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Relationships between mechanical joint stability and somatosensory function in individuals with chronic ankle instability

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HIGHLIGHTS

- People with CAI have demonstrated alterations in ankle mechanics and sensory deficits.
- Sensory function, mechanical stability, and injury history do not appear to be related.
- Causes of somatosensory impairment in individuals with CAI warrant more investigation.

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ABSTRACT

Background: Individuals with chronic ankle instability (CAI) have demonstrated alterations in ankle mechanics and deficits in sensory function. However, relationships between mechanical stability and somatosensory function have not been examined, nor have those between somatosensory function and injury history characteristics. Therefore, the objective of this study was to examine relationships between (1) somatosensory function and mechanical stability and (2) somatosensory function and injury history characteristics.

Methods: Forty adults with CAI volunteered to participate. In a single testing session, participants completed mechanical and sensory assessments in a counterbalanced order. Dependent variables included anterior/posterior displacement (mm), inversion/eversion rotation (°), SWM index values, JPS absolute error (°), number of previous ankle sprains, and number of "giving way" episodes in the previous 3 months. Spearman's Rho correlations examined the relationships between somatosensory function and (1) mechanical stability and (2) injury history characteristics ($p < 0.05$).

Results: No significant correlations were identified between any variables ($p > 0.11$), and all r-values were considered weak.

Conclusions: These results revealed somatosensory function was not significantly correlated to mechanical stability or injury history characteristics. This indicates peripheral sensory impairments associated with CAI are likely caused by factors other than mechanical stability and injury history characteristics.

1. Introduction

Ankle sprains are one of the most common injuries in athletic populations, accounting for approximately 30% of all sports-related injuries [1]. Recent estimates indicate that over three million ankle sprains occurred in the general population of the United States from 2002 to 2006 [2]. Recurrent injury and residual symptoms are major issues facing ankle sprain patients as up to 70% experience additional ankle sprains and recurrent bouts of joint instability which are both characteristics of chronic ankle instability (CAI) [3,4]. CAI has been linked to long-term, residual symptoms that may affect daily life and sport activities for years post-injury [5]. The established relationship between CAI and long-term consequences that include degenerative joint disease [6], decreased physical activity [5], and decreased health-related quality of life (HRQOL) [7,8],

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requires that clinicians seek a better understanding of this condition.

Following ankle sprain, the lateral ankle frequently demonstrates arthrokinematic alterations [9] as well as pathological ligamentous laxity [10] which subsequently leads to joint instability [3]. While excessive ankle laxity has been associated with anterior talar translation and inversion rotation, arthrokinematic restrictions have been identified with posterior talar glide [11,12]. Joint laxity and arthrokinematic restrictions are commonly measured clinically using selective tissue tests such as the anterior drawer, posterior drawer, or inversion talar tilt tests [13]. However, instrumented ankle arthrometry allows more precise, quantifiable measures of joint stability [12]. This form of testing has been capable of detecting differences in ankle mechanics post-injury and following rehabilitation [14,15]. While it is clear joint laxity and arthrokinematic restrictions directly impact mechanical ankle stability, it remains unclear how these impairments may alter sensory information arising from joint structures.

In addition to altering ankle mechanics, injury to the lateral ankle ligaments is thought to damage the mechanoreceptors in the ligamentous and capsular tissues supporting the ankle [16]. Disruption to these mechanoreceptors may impair the ankle's joint position sense (JPS) [17]. The presence of this proprioceptive deficit was confirmed in a meta-analysis of the literature which indicated individuals with CAI demonstrate diminished JPS particularly when using active repositioning methods [17,18]. While articular mechanoreceptors are a crucial source of somatosensory information, the cutaneous mechanoreceptors on the plantar aspect of the foot are also important. These receptors provide information related to the interface between the person and environment during standing and ambulation [19]. Semmes-Weinstein Monofilaments (SWMs) can be used as an evaluation tool to measure cutaneous sensation [20]. A non-invasive technique, SWMs are a series of weighted thin nylon fibers that are applied to the skin surface in a strategized sequence to determine the patient's detection threshold. Recent research examining plantar cutaneous sensation in individuals with CAI reported diminished sensation as measured by SWMs and vibrotactile detection thresholds [21,22]. Therefore, the ligamentous damage that occurs in conjunction with an ankle sprain may result in somatosensory alterations that extend beyond the articular mechanoreceptors in individuals with CAI.

