Immediate Effect of Grade IV Inferior Hip Joint Mobilization on Hip Abductor Torque: A Pilot Study

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Abstract: Joint mobilization and manipulation stimulate mechanoreceptors, which may influence the joint and surrounding muscles. The purpose of this pilot study was to determine the effect of grade IV inferior hip joint mobilization on hip abductor torque. Thirty healthy subjects were randomly assigned to a control group (grade I inferior hip joint mobilization) or an experimental group (grade IV inferior hip joint mobilization). Subjects performed a pre- and post-intervention test of five isometric repetitions on the Cybex Normö dynamometer; the average torque was determined for both pre- and post-intervention measurements. These data were analyzed using the independent samples t-test with the significance level set at $P < 0.05$. The results showed a statistically significant difference between the two groups for an increase in hip abductor torque in the experimental group ($P = 0.03$). The experimental group demonstrated a 17.35% increase in average torque whereas the control group demonstrated a 3.68% decrease in average torque. These findings are consistent with other studies demonstrating that the use of grade IV non-thrust mobilization improves strength immediately post-intervention in healthy individuals. The results of this pilot study provide physical therapists with further support for the utilization of manual therapy in conjunction with therapeutic exercise to enhance muscle strength.

Key Words: Arthrokinetic Reflex, Hip Abductors, Hip Joint, Isometric Torque, Manual Therapy, Non-Thrust Mobilization, Muscle Strength

The hip joint is a ball-and-socket joint composed of the acetabulum and femur^{1,2}. The hip has strong muscular support, with the gluteus medius functioning as an important stabilizer with a main function of hip abduction. The

anterior portion of this muscle also assists in the secondary function of internal rotation^{1,3}, and the posterior portion of the gluteus medius assists in external rotation of the hip⁴. The gluteus medius functions to stabilize the hip at mid-stance of gait in the coronal plane; it provides lateral pelvic stabilization at terminal stance⁵⁻⁷. Compromise in hip abductor muscle function can lead to a Trendelenburg gait pattern, described as a contralateral pelvic drop during stance phase. This may be compensated for by an upper body shift toward the involved side to maintain the center of gravity over the affected hip^{1,8}; the contralateral quadratus lumborum then compensates by pulling the pelvis superiorly⁹ or the lumbar spine may compensate with ipsilateral lateral trunk flexion¹⁰.

The hip abductors transfer forces from the lower extremity to the spine, explaining their frequent involvement in pa-

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tients with spinal complaints^{9,11-13}. Beckman and Buchanan¹⁴ demonstrated differences in the firing and strength of the hip abductor muscles in the presence of distal lower extremity involvement. Studies have shown that chronic ankle instability was associated with delayed firing of the hip abductor muscles^{9,14,15}. Further studies have correlated weakness with isokinetic testing of hip abductor and adductor muscles with ankle and foot injuries^{16,17}. Friel et al¹⁸ demonstrated a correlation between chronic ankle sprains and ipsilateral hip abductor weakness. Powers¹⁹ described the influence of altered lower extremity kinematics on the patellofemoral joint by identifying two possible mechanisms leading to patellofemoral pain: femoral rotation and knee valgus. Increased femoral internal rotation—as might be caused by gluteus medius weakness—results in an increased Q-angle. Powers et al²⁰ demonstrated that this femoral rotation was the primary contributor to patellar tilts and displacements. Using pressure-sensitive film, these authors reported that 30° of femoral internal rotation significantly increased patellofemoral stress (force per unit) when the knee was flexed beyond 30°. Hip abductor weakness can also lead to valgus at the knee during dynamic tasks. Knee valgus also leads to an increase in the Q-angle, displacing the patella laterally with respect to the patellar groove of the distal femur. Excessive pronation is the end result of tibial abduction, as it compensates for femoral adduction.

Joints influence motor unit activation and, therefore, muscle function. The capability of a joint to alter muscle function is mediated by the articular receptors; the articular receptors can inhibit or facilitate muscle tone²¹. In this paper, the term *arthrokinetic reflex* is used to refer to the tonic and phasic reflex neuromuscular activity, both facilitating and inhibiting, emanating primarily from the Type I and II articular mechanoreceptors^{21,22}.

