Effect of talocrural joint mobilizations on restricted ankle dorsiflexion and the kinematics of squatting tasks

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ABSTRACT

MOLLY SMITH: Effect of talocrural joint mobilizations on restricted ankle dorsiflexion and the kinematics of squatting tasks
(Under the direction of Darin Padua)

Joint mobilization treatments aimed at increasing ankle dorsiflexion range of motion (DF-ROM) may affect DF-ROM and squat kinematics in healthy subjects with restricted dorsiflexion. Measures of DF-ROM and squat kinematics (knee valgus displacement, medial knee displacement, and dorsiflexion displacement) were assessed in 43 subjects. Subjects were randomly assigned to a control (calf stretching and sham mobilization) or treatment (calf stretching, mobilization with movement treatment, and anterior to posterior talocrural joint mobilization) group. All subjects, regardless of group, demonstrated significantly improved DF-ROM at post testing. During squatting tasks, dorsiflexion displacement increased significantly from pre- to post-testing in both double and single leg squats. No significant differences were observed for knee valgus displacement or medial knee displacement. Thus, calf stretching improved passive and active dorsiflexion range of motion in subjects with dorsiflexion restrictions. Joint mobilizations did not have an additive effect on dorsiflexion gains nor affect squatting kinematics at the knee.

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CHAPTER I

INTRODUCTION

BACKGROUND

Recreational and competitive sports are widely popular in the United States, and while an active lifestyle is healthy, sports can also cause injuries. Common injuries from sports such as running, basketball, and soccer include acute knee injuries, acute ankle sprains, and chronic ankle instability (CAI). Such injuries can be painful, expensive, and may lead to altered lower extremity biomechanics, permanent disability, and the development of early osteoarthritis.

An acute knee injury seen frequently in sport is anterior cruciate ligament (ACL) sprains and full thickness tears. Each year between 80,000 and 250,000 ACL injuries occur, with more than 50% of these injuries occurring in young athletes between 15 and 25 years of age. In addition, females participating in "high-risk" sports involving pivoting and jumping are four- to six- times more likely to suffer an ACL tear than males participating in the same sports (Hewett, Myer et al. 2005; Griffin, Albohm et al. 2006). Data collected by the American Board of Orthopaedic Surgeons showed that in 2004, ACL reconstruction was the sixth most common surgical procedure performed by sports medicine fellows and the third most common surgery among general surgeons (Griffin, Albohm et al. 2006). ACL injuries cause both temporary and permanent disability, loss of time from work, school, and sports, decreased academic performance in school, and may lead to the need for further reconstructions or to degenerative joint disease (Freedman, Glasgow et al. 1998; Griffin, Albohm et al. 2006). It is estimated that surgery and rehabilitation for each ACL injury costs approximately $11,000-17,000, for a total of millions of dollars spent annually because of ACL injuries (Hewett, Myer et al. 2005; Gianotti, Marshall et al. 2009). ACL injuries may also cause increased risk of knee osteoarthritis, with up to 50% of people with reconstructed ACLs showing signs of articular degeneration 15 years after surgery (Lohmander, Ostenberg et al. 2004; Meunier, Odensten et al. 2007; Roos, Englund et al. 2007; Hui, Salmon et al. 2011).

Ankle injuries are the most common lower extremity injury in the recreational and athletic settings with more than 25,000 ankle sprains occurring daily in the United States (Mickel, Bottoni et al. 2006; Wikstrom and Hubbard 2010). The greatest predisposing factor for ankle sprains is a history of at least one ankle sprain, and suffering repetitive ankle sprains can lead to chronic ankle instability (Milgrom, Shlamkovitch et al. 1991; Bahr and Bahr 1997; McKay, Goldie et al. 2001; Hertel 2002; Beynnon, Webb et al. 2004). The recurrence rate of ankle sprains is greater than 70%, and up to 75% of people who sprain their ankle develop some level of chronic functional ankle instability (Wikstrom and Hubbard 2010). Repetitive ankle sprains have also been linked to an increased risk of osteoarthritis and articular degeneration at the ankle (Harrington 1979; Hertel 2002).

The prevalence of knee and ankle injuries is high, therefore ongoing research is attempting to identify ways to prevent and treat such injuries. Lower extremity injuries often cause altered neuromuscular movement patterns and biomechanical changes, which can lead to movement compensations and further injury. One factor that has been associated with both knee and ankle injuries is ankle dorsiflexion range of motion.