Individuals with CAI have displayed changes in joint mechanics and decreased sensory function [3,18,21], but at this point, the relationships between these deficits remain unclear. Additionally, the relationships between number of previous ankle sprains, episodes of "giving way", and sensory function have not been examined. Examining the relationship between somatosensory function, ankle mechanics, and injury history may provide insight into subgroups of CAI patients who experience sensory alterations which would enable clinicians to focus potential treatment strategies. Therefore, the purpose of this study was to examine the relationships between somatosensory function and (1) mechanical stability and (2) injury history characteristics. It was hypothesized that individuals with CAI who demonstrated diminished somatosensory acuity would also exhibit greater mechanical instability and a greater number of previous ankle sprains and episodes of "giving way".

2. Methods

2.1. Study design

This data was collected as part of a larger cross-sectional study [23]. Dependent variables included somatosensory function (JPS and plantar cutaneous sensation), mechanical stability (anterior/posterior displacement and inversion/eversion rotation), and injury history characteristics (number of previous ankle sprains and number of episodes of "giving way").

2.2. Participants

Forty physically active adults with CAI (13 males and 27 females; 23.25 ± 4.79 years, 168.85 ± 9.20 cm, 72.04 ± 14.36 kg) were included in this study. Participants were recruited over a one-year time period from a large, public university community. To meet the inclusion criteria, a participant had to self-report a history of one or more ankle sprains, at least one episode of "giving way" in the last three months, a score less than 24 on the Cumberland Ankle Instability Tool (CAIT), and five or more "yeses" on the Ankle Instability Instrument [24]. Ankle sprain was defined as an acute traumatic injury to the lateral ligament complex of the ankle following excessive inversion of the rear foot or a combined plantarflexion and adduction of the foot, with some initial deficits of function and disability [25] (i.e., swelling, pain, time lost). An episode of "giving way" was described to participants as an incident in which the rearfoot suddenly rolled, felt weak, or lost stability that did not result in an acute ankle sprain [25]. Participants who experienced any lower extremity injury in the last six months or suffered from any neurological disorders that could influence balance were excluded. If a participant complained of bilateral CAI, the ankle with the lower CAIT score was selected for testing. Prior to data collection, institutional review board approval was obtained, and all participants provided informed consent.

2.3. Procedures

Participants attended one data collection session during which they completed the inclusionary instruments followed by measures of somatosensory function and ankle-subtalar mechanical stability. A Hollis Instrumented Ankle Arthrometer (Blue Bay Research Inc., Navarre, FL) was used to measure mechanical stability in the anterior, posterior, inversion, and eversion directions. The participant was positioned sitting off of the edge of an evaluation table, and the foot was placed in the device then secured with the dorsal and heel clamps. The participant then moved to a supine position on the table with the assistance of the investigator. An investigator secured the participant's leg to the table using two adjustable straps to ensure the leg remained in the same position throughout testing. Each trial began with the participant's foot in neutral, and then the ankle was loaded with 125 N of force in the anterior direction, immediately followed by the posterior direction. After three anterior/posterior trials, the ankle was loaded with 4000 Nm of torque in inversion immediately followed by eversion [26]. The average of three trials in each direction was used for analysis. The same investigator measured mechanical stability throughout testing as ankle arthrometry has demonstrated excellent intratester reliability (ICC = 0.91–0.99) [27].

To capture JPS, a bubble inclinometer (Baseline Bubble Inclinometer, Fabrication Enterprises Inc., White Plains, NY) was fixed to the lateral side of the participant's affected foot via two velcro straps. The affected ankle was then placed in 20° of plantarflexion using a standard goniometer. To prevent any visual stimuli, participants were asked to close their eyes and focus on the position of their ankle. The investigator held the ankle in the pre-set position for five seconds. Participants were then instructed to move their ankle through the entire range of motion and indicate when they had returned to the pre-set position [28]. Each participant completed one practice trial for familiarization followed by three test trials from which the absolute error (°) was recorded and rounded