The *Guide to Physical Therapist Practice*²³ has defined mobilization and manipulation as synonymous terms describing 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. During mobilization/manipulation, the capsuloligamentous tissues of a joint are mechanically stretched²¹. One primary goal of mobilization is to improve extensibility of restricted capsuloligamentous tissue; secondarily, articular mechanoreceptor activation level is affected. Joint mobilization has been demonstrated to improve physiologic and accessory motions to hypomobile structures²⁴. This in turn causes an alteration in the articular mechanoreceptor resulting by way of arthrokinetic reflex activity in enhanced muscle strength^{21,22}. These arthrokinetic reflex actions have been hypothesized to occur through the down-regulation of inhibitory input on motor unit activity^{21,22}. Joint mobilization not only has an impact on the motor unit activity in muscles functioning over the joint, but it

also has been shown to affect more remote muscles as well, including muscles on the contralateral side of the body²². Herzog et al²⁴ demonstrated that distracting cervical facet joints stimulated the articular mechanoreceptors exerting significant coordinated reflexogenic influences on the activity of the neck and limb musculature. Cibulka²⁵ performed mobilization to a dysfunctional sacroiliac joint and restored the normal length-tension relationship of the hamstrings, thereby increasing the main torque produced. Liebler et al²⁶ demonstrated a significant increase in lower trapezius strength with the utilization of grade IV spinal mobilization: The Cybex Norm[®] dynamometer recorded a 6% increase in lower trapezius strength in the experimental group as compared to a 0.2% increase in the control group. Cleland et al²⁷ similarly demonstrated improved lower trapezius strength in response to manipulative treatment of the lower thoracic spine (T6-12) using grade V thrust techniques; they reported a statistically significant increase ($P < 0.01$) in peak strength of 14.5% for the experimental group versus 3.9% for the control group. Yerys et al²⁸ demonstrated a significant effect of grade IV mobilization on gluteus maximus strength; the experimental group demonstrated a 14% increase in strength as compared to a 4% increase in the control group. As in the present study, both Liebler et al²⁶ and Yerys et al²⁸ applied a grade IV non-thrust mobilization to the subjects in the experimental group and a grade I to those in the control group.

The above studies highlight the role of the joint capsule and its reflexogenic influence on muscles. Failure to recognize the importance of these arthrokinetic reflex circuits may explain the difficulty in neuromuscular re-education and strengthening of muscle groups. This in turn leads to failure of an exercise regime to achieve the desired results with regard to improved muscle function²⁹. Many rehabilitation programs focus on strengthening exercises using resistance regimens; however, few focus on the actual quality and control of movement. Manual techniques may effectively be used in cases of muscle imbalances, which are a form of dysfunction. Bookhout²⁹ suggested that greater success in rehabilitation might be achieved through the use of manual techniques, either before or in conjunction with resistive exercises.

Mobilizing a restricted joint may increase muscular strength by removing the reflexogenic inhibition emanating from the joint mechanoreceptors^{21,22,24,26,29}. For example, a mechanical hip joint disorder associated with ipsilateral adductor muscle contracture, inferior capsuloligamentous hypomobility, and gluteus medius weakness, especially of the posterior fibers³⁰, will theoretically impose inhibitory neural input on the gluteus medius while simultaneously imposing reflex facilitation on the adductor muscles each time that the hip abducts against its restrictive barrier of motion^{21,22}. This may lead to further functional destabilization of the hip joint. Above we discussed the important role of the gluteus

medius muscle not only at the hip but also in the entire lower extremity and in the spine. Considering this important role of the gluteus medius muscle and the information on arthrokinetic reflex circuits discussed above, the research hypothesis in this pilot study is that grade IV inferior hip joint mobilization performed at the end of abduction will result in an immediate increase in hip abductor torque when compared to a grade I inferior hip joint mobilization.

Materials and Methods

Subjects

For this study we used a sample of convenience from the New York Institute of Technology (NYIT) Old Westbury campus and the surrounding community. Subject recruitment involved the use of flyers and word of mouth. Inclusion criteria included age between 20–65 years, subject report of normal functioning, and subject willingness to commit to a 1-hour research study. We did not control for the subjects' level of athletic training. None of the subjects had prior knowledge of mobilization/manipulation and, therefore, could reasonably be expected not to be able to distinguish between the two different grades of manual mobilization used as interventions in this study.