Decreased or restricted dorsiflexion predisposes athletes to patellar tendinopathy and has been shown to alter biomechanics potentially contributing to injury (Malliaras, Cook et al. 2006; Backman and Danielson 2011). For example, decreased dorsiflexion range of motion has been associated with factors that increase ACL injury risk during a jump landing task. These include less knee-flexion displacement, greater knee-valgus displacement and greater ground reaction forces (Fong, Blackburn et al. 2011). Similarly, decreased dorsiflexion range of motion is associated with increased frontal plane knee excursion during a drop land task in young female soccer players (Sigward, Ota et al. 2008). It has also been found that affording individuals more ankle dorsiflexion with the use of a heel lift during a squat eliminated the presence of medial knee displacement (MKD), which is associated with tight and weak ankle musculature and can increase the risk of ACL injury and patellofemoral pain syndrome (Bell, Padua et al. 2008). However, there seem to be a number of factors that can contribute to restricted dorsiflexion range of motion.

Ankle dorsiflexion restrictions seem to be important factors in human movement and potentially lower extremity injury. Interventions to increase dorsiflexion motion may improve biomechanics and prevent injury. Dorsiflexion restrictions can be due to multiple factors, therefore identifying the cause of the restriction is crucial for intervention. Decreased dorsiflexion range of motion is present following several lower extremity injuries, such as acute inversion ankle sprains and chronic ankle instability (Youdas, McLean et al. 2009). In fact, functional dorsiflexion may even be decreased during jogging in individuals with CAI compared to healthy controls (Drewes, McKeon et al. 2009). These dorsiflexion restrictions can be due to decreased osteokinematic motion, decreased arthrokinematic motion, and/or positional faults (Denegar, Hertel et al. 2002; Mulligan

2004; Grindstaff 2009). Osteokinematic motion is due to contractile tissue (i.e. muscle, tendon, and fascia) and restrictions can be addressed through stretching (Prentice 2004). Ankle dorsiflexion, for example, can be increased through static stretching of the calf musculature (Radford, Burns et al. 2006). Arthrokinematic motion is the movement of articulating surfaces relative to each other, and can be restricted by inert connective tissue (i.e. ligaments and joint capsule). Normal arthrokinematic motion is necessary for normal osteokinematic motion to occur, and arthrokinematic motion can be restored through joint mobilizations (Prentice 2004). Joint mobilizations have been shown to increase dorsiflexion after ankle sprains or immobilization and in people with chronic ankle instability (Green, Refshauge et al. 2001; Reid, Birmingham et al. 2007; Landrum, Kelln et al. 2008; Hoch and McKeon 2010). This increase in dorsiflexion motion may be due to a restoration of posterior talar glide or because of a correction of a bony positional fault, which may occur following injury and can cause movement restrictions and/or pain (Denegar, Hertel et al. 2002). Specifically in the ankle, an anteriorly positioned talus can cause decreased dorsiflexion motion by limiting the amount of posterior glide that the talus can achieve during dorsiflexion (Mulligan 2004). In a study of chronic ankle instability, talar position was significantly more anterior in CAI limbs than in non-CAI limbs (Wikstrom and Hubbard 2010). It has been proposed that without joint mobilization, ankle dorsiflexion motion may be restored to a normal range through excessive stretching of the plantar flexors, extreme motion at surrounding joints, or forced at the talocrural joint through an abnormal axis of rotation (Denegar, Hertel et al. 2002). Talar laxity may also be affected by lower extremity injury. Talar laxity represents mechanical laxity in the talocrural joint, and is often seen after ankle sprains and in individuals with CAI (Denegar et al., 2002; T. J. Hubbard, Kaminski, Vander Griend, & Kovaleski, 2004; Nauck, Lohrer, & Gollhofer, 2010).

Since dorsiflexion range of motion is related to a variety of lower extremity injuries, an accurate measurement of dorsiflexion range of motion is essential to identify deficits and create injury prevention and intervention strategies. Measures of lower extremity range of motion can be taken passively, actively, or functionally. While passive and active range of motion measurements are easier clinical measures that allow for identification of range of motion impairments and tracking of changes over time, functional measurements may allow for a better representation of how the individual moves during physical activity. Double and single leg squat tasks represent functional lower extremity movements and provide information on a number of variables including functional ankle dorsiflexion and medial knee displacement. Double and single leg squatting tasks have been used in a variety of research studies looking at variables such as dorsiflexion motion, muscle strength, and neuromuscular characteristics (Bell, Padua, & Clark, 2008; Padua, In Review; Macrum, In Review; (Dill, Begalle et al. In Review).

Restricted dorsiflexion has been shown to play a role in a variety of lower extremity injuries. Research has assessed the role of both stretching and joint mobilizations on dorsiflexion range of motion. There is a gap in the literature, however, in comparing interventions which address both soft tissue and bony involvement in dorsiflexion restriction. This study will identify the specific contributions of joint mobilizations in addition to stretching, and will also look at a variety of ankle and knee kinematics prior to and during functional movement. Therefore, the purpose of this study is to determine the effects of a Mulligan's mobilization with movement (MWM) joint mobilizations on passive dorsiflexion range of motion, talar laxity, and double and single leg squat kinematics in subjects with restricted dorsiflexion.

