ORIGINAL RESEARCH

Effect of Knee Joint Mobilization on Quadriceps Muscle Strength

Ali Ghanbari, Shirin Kamalgharibi

Dr Ali Ghanbari PhD is Assistant Professor, Department of Physiotherapy, Faculty of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran.

Shirin Kamalgharibi MSc , Department of Physiotherapy, Faculty of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran.

Corresponding Author:
Shirin Kamalgharibi
E-mail:
kamalis_24@yahoo.com

Background: Mobilization can affect motor unit activity in the muscles functioning over the joints and improve muscle strength by suppressing inhibitory reflexes. Several researchers have investigated the effect of mobilization on the strength of different muscles; however, there is no research on the effect of knee joint mobilization on quadriceps muscle strength.

Objectives: To investigate the immediate effect of a single session of tibiofemoral joint mobilization on quadriceps muscle strength in healthy young women.

Materials and Methods: This Quasi experimental study (Repeated measures design) was conducted a motion analysis laboratory at a large medical university in the Middle East. Healthy women volunteers currently enrolled at the university participated in this study. Grade 4 mobilization in a posterior-anterior direction was performed at the knee joint for 3 minutes while the individual was seated with the joint in 90° flexion. Before and 30 minutes after the intervention, quadriceps strength was measured as maximal voluntary isometric contractions (MVIC)(in Newton) by a digital dynamometer with the participant seated and the knee joint at 90° flexion.

Results: MVIC were significantly larger than the pre-mobilization value immediately (P=0.0001) and 30 minutes post joint mobilization (P=0.0001).

Conclusion: Mobilization increased quadriceps strength and the increase persisted for 30 minutes. Increasing knee joint mobility may remove neuromuscular inhibition on the quadriceps and thus enhance muscle strength. The technique may have the potential to be an effective treatment in re-education programs for the quadriceps.

Keywords: Joint mobilization, Muscle strength, Maximal voluntary contraction, Arthrokinetic reflex.

INTRODUCTION

Joint mobilization has been defined as a low-amplitude passive movement that produces gliding or traction, i.e. joint play movements, at the joint surface.[1] The technique is used for a number of therapeutic purposes which include improving range of motion, reducing effusion, relieving pain and reducing muscle guarding.[2] Joint mobilization involves mechanical stretching of capsuloligamentous tissues, and secondarily affects articular mechanoreceptors.[3] The stimulated mechanoreceptors exert reciprocally coordinated reflexogenic influences on muscular tone;[4] thus, through an arthrokinetic reflex mechanism, mobilization can affect the motor unit activity in the muscles functioning over the joint that is being mobilized.[4]

Previous researchers have proposed that the arthrokinetic reflex may act through the downregulation of inhibitory inputs on motor unit activity.[5,6] According to Janda, the altered motor regulation due to afferent inputs from the tissues surrounding a dysfunctional joint may be responsible for muscle weakness.[7]The terms "functional weakness"[8] or "arthrogenous weakness"[9] may be used in this sense, and are defined as the inhibition of muscle activity by anterior horn cells secondary to joint dysfunction or swelling.[9] The decrease in muscle strength is theorized to occur when the motor regulation system limits the full firing of a muscle.[7] Based on this theory, mobilization of a restricted or dysfunctional joint may improve muscle strength by removing the inhibitory reflexes.[10] As a result, removal of the inhibition caused by the arthrokinetic reflex has been proposed as the mechanism responsible for enhanced muscle strength.[11]

Several researchers have investigated the effect of mobilization techniques on the strength of different muscles both in normal and symptomatic individuals. Positive effects of joint mobilization have been shown on trapezius, shoulder external rotators, paraspinal muscles gluteus maximus and hip abductors[3,4,11-13]. Contrarily, sacroiliac joint mobilization was ineffective in improving quadriceps strength.[14]

Other researchers have investigated the effects of joint manipulation or thrust techniques on muscle strength.[15-25] Generally, these studies have shown the effectiveness of joint manipulation in increasing muscle strength. The same mechanism, i.e. removing the inhibition caused by the arthrokinetic reflex, has been proposed to account for this effect.

Previous studies have highlighted the role of the reflexogenic influences on muscle performance.[3] According to Makofsky and colleagues, the failure to address this issue may explain "the difficulty of neuromuscular re-education and muscle strengthening" in rehabilitation programs.[3] Consequently, an exercise regimen which focuses only on strengthening exercises may fail to obtain the highest level of the desired outcomes regarding muscle performance.[3] Mobilization or other manual therapy techniques may effectively be used in conjunction with resistive exercises in cases of muscle imbalances or functional weaknesses.

