Effect of Mobilization of the Anterior Hip Capsule on Gluteus Maximus Strength

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Abstract: Loss of hip extension is often compensated for by extension of the lumbar spine. This compensation can result in hypermobility and ultimately be a source of low back dysfunction and pain. Joint mobilizations have been known to return physiologic and accessory motion to hypomobile structures. Mobilization has also been demonstrated to improve muscular strength when secondary to joint hypomobility. The purpose of this study was to determine the usefulness of posteroanterior (P-A) hip-joint mobilization in improving strength of the gluteus maximus muscle. Forty subjects were randomly assigned to a control group (Grade I P-A mobilization) and an experimental group (Grade IV P-A mobilization). The subjects performed a pretest/posttest set of five isometric repetitions on the Cybex Norm™ isokinetic machine. The peak torque was determined for both pretest and posttest measurements. The data collected were analyzed using an independent t-test with a significance level of $p < .05$. The results demonstrated a statistically significant difference between the experimental and control groups ($t=1.68$, $p=0.002$). This study demonstrated a significant increase in gluteus maximus strength in response to Grade IV P-A mobilizations performed on the anterior hip capsule. Clinicians can utilize these findings in everyday practice to improve muscle strength by integrating manual therapy with therapeutic exercise.

Key Words: Arthrokinetic reflex (AKR), Mobilization/manipulation, Hypomobility, Hip Joint, Gluteus Maximus, Muscle Strength, Manual Therapy

In the geriatric population, one of the first motions lost is hip extension. This is evident by a shuffling gait pattern or decreased step length during ambulation[1]. As a result of decreased extension, there is an associated decrease in gluteus maximus strength. Although this weakness has many factors, one often-neglected cause is the neurally mediated inhibition arising from the articular mechanoreceptors. Although it is established[2] that the articular receptor system contributes significantly to joint position sense (i.e., static and dynamic aspects of proprioception), the contribution of this same system to muscle performance is still under appreciated. Recently, Liebler et al[2] demonstrated a relationship between increasing lower thoracic spine extension and lower trapezius strength. They postulated that the improvement in muscle strength was due to the removal of neural inhibition generated from the mechanoreceptors of the apophyseal joints.

In this study, the authors investigated a similar relationship between hip-joint extension and gluteus maximus strength. We hypothesized that improving the mobility of hip extension would remove the inhibitory influence of the arthrokinetic reflex (AKR) on the gluteus maximus muscle, resulting in enhanced muscle performance[3]. The authors hoped to underscore with sound evidence

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what manual therapists have known for years, namely that mobilization helps to restore all aspects of a hypomobile joint's function, including normalization of strength in the muscles related to it.

Review of Literature

The primary function of the hip joint is to support the weight of the head, arms, and trunk in static and dynamic postures such as ambulating, running, and stair-climbing. Abnormal joint mobility is an important factor in movement dysfunction. Roach and Mills reported that hip extension demonstrated the only significant loss with age. This loss of motion is evident as early as 40 years of age and may play a role in the development of osteoarthritis[4-5]. The head of the femur and the acetabulum are in greatest contact at full extension[5]; with loss of extension, the area of contact will diminish progressively as the deformity increases. Consequently, the body weight will be carried through a smaller area of the articular cartilage resulting in degenerative changes, detachment of debris, and the development of capsular fibrosis[5]. Even though Norkin and Levange[6] state that a combination of flexion, abduction and slight lateral rotation will improve articular contact between the femur and acetabulum, loss of hip extension is still considered a significant etiologic factor in the development of degenerative hip disease[4-5].

The primary extensors of the hip include the gluteus maximus, semimembranosus, semitendinosus and biceps femoris[7]. The gluteus maximus muscle, however, is the strongest extensor of the hip[8-9]. In addition to hip extension, it helps to straighten the leg when walking, running, or climbing. The gluteus maximus is also usually active simultaneously with the paraspinal muscles during back extension, and fatigue of the gluteus maximus is often associated with chronic low back pain[8].

Kanakaanpaa et al[9] reported that the gluteus maximus fatigued faster in women with chronic low back pain than in control subjects. Patients who suffer from chronic low back pain very often have hypoactive, hypotonic, and weak gluteus maximus muscles[10]. In patients with low back pain, the hip-spine interaction is disturbed[11]. The weakness of the gluteus maximus muscle may be an underlying cause of chronic low back pain; therefore, strengthening this muscle may reduce its incidence.