INDEPENDENT VARIABLES

- Group
    - Control Group: Stretching plus sham mobilization
    - Intervention Group: Stretching plus joint mobilization
- Time
    - Pre-treatment
    - Post-treatment

DEPENDENT VARIABLES

- Passive dorsiflexion range of motion
    - Weight-bearing lunge
    - Passive, knee extended
    - Passive, knee flexed
- Posterior talar laxity
- Ankle stiffness
    - Anterior-posterior
    - Medial-lateral
- Double and single leg squat knee and ankle kinematics
    - Dorsiflexion displacement
    - Medial knee displacement
    - Knee valgus displacement

RESEARCH QUESTIONS AND HYPOTHESES

- Research Question #1: Is there a significant difference between the effect of ankle joint mobilizations plus stretching and stretching alone on measures of passive range of motion, ankle stiffness, and posterior talar laxity in individuals with restricted dorsiflexion ROM?
    - Research Question #1a: Is there a significant difference between the effect of ankle joint mobilizations plus stretching and stretching alone on measures of passive range of motion?
        - Research Hypothesis #1a: There will be significant increases in measures of passive range of motion for both groups, and significantly greater increases for the mobilization group compared to the stretching only group.

- Research Question #1b: Is there a significant difference between the effect of ankle joint mobilizations plus stretching and stretching alone on measures of ankle stiffness?
    - Research Hypothesis #1b: There will be a significant increase between the joint mobilization group and the stretching group on measures of ankle stiffness.
- Research Question #1c: Is there a significant difference between the effect of ankle joint mobilizations plus stretching and stretching alone on measures of posterior talar laxity?
    - Research Hypothesis #1c: There will be a significant increase between the joint mobilization group and the stretching group on measures of posterior talar laxity.

- Research Question #2: Is there a significant difference between the effect of ankle joint mobilizations plus stretching and stretching alone on measures of dorsiflexion displacement and medial knee displacement during double and single leg squatting tasks in individuals with restricted dorsiflexion ROM?
    - Research Question #2a: Is there a significant difference between the effect of ankle joint mobilizations plus stretching and stretching alone on measures of dorsiflexion displacement during double and single leg squatting tasks in individuals with restricted dorsiflexion ROM?
        - Research Hypothesis #2a: There will be significant increases in measures of dorsiflexion displacement during double and single leg squatting tasks for both groups, and significantly greater increases among the joint mobilization group than the stretching only group.
    - Research Question #2b: Is there a significant difference between the effect of ankle joint mobilizations plus stretching and stretching alone on measures of medial knee displacement during double and single leg squatting tasks in individuals with restricted dorsiflexion ROM?
        - Research Hypothesis #2b: There will be significant decreases in measures of medial knee displacement during double and single leg squatting tasks for both groups, and significantly greater decreases among the joint mobilization group than the stretching only group.
    - Research Question #2c: Is there a significant difference between the effect of ankle joint mobilizations plus stretching and stretching alone on measures of knee valgus displacement during double and single leg squatting tasks in individuals with restricted dorsiflexion ROM?
        - Research Hypothesis #2c: There will be significant decreases in measures of knee valgus displacement during double and single leg

squatting tasks for both groups, and significantly greater decreases among the joint mobilization group than the stretching only group.

STATISTICAL HYPOTHESES

- Statistical Hypothesis #1
    - H_0: EXP=CON
    - H_A: EXP$\neq$CON
    - H_{R1a}:EXP $>$CON
    - H_{R1b}:EXP $>$CON
    - H_{R1c}:EXP $>$CON
- Statistical Hypothesis #2
    - H_0: EXP=CON
    - H_A: EXP$\neq$CON
    - H_{R2a}:EXP $>$CON
    - H_{R2b}:EXP $<$CON
    - H_{R2c}:EXP $<$CON

OPERATIONAL DEFINITIONS

- Healthy subject: Subjects that have no history of lower extremity surgery, no history of knee or ankle injury in the past six months (i.e. an injury that caused the subject to refrain from activity from two or more days), and are not currently doing rehabilitation on any ankle or knee injuries.
- Double leg squat: Participants perform a squat maneuver, beginning with their feet shoulder-width apart, toes pointing straight ahead, and arms extended over their head. Subjects then flex their knees such as when sitting into a chair, to a depth of at least 60 degrees of knee flexion.
- Single leg squat: Participants perform a single leg squat maneuver, beginning by standing on their dominant leg with their hands on their waist and their non-dominant leg flexed to 45 degrees at the hip and 90 degrees at the knee. Subjects will then squat to a depth of at least 60 degrees of knee flexion.
- Restricted dorsiflexion: Equal to or less than 40 degrees of passive dorsiflexion measured with the weight-bearing lunge test.
- Talocrural joint mobilization treatment: A single treatment session of 3-30 second bouts of a Mulligan's mobilization with movement (MWM) talocrural joint mobilizations.
- Stretching treatment: A single treatment session of 2-30 second bouts of knee extended calf stretching and 2-30 second bouts of knee bent calf stretching on a slant board.