Exclusion criteria were established to minimize the influence of extraneous factors that could be a potential source of data contamination (i.e., pain, muscle splinting, systemic disease, orthopaedic surgery, etc.) and included a patient report of lower back pain at present or in the last six weeks; hip, knee or ankle pathology; osteoporosis; history of trauma to the back, hip, knee, or ankle; hyper- or hypomobility at the hip joint; or any related surgeries.

Possible risks involved in this pilot study were discussed, which consisted of possible malfunction of the Cybex Norm[®] dynamometer and delayed onset muscle soreness following strength testing. All subjects then signed an informed consent form. The Institutional Review Board at NYIT granted approval for this study.

Materials

For the torque measurements, we used the Cybex Norm[®] Isokinetic Device, a single-chair rehabilitation and testing system (Figure 1). Reliability of this dynamometer has been previously established^{31,32}. Karatas et al³¹ had 15 healthy subjects tested three times by two physicians at the same time of day with at least 48 hours between sessions. They reported intrarater reliability intraclass correlation coefficients (ICC) for the trunk flexors ranging from 0.89 to 0.95; for the extensors, values ranged from 0.80 to 0.92 for peak torque values

at angular velocities of 60° and 90° sec⁻¹. The ICC values for interrater reliability were also found to indicate highly reliable measurements: Peak torque demonstrated ICC values ranging from 0.95 to 0.98. The trunk flexors at both 60° and 90° sec⁻¹ angular velocities had higher interrater reliability (0.98 and 0.98, respectively) than the trunk extensors (0.97 and 0.95, respectively).

For consistency in measurement position on the dynamometer, we used a goniometer. Ekstrand et al³³ studied intratester reliability of hip abduction goniometry and reported an inter-assay coefficient of variation of 7.5 +/- 2.9%.

Procedure

Subjects were randomly assigned to either an experimental or a control group using a table of random numbers. This study was double-blinded: both subjects and the operator of the Cybex Norm[®] dynamometer were blinded to group assignment. Data collection took one day.

We used the Cybex Norm[®] dynamometer to obtain all torque measurements (expressed as ft-lb). Hip abductor torque was measured in the right sidelying position at the predetermined motion barrier of the left hip abduction, which in all subjects was near 45° of hip abduction (Figure 1). The reason for testing and treating at end-range abduction (which corresponds to 45° in normal hips) was to engage the capsuloligamentous structures of the hip. It is this end-range position of mechanical stress that is hypothesized to evoke reflexogenic effects on surrounding musculature consistent with the arthrokinetic reflex mechanism^{21,22,24,26-28}. After one practice repetition to ensure proper technique, subjects performed five 5-second duration isometric repetitions with a 10-second rest period between repetitions. The average of these five repetitions was recorded as pre-intervention torque (Tables 1–2).

Fig. 1. Cybex Norm[®] isometric torque measurement set-up.

TABLE 1. Control group pre- and post-intervention average torque measurements

	Pre-Intervention Average Torque (ft-lb)	Post-Intervention Average Torque (ft-lb)	Increase in Torque	% Increase
	14	9	-5	-35.71%
	13	17	4	30.77%
	16	17	1	6.25%
	10	5	-5	-50.00%
	10	9	-1	-10.00%
	14	15	1	7.14%
	9	8	-1	-11.11%
	8	15	7	87.50%
	12	12	0	0.00%
	10	10	0	0.00%
	25	21	-4	-16.00%
	15	11	-4	-26.67%
	2	3	1	50.00%
	4	1	-3	-75.00%
	1	4	3	300.00%
Mean	10.87	10.47	-0.27	-3.68%
St. Dev	6.01	5.78	3.65	

TABLE 2. Experimental group pre- and post-intervention average torque measurements

	Pre-Intervention Average Torque (ft-lb)	Post-Intervention Average Torque (ft-lb)	Increase in Torque	% Increase
	19	26	7	36.84%
	6	4	-2	-33.33%
	13	12	-1	-7.69%
	28	26	-2	-7.14%
	15	16	1	6.67%
	13	15	2	15.38%
	9	20	11	122.22%
	14	17	3	21.43%
	14	14	0	0.00%
	14	19	5	35.71%
	9	11	2	22.22%
	16	18	2	12.50%
	12	11	-1	-8.33%
	3	3	0	0.00%
	11	18	7	63.64%
Mean	13.07	15.33	2.33	17.35%
St. Dev	5.75	6.61	3.82	

