Ultrasonography Comparison of Peroneus Muscle Cross-sectional Area in Subjects With or Without Lateral Ankle Sprains

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Abstract

Objective: The purpose of this study was to quantify the cross-sectional area (CSA) of the peroneus brevis, the peroneus longus, and connective tissue; to compare these measures in participants with and without lateral ankle sprains (LAS); and to determine the intraexaminer reliability of the protocol used to acquire these measures.
Methods: A cross-sectional case-control study was undertaken. B-mode ultrasound imaging was performed to measure the resting CSA and circular perimeter of the muscles and connective tissue and the total area and ratio between the CSA of the peroneus longus and the peroneus brevis. The imaging was performed for 56 feet, 28 with LAS and 28 without LAS (the mean numbers ± SD of total LAS, grade-I LAS and grade-II LAS were 4.1 ± 3.6, 2.71 ± 3.2, and 1.39 ± 0.9, respectively). A univariate correlation analysis using Pearson (r) and the Kendall *tau_b* (τ_B) coefficients was performed to evaluate the ultrasound imaging measurements ($\alpha = 0.05$).
Results: Statistically significant differences ($P < .05$) were observed between the 2 groups, with a moderate negative correlation for the circular perimeter of the peroneus longus ($P = .001$; $r = -0.444$) and a weak association for the CSA of the peroneus longus ($P = .002$; $\tau_B = -0.349$), the ratio between the CSA of the peroneus longus and the peroneus brevis ($P = .008$; $\tau_B = -0.293$), and the circular perimeter of connective tissue ($P = .013$; $\tau_B = -0.277$).
Conclusions: The peroneus longus CSA is reduced in participants with LAS compared with that in participants without LAS. The intraexaminer reliability of the ultrasonography protocol was excellent when quantifying the peroneus brevis and the peroneus longus muscle tissues and acceptable when quantifying connective tissue. (J Manipulative Physiol Ther 2016;xx:1-10)
Key Indexing Terms: *Anatomy, Cross-sectional; Ankle Injuries; Lateral Ligament, Ankle; Ultrasonography; Physical Therapy Modalities*

Introduction

Lower limb conditions are frequent in developed countries. Approximately 8% of primary care consultations are related to foot and ankle pathologies.[1] Acute ankle sprain is the most prevalent acute sport trauma and accounts for approximately 14% of all sport-related injuries. Lateral ligamentous sprains that originate from explosive inversion or supination comprise 80% of these injuries.[2]

Consequently, lateral ankle sprain (LAS) exhibits a high recurrence rate and results in considerable economic loss resulting from medical care, prevention, and secondary disability.[3] Although sensorimotor deficits caused by chronic and functional ankle instability may produce pain and muscle

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weakness, limit the range of motion, and alter postural motor control, the causes of these deficits remain controversial.[3,4] Despite these effects, immobilization is not recommended in some cases because of the risk of secondary joint stiffness, muscle atrophy, and the loss of proprioception, as well as the relationship of these effects with the delayed reaction time of the peroneal muscles at the lateral aspect of the ankle (60-90 ms).[2]

Rehabilitative ultrasound imaging (RUSI) has been used to measure the cross-sectional area (CSA), thickness, and connective tissue of various muscles associated with musculoskeletal conditions that affect physical therapy evaluation.[5] In the trunk region, connective and muscular tissues of the multifidus and the abdominal wall muscles have been associated with lumbopelvic pain.[6,7] Moreover, the presence of scapular dyskinesis increases the thickness of the lower trapezius during activation.[8] In patients with chronic neck pain, the CSA, width, and thickness of the longus colli and sternocleidomastoid in the cervical region can be changed through a training program.[9] Additionally, the thickness and function of the masseter, the anterior part of the temporalis and sternocleidomastoid muscles, has been associated with temporomandibular disorders.[10] In the upper limb, the supraspinatus muscle has been linked with subacromial impingement syndrome.[11] Ultrasonographic measurement of the CSA of intrinsic hand muscles can predict muscle strength validly and reliably in patients with nerve injuries.[12] For the lower extremities, a recent study used RUSI to investigate the relationship between the vastus medialis and other lower extremity muscles in women with early-stage osteoarthritis of the knee.[13]