Restricted hip extension is often compensated for by extension of the lumbar spine[12]. This compensation can result in lumbar hypermobility and ultimately be a source of low back dysfunction and pain. Hip extension is also associated with anterior rotation of the innominate bone[13]. Therefore, a loss of hip extension can also result in compensation at the iliosacral joint and be another source of low back pain[13-14].

Minimal research has been performed in the management of decreased hip range of motion (ROM)[15]. Mobilization is one of the most commonly recommended treatments for this condition. The goal of mobilization is to restore the normal arthrokinematics of a joint, including spins, rolls and glides, by improving the extensibility of the ligamento-capsular tissue. Joint mobilization has been known to return physiologic and accessory motions to hypomobile structures[16-18]. Mobilizations/manipulations are defined by the Guide to Physical Therapy Practice as "a manual therapy technique comprising a continuum of skilled passive movements to the joints and/or related soft tissues that are applied at varying speeds and amplitudes, including a small-amplitude/high-velocity therapeutic movement"[19]. This technique is used on soft tissues and joints for the dual purpose of evaluating and treating somatic impairment. Mobilizations are often combined with traditional physical therapy modalities as well[20].

Arthrokinematically, translational motion of the femoral head on the acetabulum is believed to occur during normal function of the hip[6,21]. During hip extension, specifically, the femoral head demonstrates a slight anterior gliding motion on the acetabulum[19-20]. However, according to Paris and Loubert[22], the depth of the concave acetabulum limits the amount of translation that occurs in the hip. Norkin and Levangie report normal ROM for hip extension to be 10-30°[6], whereas Palmer and Eples report the normal extension to be 10-15°[23].

Joint mobilization also causes physical loading and unloading of joint cartilage to facilitate the flow of synovial fluid within the joint. This flow of fluid ensures adequate nutrition to the articular cartilage. When compression is combined with mobilization, there is thought to be even greater stimulation of synovial fluid flow[24].

The muscle-firing pattern of active hip extension in the prone position is as follows: ipsilateral lumbar erector spinae, ipsilateral hamstrings, contralateral lumbar erector spinae, ipsilateral tensor fascia latae, and ipsilateral gluteus maximus[4]. Visible muscle wasting, particularly in the gluteal muscles, is often seen when tightness is present in the anterior muscle group (iliopsoas) or when pain is present[25].

The muscles about the pelvis that are most commonly affected by hip pathologies are the gluteal muscles[11]. Effective treatment of muscle weakness relies on addressing its cause. Muscles become weak from myogenic causes, diminished use, aging, or disorders of nerve conduction of either peripheral or central origin. Muscle weakness may also be caused by inhibition of a muscle related to capsular hypomobility of the underlying joint[3].

Throughout our body, there are three different types of articulating joints: 1) synarthroses, 2) amphiarthroses, and 3) diarthroses. Manual therapy is geared toward the diarthrodial joints, which have four varieties of mechanoreceptors[26-27]. Type-I mechanoreceptors are located on the superficial aspect of the joint capsule and have static and dynamic proprioceptive functions. Type-II mechanoreceptors are located in the deeper layers of the capsule and have only dynamic proprioceptive function. Type-III mechanoreceptors are much larger and are found primarily on the surface of joint ligaments and, to a lesser degree, within joint capsules[28]. The aforementioned mechanoreceptors (Types I, II, and III) are corpuscular mechanoreceptors (i.e., biological transducers) that are stimulated by increases in tension in the tissues in which they are embedded. The Type-IV variety, is represented by a non-encapsulated, unmyelinated plexus of nerve fibers. The Type-IV system is normally inactive but is triggered into action when abnormally high tension or inflammation develops in the articular tissues[27].

The four articular mechanoreceptors discussed above also exert reciprocally coordinated, reflexogenic influences on muscle tone[27]. Through the arthrokinetic reflex mechanism, joint mobilization/manipulation not only affects the motor unit activity in the muscles operating over the joint being manipulated, but it also affects more remote muscles as well, including the muscles on the contralateral side of the body. This results from the multi-segmental organization of the mechanoreceptor afferents within the neuroaxis[27]. Consequently, in addition to its traditional role as an intervention for stiff and painful joints, manual therapy also has the potential to achieve reflexogenic changes in muscle tone (e.g., facilitation and inhibition) locally and to some degree, globally as well.