Although previous studies have investigated the effects of joint mobilization in several muscles, there is no research on the effects of knee joint mobilization on quadriceps muscle strength. The strength of this muscle group is important for both stability and body motion.[26] It has been shown that disability in patients with knee pain is more strongly affected by quadriceps muscle weakness than intensity of pain or radiographic changes.[27] Based on Makofsky's view, if a relationship exists between knee joint hypomobility and weakness of the quadriceps muscle, it follows that any attempt to restore strength to this muscle group should include knee joint mobilization.

We hypothesize that a normal degree of hypomobility exists in the joint play movements of knee joint, and that this hypomobility is responsible for the neuromuscular inhibition exerted on the quadriceps muscles. Increasing knee joint mobility would be expected to remove this inhibition and enhance quadriceps muscle performance. The purpose of this study was to investigate the immediate effect of a single session of tibiofemoral joint mobilization on quadriceps muscle strength in young healthy individuals.

MATERIALS AND METHODS

Participants

The study participants were 35 healthy female students from a large medical university in the Middle East. They entered the study if

Table 1 Comparison of Quadriceps Strength Before, Immediately After, and 30 Minutes After Knee Joint Mobilization

Time of Strength Measurement	MVIC in Newton (Mean ± SD)	Percentage Strength Change	P Value
Before	119.00 ± 40.17	18.7%	0.0001*
Immediate	141.26 ± 44.94		
Before	119.00 ± 40.17	23.6%	0.0001*
30 min after	147.13 ± 44.70		
Immediate	141.26 ± 44.94	4.2%	0.088
30 min after	147.13 ± 44.70		

MVIC – Maximal Voluntary Isometric Contraction, * - Significant (P < 0.05)

they were in the age range of 18-30 years and did not have any acute or chronic problem in 85the knee joints. Women who reported a history of trauma, surgery, disease, pathology, or 86 pain were excluded from the study. The group had a mean age of 22.14±2.39, height of 160.43± 5.773 and body weight of 54.44±7.439.

Procedure

After each participant signed a consent form, baseline quadriceps isometric strength was measured in the dominant leg by a digital strain gauge dynamometer (MIE, Ltd., Leeds, UK). The reproducibility of measurements obtained with this device was previously established in research that reported an interaclass correlation coefficient of 0.76 to 0.85.[28] With the participant seated upright and the hip and knee joints at 90° flexion, the strap of the dynamometer was attached to the leg proximal to ankle joint. Then she was asked to pull and hold the strap with her maximal effort. Each contraction was held for 5 seconds, followed by a rest period of 10 seconds. The average force (in Newton) of the 3 MVICs was recorded as quadriceps strength. Then grade 4 mobilization in a posterior-anterior direction was performed at the tibiofemoral knee joint for 3 minutes while the individual was seated with the knee joint in 90° flexion. Immediately after the intervention, quadriceps strength was measured with the same method for the baseline measurement. Maximal voluntary contractions were assessed again 30 minutes after the intervention. During the period between the two sets of measurements the person was required to sit still. The same examiner who measured muscle strength also performed the joint mobilization techniques. The study was approved by the university ethics committee.

Statistical analysis

Version 15 of the SPSS was used to analyze the study data. One-way analysis of variance with the repeated measure test was used to compare quadriceps strength before and after knee joint mobilization. When significance was found (P<0.05) post-hoc analysis was performed for pair wise comparisons.

RESULTS

Mean MVIC in all three sets of strength measurements (**Table 1**) were significantly different (P=0.0001). Post-hoc analysis revealed that the MVC was significantly higherthan the pre-mobilization value immediately (P=0.0001) and 30 min after joint mobilization(P=0.0001).

No significant differences in muscle strength were found between MVC measured immediately after mobilization and the values obtained 30 min later (P=0.088).