Considering the lower leg region, Crofts et al.[14] reported that the CSA and thickness of plantar muscles (flexor hallucis brevis; flexor digitorum brevis; abductor hallucis; flexor digitorum longus; flexor hallucis longus; tibialis anterior; and peroneus longus and peroneus brevis) and fascia can be used to explain how injuries may be related to alterations in foot function and clinical pathology. These RUSI measurements presented an excellent interrater reliability (intraclass correlation coefficient [ICC]) for muscle thickness (0.90-0.97), plantar fascia thickness (0.94-0.98), and CSA (0.91-0.98).[14] Participants with pes planus also have been reported to have variations in CSA and thickness in these intrinsic and extrinsic soft tissue structures.[15]

Atrophy, tendon rupture, and delayed reaction times of the peroneus muscles have been related to ankle sprains.[2,16] RUSI measurements have also revealed a 14.7% reduction in the CSA of the peroneus muscles and a 10% reduction in peroneus muscle thickness in participants with pes planus.[15] Nevertheless, to date, no study has compared the peroneus longus and the peroneus brevis separately or assessed their soft tissue CSA changes in relation to ankle sprains. Accordingly, the aim of this study was to determine the CSA of the peroneus brevis, the peroneus longus, and connective tissue and to compare these measurements in participants with ankle sprains and in those without ankle sprains. The intraexaminer reliability of the ultrasonography protocol used to quantify these measures was also assessed.

Methods

Participants

A convenience sample of 56 feet was obtained from medical records at the CARMASALUD clinical and research center, Madrid, Spain (26 feet with a prior grade I or II diagnosis of LAS and 26 feet without this condition).[17] None of the participants had been treated by the investigators or received physical therapy of the leg, foot, or forefoot areas in the 6 months before data collection.[6]

Participant inclusion criteria included an age 18 to 65 years; no pain in the leg, foot, and forefoot regions; and absence of ankle sprains over the previous 6 months.[14] Exclusion criteria included self-reported previous fractures, surgeries, ligament or muscle tears, tendinopathies, neuropathy injuries, systemic disease (eg, diabetes, rheumatoid arthritis, or osteoarthritis), or pharmacotherapy (eg, muscle relaxants or chemotherapy).[14,15,18] Exclusion criteria also included past diagnosis of a neuromusculoskeletal condition of the foot or forefoot (eg, deltoid ligament and tibiofibular syndesmosis ankle sprains, use of plantar orthoses, pes planus and cavus, hallux valgus and rigidus, plantar fasciitis, heel spurs, Morton neuroma, Sever disease, tarsal tunnel syndrome, or entrapment of the deep or superficial peroneal nerve)[14,15,18-23]; of the leg (eg, fibular tunnel syndrome or degeneration or inflammation of the tibial periosteum)[14,15,18]; of the knee (eg, meniscopathy, lateral and cruciate ligament sprains, Baker cysts, or bursitis)[24,25]; of the thigh (eg, hamstring tunnel syndrome of the sciatic nerve)[26]; of the hip (eg, impingement syndrome or labral injuries)[27]; or of the lumbosacral region (eg, piriformis muscle syndrome or sacroiliac joint dysfunction).[28,29] Participants with conditions involving the peroneus quartus muscle, tendon rupture, or peroneus longus and the peroneus brevis muscles of a large volume that did not permit proper RUSI evaluation within the limits of the ultrasound transducer were also excluded.[16,30] In addition, participants who exercised for less than 1 hour or more than 3 hours per week or at a high intensity (eg, competition) were excluded because of CSA changes in the lower limbs (eg, peroneal muscles) that may be generated by exercise, injury, or disuse.[31]

The study protocol was approved by the Intervention Clinical Committee of the European University of Madrid, Spain (CIPI/044/15). Consent was obtained from all participants before the start of the study. The study also adhered to the ethical standards of the Declaration of Helsinki and the STROBE guidelines for human experimentation.[32,33]

The following participant characteristics were collected: sex (male or female), age (years), number of lateral ligament ankle sprains (total, grade I and grade II), weight (kg), height (cm), body mass index (BMI; kg/m^2), side