Herzog et al[29] findings confirmed the principle of reflex activation of muscles after mechanical intervention of the spine. Similarly, Wyke demonstrated that a distraction of the cervical facet joints in cats produced a simultaneous onset of electromyographic (EMG) activity in selected forelimb muscles, which was attributed to a capsular mechanoreceptor reflex response[27]. Cibulka et al[16] reported that mobilization of a dysfunctional sacroliac joint restored the normal length-tension relationship of the hamstrings, thus increasing its torque production. McNair et al[30] demonstrated the inhibitory effects of experimentally-induced knee swelling on the quadriceps muscle, then reversed this inhibition/muscle weakness with submaximal exercise. As mentioned previously, Liebler et al demonstrated a significant increase in bilateral lower trapezius strength in response to Grade-IV posteroanterior (P-A) mobilizations performed on asymptomatic thoracic vertebrae (T6-T12)[2].

The purpose of this study was to determine the effect of hip-joint mobilization directed to the anterior capsule on the strength of the gluteus maximus muscle. If a relationship exists between hip-joint hypomobility and a weakness of the gluteus maximus, it follows that any attempt to restore strength to the gluteus maximus should include joint mobilization. As discussed previously, gluteus maximus function is a crucial component in lower extremity, pelvic girdle, and lumbar spine mechanics[9-10,12]. The ability to improve its functional strength in any way possible, including manual therapy, is therefore worth investigating.

Methods

Subjects

A convenience sample of 40 asymptomatic students from the New York Institute of Technology (NYIT) in Old Westbury, NY, volunteered to take part in the study. Volunteers ranged in age from 19 to 39 years; they were permitted to participate in the study unless meeting one or more exclusion criteria governing selection. The first exclusion criterion eliminated subjects presenting with hypo/hypermobility at the hip joint. Hypomobility was defined as hip extension ROM < 10°, whereas hypermobility was defined as hip extension ROM >20° as determined by standard goniometry. The second exclusion criterion eliminated subjects with hip pathology, a history of trauma, low back pain, and/or past surgery of the hip. The Institutional Review Board at NYIT granted approval for this research; informed consent was obtained from each subject.

Procedure

Subjects underwent a standardized interview, musculoskeletal assessment of the lower quarter, and a baseline strength measurement of the gluteus maximus muscle. This study utilized double-blind techniques for all measurement procedures[31]. The strength of the gluteus maximus was measured by using the Cybex Norm™ Testing & Rehabilitation System (Cybex Division of Lumex, Ronkonkoma, NY). Isokinetic testing has been shown to have high specificity and reliability[32]. Gluteus maximus strength was measured in prone at the predetermined motion barrier of hip extension (between 10° and 20° hip extension) as illustrated in Figure 1. The subjects performed five isometric repetitions. The peak torque was calculated (ft·lbs) by computer and recorded by the ex-

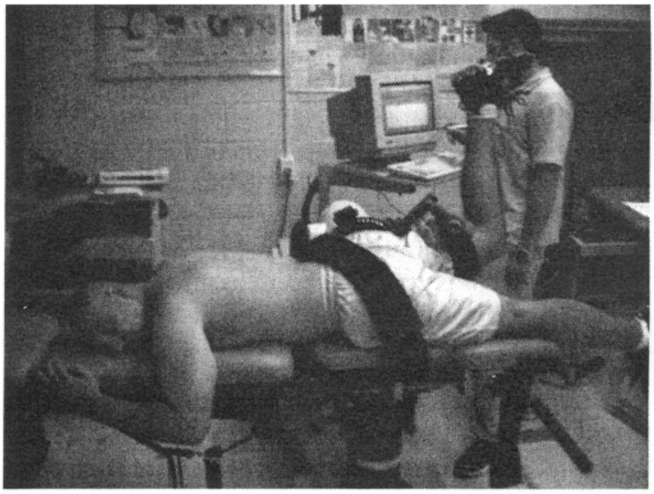


Fig. 1: Test position for strength testing.

amining clinician.