DISCUSSION

The results of the study supported the research hypothesis. There was a significant increase in quadriceps strength immediately after knee joint mobilization. In addition, the enhancement of muscle performance persisted after 30 min. The mechanism responsible for this increase is believed to be the arthrokinetic reflex, defined as the influence of joint mechanoreceptor afferents on muscles around the joint.[3] We suggest that knee joint mobilization decreases the inhibitory input on quadriceps muscles in the same manner as was

postulated in previous studies for the effects of mobilization on other body muscles. [3,4,11,12]

Our findings are consistent with most previous studies with regard to the positive influence of joint mobilization on muscle strength. In this study, an 18.7% increase in quadriceps strength was observed immediately after mobilization; this is comparable to the findings of other studies. Liebler et al found a 6% increase in lower trapezius strength after mobilization of the thoracic spine.[11] After hip joint mobilization, Yerys et al reported a 14% increase in muscle strength, and Makofsky et al observed a 19.35% increase.[3,4] Wang and Meadows observed a 10.4% increase in the strength of the shoulder external rotators after C5-C6 joint mobilization.[13] Therefore, the percentage increase in muscle strength in the present study is within the range reported by previous studies. [3,4,11-13]

The study by Eybers was the only previous research to report that joint mobilization had no significant effect on quadriceps muscle strength.[14] One explanation regarding the contrasting results of Eybers' study may be the use of a short period (1 min) for joint mobilization[14]. The duration of mobilization may be an influential factor in strength gain or the persistence of gains. In the present study joint mobilization was applied for 3 minutes. Other researchers have used the technique for 2 to 3.5 minutes.[3,4,11-13] While this seems to be a routine and reasonable duration of mobilization for practitioners, future studies should test the effects of longer application periods.

Wang and Meadows repeated strength measurement 20 and 30 min after mobilization; however, post-mobilization muscle strength in their study did not differ significantly from pre-mobilization strength.[13] Makofsky et al reported a significant increase in muscle strength 15 minutes after mobilization.[3] Hanrahan et al found a significant increase in force production 24 hours after mobilization.[12] Other studies have only measured muscle strength immediately after mobilization and did not repeat the test at later times.[4,11,14] Therefore, except for the research by Wang and Meadows, all other studies including the present one have shown that the enhancement of muscle performance persists for time periods between 15 minutes to 24 hours after joint mobilization. While we acknowledge the inconclusiveness of these findings and the need for further research, we suggest that the effects of joint mobilization may persist long enough to be useful in muscle re-education programs during a single session of rehabilitation. Future studies should also be done to compare different follow-up times.

In accordance with the findings of other studies, our results show that joint mobilization may be a useful adjunct to exercise therapy in the treatment of cases with muscle imbalance or functional weakness. More specifically, knee joint mobilization may be used in re-education programs for the quadriceps group, in conditions such as patellofemoral pain syndrome, where muscle function may be inhibited by pain reflex mechanisms, biomechanical deficiencies or patellar malalignment. Increasing knee joint mobility may remove neuromuscular inhibition on the quadriceps and thus enhance the muscle performance.

The study has limitations. The participants were young, healthy women and thus, the findings may not be fully applicable to other populations or patients. However, they can be used as a basis for further research in other age groups and cases with patellofemoral pain syndrome or other knee conditions.

CONCLUSION

The study documents the effectiveness of knee joint mobilization in improving quadriceps muscle strength. The enhanced muscle performance persisted at least 30 minutes after application of the technique. Clinicians could use knee joint mobilization in conjunction with exercise therapy in re-education programs for the quadriceps muscle group.

CONFLICTS OF INTEREST

None declared

ACKNOWLEDGEMENT

This study was derived from the MSc thesis by Shirin Kamalgharibi and was supported by the Vice-Chancellery for Research of Shiraz University of Medical Sciences through contract No 89-5252. We thank Dr J. Zare for statistical analysis of the study and K. Shashok for the improving the use of English in the manuscript.