To maintain blinding, the hip mobilizations were performed in a different room from that where the Cybex strength testing took place. Randomization determined whether a grade I or IV inferior hip joint mobilization was performed. One physical therapy student performed all grade I mobilizations on subjects randomized to the control group, whereas a second student performed all grade IV techniques randomized to the experimental group; a board-certified orthopaedic physical therapy specialist had trained both students in these techniques. Grade I mobilization consisted of a small-amplitude passive movement at the beginning of range with no tissue resistance encountered. Grade IV mobilization was a small-amplitude passive movement at the end of range against tissue resistance³⁴. All subjects were positioned in right sidelying for both techniques (Figure 2). The left hip was positioned in 45° of hip abduction as determined with a goniometer to ensure a more consistent intervention.

Fig. 2. Hip mobilization position.

Fig. 3

Both interventions consisted of three repetitions of 1 minute with a 30-second rest between repetitions. Approximately 15 minutes following mobilization, all subjects were then retested on the Cybex Norm[®] dynamometer using the same method as pre-intervention to establish post-intervention torque (Tables 1–2).

Statistical Analysis

We described within-group pre- to post-intervention differences in average torque only with descriptive statistics, i.e., percentage change. To establish whether a true difference in average torque had in fact occurred from pre- to post-intervention, we also calculated the minimal detectable change (MDC) using the formula $MDC_{95} = (1.96) \times (\sqrt{2}) \times \text{standard error of measurement (SEM)}$ ³⁵. If a pre- to post-intervention change exceeds this MDC_{95} , we can state with a 95% confidence level that a true change did indeed occur. The SEM is normally calculated from two sets of data collected without an intervening intervention but can be estimated using an index of agreement for the measurement involved³⁵. As we did not establish test-retest reliability of the Cybex Norm[®] measurement specific to this study, we estimated the SEM and subsequently the MDC_{95} using the higher intraclass correlation coefficient of 0.95 reported by Karatas et al³¹ as representative for the test-retest reliability of the Cybex Norm[®] torque measurement. Considering the likely greater measurement error associated with the dynamic multi-joint trunk motions studied by Karatas et al³¹ as compared to an isometric single-joint torque measurement and the fact that we used an average torque measurement established from five isometric repetitions, which would likely result in a smaller SEM than a single measurement, using this method of estimation in our opinion seemed justified.

The independent variable in this study was the grade of inferior hip joint mobilization (grade I for the control and grade IV for the experimental group); the dependent variable was hip abductor average torque. We investigated between-group differences in average torque at pre-intervention with an independent samples t-test (1-tailed) to establish pre-intervention group equivalence. We used a similar independent samples t-test to study post-intervention significance of between-group differences. For both statistical analyses, the significance level was set at $P < 0.05$.

Results

We recorded pre- and post-intervention hip abductor torque measurements for the control (Table 1) and experimental groups (Table 2). The control group demonstrated a 3.68% decrease in average torque from pre- to post-intervention torque measurement, whereas the experimental group dem-

onstrated a 17.35% increase (Fig. 4). The MDC_{95} for the torque measurements established as indicated above was 1.88 (ft-lb). Therefore, the mean torque increase of 2.33 (ft-lb) indicated that a likely true change in torque had occurred in the experimental group. In contrast, the -0.27 (ft-lb) change in the control group did not represent a meaningful decrease or change in torque.

To compare the experimental and control groups, we analyzed the difference in mean average torque between groups both pre- and post-intervention. The pre-intervention between-group comparison revealed between-group equivalence with regard to pre-intervention torque ($t = 1.024$, $P=0.314$). The results of the post-intervention between-group comparison demonstrated a statistically significant between-group difference, indicating an increase in hip abductor torque for the experimental group ($P=0.03$).