Each subject underwent a familiarization trial on the Cybex Norm prior to baseline data collection. This procedure eliminated any false positive results that may have occurred due to the learning curve. The familiarization trial consisted of finding and recording the settings on the Cybex Norm for each subject followed by a 2-3 minute trial. The subject then performed five isometric repetitions with maximum effort. The familiarization trial was performed on the same day but before actual experimental testing and data collection began. There was a five-minute rest period between the familiarization trial and the actual experimental testing to allow for adequate recovery time and avoid skewing data due to fatigue.

The baseline strength measurements were taken prior to the mobilization for each subject. After a "blinded" examiner completed the baseline measurements, the subjects were randomly assigned to the experimental and control groups using a table of random numbers[31]. All subjects were then placed in prone with the uninvolved limb positioned off the side of the plinth (Figure 2). The angle at the hip and knee for the uninvolved limb was standardized at 110° hip flexion to ensure reliability between trials. The involved hip was placed in 10-20° extension (at the barrier) and a towel roll was placed under the knee. A second member of the research team, who had taken two courses in manual therapy covering the mobilizations used in the experiment, performed P-A mobilizations on the anterior hip capsule. The experimental group received Grade IV P-A mobilization, whereas the control group received Grade I P-A mobilization. One researcher performed all the mobilizations to maximize reliability between subjects. Each subject underwent three sets of 1-minute mobilizations with 30 seconds rest between each set. Immediately after mobilization, all subjects were re-tested by the original "blinded" researcher on the Cybex Norm for post-intervention gluteus maximus strength. The final, post-intervention measurements followed the same procedure as the baseline measures.

Data and statistical analysis

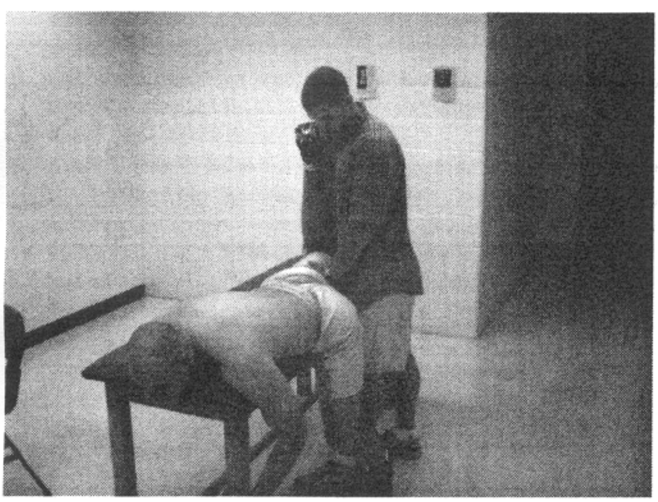
The independent variable was the Grade IV P-A mobilization. The dependent variable was gluteus maximus strength. Parametric interval data was recorded and used throughout the analysis. Strength measurements were recorded as the peak torque of five isometric repetitions on the right lower extremity. A randomized, placebo-control, double-blind study design was used to compare differences in strength between the experimental and control groups[31].

An independent group t-test compared the mean change in pretest and posttest scores between the two groups. The analysis of the data was tested at the $p < .05$ level for an increase in gluteus maximus strength in the experimental group.

Results

Pretest and posttest measurements of muscle strength were assessed for both the control and the experimental groups. The peak torque for pretest and posttest measurements is shown in Table 1.

To compare the experimental and control group, the mean difference between the two groups was analyzed. The results demonstrated statistical significance between the experimental and control groups ($t = 1.68$, $p = 0.002$). Clinically, these results yielded a 14% increase in strength for the experimental group while the control group showed an increase of 4% (Figure 3).



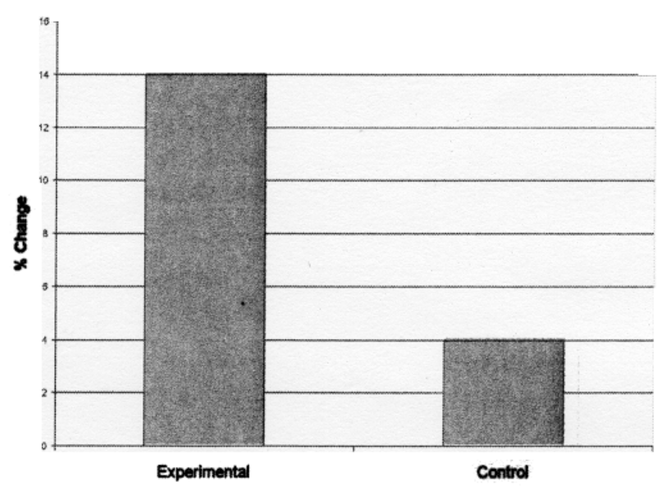


Fig. 3: Average strength change following mobilization.

