no appreciable difference in gluteus medius strength after a high velocity technique. Even when a subgroup of subjects with significant weakness was analyzed, a difference in strength was not found after mobilization. Studies on the ankle region have suggested that high velocity mobilization would be better to address neurophysiological effects while low velocity mobilization would be more appropriate to address range of motion restricts (Fisher et al., 2016). Future studies need to compare the effect of low velocity and high velocity techniques on hip strength.

The results of the current study support the use of HVLA hip distraction as part of a comprehensive treatment program to improve maximal strength output of the gluteus maximus in patients with knee injuries. Before having a patient with gluteus maximus weakness engage in strengthening exercises or perform functional tasks targeting the gluteus maximus, a clinician could utilize HVLA a hip distraction technique to improve muscular activation. It has also been suggested that during the period immediately following a HVLA technique, the increase strength may be used to enhance movement pattern learning and skill acquisition (Fisher et al., 2016). This is a concept that requires further study.

There are limitations associated with this study. The duration of the strength gains were not assessed. Additional, the effects of the HVLA hip distraction on functional performance, kinematics, pain, and range of motion were not studied. This study consisted of patients with a limited number of knee pathologies. Further research could directly compare low and high velocity techniques in patients with other lower extremity related disorders.

5. Conclusion

A single HVLA hip distraction mobilization resulted in a significant increase in gluteus maximus strength but did not produce a change in gluteus medius or quadriceps strength in subjects with knee injuries and lower extremity weakness. A therapist could utilize HVLA hip distraction to potentially maximize muscular output before having a patient with knee pathology and gluteus maximus weakness engage in strengthening exercises or functional tasks targeting the gluteus maximus.

Conflicts of interest

There is no conflict of interest for this study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2019.102051.

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