Discussion

The results of this study confirm the research hypothesis that non-thrust grade IV inferior hip joint mobilization performed at the end of hip abduction leads to an immediate post-intervention increase of average hip abductor torque as compared to a grade I placebo technique. The data collected not only demonstrated a statistically significant between-group post-intervention difference ($P=0.03$) with regard to average hip abductor torque favoring the experimental group despite established pre-intervention group equivalence with regard to abductor torque, but they also demonstrated that only 3 minutes of mobilization produced a 17.35% improvement exceeding the calculated MDC_{95} , thereby constituting a likely true increase in isometric hip abductor torque in the experimental group as measured on the Cybex Norm^o dynamometer.

The mechanism responsible for this reported dramatic strength increase following mobilization/manipulation remains a matter of speculation. However, these authors consider the arthrokinetic reflex defined as the tonic and phasic

influence of joint mechanoreceptor afferents on periarticular muscle tone to be one possible and plausible explanation^{21,22}. We suggest that grade IV mobilization decreases the inhibitory input on the hip abductor muscles in the same manner that it was postulated to negate inhibitory input on the lower trapezius and hip extensors in previous studies²⁶⁻²⁸.

The assumed clinical implication of the findings in this study is that the mobilization of restricted capsuloligamentous tissue in the inferior hip capsule may allow the hip abductors to function more optimally through the full range of hip abduction, i.e., in positions other than terminal abduction. Even if this assumption were not true for a function increase throughout the range, any change in torque becomes even more clinically relevant in a dysfunctional or destabilized hip joint, where this suggested neurogenic inhibition on the hip abductors may occur at the pathological limit of abduction, which will likely occur much earlier than in a normal joint. Consequently, the favorable change in hip abductor muscle function observed in this study with grade IV hip mobilization at end-range might be expected to occur earlier in the range in patients with hip disorders. The findings of this study may impact the management of patients with a variety of orthopaedic conditions including degenerative joint disease and other biomechanical causes of a Trendelenberg gait, lumbopelvic and hip pain of biomechanical origin, lower extremity malalignment (e.g., patellofemoral dysfunction, hyperpronation, etc.), and chronic ankle instability. Based on these data, the authors recommend that accessory motion of the hip joint in an inferior direction, especially at end-range, where the arthrokinetic reflex exerts its greatest influence, should be restored prior to strengthening the hip abductor muscle group. A simple clinical rule of thumb is to stretch what's tight and mobilize what's stiff prior to strengthening what's weak! Regardless of the mechanism involved and the validity of the above extrapolation of study results to a pathological population, it is noteworthy that manual therapy interventions can be utilized to produce immediate improvements in the neuromusculoskeletal function of hip abductors in subjects with a normally functioning central and peripheral nervous system.

We acknowledge that this study has limitations. These limitations include the subjective nature of the graded mobilization intervention with potential between-therapist difference of force applied during the different grades of mobilization. We also acknowledge that this study only collected data on the immediate post-intervention effect; the lack of longer-term follow-up does not allow extrapolation to potential long-term effects on hip abductor torque. One can also question the external validity of our study where we only used healthy individuals: extrapolating the study results to patients with hip, knee and ankle joint impairments may not be warranted. Also, our assumption that end-range mobilization of the hip may produce through-range torque improvements may prove an unwarranted assumption. Finally, a

Comparison of Percentage Change in Strength:
Pretest vs Posttest

Fig. 4

major limitation is that in the absence of reliability data collected for the dynamometer measurement used in this study, the MDC_{95} calculated based on previous reliability studies that only studied isokinetic measurements of sagittal plane trunk movements may not represent the true minimal detectable change; therefore, we realize that the change observed here in the experimental group may not represent a true increase in hip abductor torque.

Conclusion

This pilot study demonstrated a significant increase in hip abductor torque following three minutes of grade IV inferior

hip joint mobilization in healthy individuals. The removal of neurogenic inhibition on the hip abductor muscles by way of arthrokinetic reflex circuits has been suggested as the mechanism whereby manual therapy is able to achieve this short-term effect so rapidly. Based on these data, we recommend that accessory end-range inferior femoral head motion in the fully abducted position be enhanced prior to commencing strengthening exercises of the hip abductor muscles. The results of this study seem to warrant follow-up studies of this topic, but related to the limitations of this study, we recommend that such studies include subjects from various relevant patient populations, assessment of test-retest reliability and the associated minimal detectable change of the outcome measures used, longer-term follow-up, and further standardization of mobilization forces. ■

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