REFERENCES

1. Maitland GD, Hengeveld E, Banks K, English K. Maitland's vertebral manipulation: Butterworth-Heinemann; 2001: 170-171.
2. Kisner C, Colby LA. Therapeutic exercise: FA Davis; 2002:109.
3. Makofsky H, Panicker S, Abbruzzese J, Aridas C, Camp M, Drakes J, et al. Immediate effect of grade IV inferior hip joint mobilization on hip abductor torque: a pilot study. J Manual Manipulative Ther. 2007;15(2):103.
4. Yerys S, Makofsky H, Byrd C, Pennachio J, Cinkay J. Effect of mobilization of the anterior hip capsule on gluteus maximus strength. J Manual Manipulative Ther. 2002;10(4):218-224.
5. Warmerdam A. Arthrokinematic Therapy: Improving Muscle Performance through Joint Manipulation: Wantagh, NY: Pine Publications; 1999: 32-44
6. Wyke B. Articular neurology. In: Glasgow EF, Twoney LT, Scull ER, Kleynhams AM, eds Aspects of Manipulative Therapy: New York, NY: Churchill Livingstone; 1985:72-77.
7. Janda V. Muscles, central nervous motor regulation and back problems. The Neurobiologic Mechanisms in Manipulative Therapy: New York, NY, Plenum Publishing Corp. 1978:27-41.
8. Schamberger W. The malalignment syndrome: Churchill Livingstone; 2002:27-29
9. Page P, Frank C, Lardner R. Assessment and Treatment of Muscle Imbalance:The Janda Approach: Human Kinetics; 2010:49-52.
10. Warmerdam A. Manual Therapy: Improve Muscle and Joint Functioning: Pine Publications; 1999:32-44.
11. Liebler EJ, Tufano-Coors L, Douris P, Makofsky H, McKenna R, Michels C, et al. The effect of thoracic spine mobilization on lower trapezius strength testing. J Manual Manipulative Ther. 2001;9(4):207-12.
12. Hanrahan S, Van Lunen BL, Tamburello M, Walker ML. The short-term effects of joint mobilizations on acute mechanical low back dysfunction in collegiate athletes.J Athl Train. 2005;40(2):88.
13. Wang SS, Meadows J. Immediate and Carryover Changes of C5-6 Joint Mobilization on Shoulder External Rotator Muscle Strength.J Manipulative Physiol Ther. 2010;33(2):102-8.
14. Eybers BD. The effect of flexion distraction therapy of the sacroiliac joints on quadriceps femoris muscle strength [Master dissertation]. [Johannesburg university]; 2004 [Cited 2004 october 18]. Available from: www.google.com
15. Dishman J, Bulbulian R. Comparison of effects of spinal manipulation and massage on motoneuron excitability. Electromyogr Clin Neurophysiol. 2001;41(2):97-106.
16. Dishman JD, Ball KA, Burke J. First prize central motor excitability changes after spinal manipulation: A transcranial magnetic stimulation study. J Manipulative Physiol Ther . 2002;25(1):1-9.
17. Dishman JD, Bulbulian R. Spinal reflex attenuation associated with spinal manipulation. Spine. 2000;25(19):2519.
18. Dishman JD, Burke J. Spinal reflex excitability changes after cervical and lumbar spinal manipulation: a comparative study. Spine J. 2003;3(3):204.
19. Dishman JD, Cunningham BM, Burke J. Comparison of tibial nerve H-reflex excitability after cervical and lumbar spine manipulation. J Manipulative Physiol Ther. 2002;25(5):318-25.
20. Dishman JD, Dougherty PE, Burke JR. Evaluation of the effect of postural perturbation on motoneuronal activity following various methods of lumbar spinal manipulation. Spine J. 2005;5(6):650-9.
21. Grindstaff TL, Hertel J, Beazell JR, Magrum EM, Ingersoll CD. Effects of lumbopelvic joint manipulation on quadriceps activation and strength in healthy individuals. J Manual Ther. 2009;14(4):415-20.
22. Cibulka MT, Rose SJ, Delitto A, Sinacore DR. Hamstring muscle strain treated by mobilizing the sacroiliac joint. Phys Ther. 1986;66(8):1220.
23. Suter E, McMorland G, Herzog W, Bray R. Decrease in quadriceps inhibition after sacroiliac joint manipulation in patients with anterior knee pain. J Manipulative Physiol Ther. 1999;22(3):149-53.
24. Suter E, McMorland G, Herzog W, Bray R. Conservative lower back treatment reduces inhibition in knee-extensor muscles: A randomized controlled trial* 1. J Manipulative Physiol Ther. 2000;23(2):76-80.
25. Hillermann B, Gomes AN, Korporaal C, Jackson D. A pilot study comparing the effects of spinal manipulative therapy with those of extra-spinal manipulative therapy on quadriceps muscle strength. J Manipulative Physiol Ther. 2006;29(2):145-9.
26. Hahn T, Foldspang A, Ingemann-Hansen T. Dynamic strength of the quadriceps muscle

and sports activity.Br J Sports Med. 1999;33(2):117.

27. Slemenda C, Heilman DK, Brandt KD, Katz BP, Mazzuca SA, Braunstein EM, et al. Reduced quadriceps strength relative to body weight: a risk factor for knee osteoarthritis in women? Arthritis Rheum. 1998;41(11):1951-59.

28. van der Linden ML, Aitchison AM, Hazlewood ME, Hillman SJ, Robb JE. Test-Retest repeatability of gluteus maximus strength testing using a fixed digital dynamometer in children with cerebral palsy 1. Arch Phys Med Rehabil. 2004;85(12):2058-63.