Discussion

These results indicate that an increase in strength of the gluteus maximus can be obtained following a Grade IV P-A mobilization of the anterior hip capsule. The clinical significance of this finding is that therapists should consider using manual therapy as a valid intervention for gluteus maximus weakness in the presence of anterior capsular hypomobility[3]. The 14% increase in strength was observed after only three minutes of joint mobilization.

This increase in strength is thought to be due to a neurophysiologic alteration in joint mechanorecpetor threshold. Theoretically a tightened anterior hip capsule would facilitate the iliopsoas muscle while inhibiting the gluteus maximus through the arthrokinetic reflex (AKR). By virtue of a set of Grade IV mobilizations on the anterior hip capsule, the firing threshold of the Type-I and Type-II mechanoreceptors in the experimental group would be rendered less sensitive to stretch. This alteration in mechanoreceptor discharge theoretically removes the neurally-driven inhibition of the gluteus maximus muscle while simultaneously defacilitating the iliopsoas muscle through reciprocal innervation. Regarding the argument that other neurologic and mechanical factors in addition to the AKR were responsible for the strength changes observed, the researchers were careful to control all other variables except for the influence of joint mobilization (i.e., iliopsoas length, sensorimotor learning, etc.). Therefore, with a reasonable degree of confidence, these data point to the role of the capsular mechanoreceptors and the AKR as crucial in mediating the increase in gluteus maximus strength seen in the experimental group.

Another interpretation of these data suggests that the experimental group demonstrated increased strength due to the learning curve. This may explain the 4% increase in strength for the placebo-control, but it does not explain the 14% strength increase observed in the experimental group after only 3 minutes of mobilization.

Table 1. Peak strength for pretest and posttest measurements.

CONTROL			EXPERIMENTAL		
Subjects	Pretest MMT ft lbs	Posttest MMT ft lbs	Subjects	Pretest MMT ft lbs	Posttest MMT ft lbs
1	23	30	3	54	58
2	40	45	7	44	51
4	47	48	8	28	31
5	42	46	10	24	28
6	26	33	11	31	32
9	41	36	13	20	26
12	23	26	15	13	17
14	22	24	17	63	66
16	20	21	18	28	36
20	27	25	19	33	33
21	27	25	22	15	19
26	21	20	23	25	28
27	30	33	24	65	69
30	26	29	25	37	39
32	37	39	28	20	24
33	22	21	29	19	23
35	33	33	31	15	16
36	23	21	34	19	29
38	33	38	37	17	22
40	19	20	39	43	50
	Mean = 29.10	Mean = 30.65		Mean = 30.65	Mean = 34.85
	SD = 1.87	SD = 2.02		SD = 3.53	SD = 3.54

The authors chose the gluteus maximus muscle because of the weakness that occurs in much of the "normal" population and the implications of such weakness (i.e., hip and low back pain and impairment). In addition, anterior hip capsular tightness is a common finding in the general population. The results of this study together with the Liebler et al[2] study provide evidence to suggest that the use of manual therapy to improve muscle strength may be applicable to the other synovial joints of the musculoskeletal system as well. Future studies should test for the presence of these joint/muscle interactions at these other peripheral and vertebral articulations. It is also recommended that the duration of these reflexogenic effects be studied and that patients with clinical impairments be compared to an asymtomatic, normal cohort.

Conclusion

This study demonstrated a significant increase in gluteus maximus strength in response to 3 minutes of Grade IV P-A mobilizations performed on the anterior hip capsule. It is theorized that a direct alteration in joint mechanoreceptor discharge via Grade IV mobilizations caused an immediate decrease in mechanoreceptor-associated inhibition of the gluteus maximus muscle. Clinically, these findings indicate the need for therapists to assess muscle weakness as a consequence of joint restrictions (i.e., the arthrokinetic reflex). Therapists can utilize these findings in clinical practice to improve patient outcomes by integrating manual therapy with therapeutic exercise.■

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