Spinal Reflexive and Corticomotor Fibularis Longus Excitability Predict Self-Reported Function in Patients with Chronic Ankle Instability

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ABSTRACT INTRODUCTION:
Chronic ankle pain accounts for approximately 20 percent of all joint related pain in the United States. Ankle sprains are the most prevalent lower extremity injuries in sport, and the incidence of an initial sprain is as development of physical disability. Chronic ankle instability is contributed to by mechanical factors, including ligamentous laxity, and functional factors, including neuromuscular alterations. Neural control of stabilizing muscles around the ankle is generated through spinal reflexive and descending corticomotor neural excitability pathways. Both spinal reflexive and descending corticomotor neural excitability pathways have been reported to be altered in patients with chronic ankle instability compared to healthy individuals. While there is a significant amount of current research being invested in therapeutically improving neural excitability, it remains unknown if these pathways affect disability in these patients with chronic ankle instability. Therefore, the purpose of this study was to determine the ability of spinal reflexive and descending corticomotor neural excitability pathways corresponding to the fibularis longus to predict self-reported disability in patients with chronic ankle instability. We hypothesized that both neural excitability pathways would be influential in predicting disability.

METHODS:
Twenty patients with unilateral chronic ankle instability (13F/7M, 20.85±1.50 years, 171.01 ±11.22 cm, 67.95±11.63 kg) volunteered for this study. All patients read and signed a consent form approved by the Institutional Review Board. All patients reported a history of a significant lateral ankle sprain, and at least two episodes of a subsequent feeling of “giving way” or a “feeling of instability” in the ankle during the previous 3 months. Additionally, all scored less than 80% on the Foot and Ankle Disability Sport Index (FADISport). The FADISport includes 8 questions that ask the participant to rate their disability during performance of demanding physical activities, such as running. The FADISport is represented as a percentage score and used to evaluate self-reported disability. Participants reported to the research laboratory for a single session. Participants were positioned in a Biodex System II Pro dynamometer with hips flexed to 85°, knees flexed to approximately 10° and the ankle plantar flexed to 10° for evaluation of both the spinal and corticomotor excitability pathways. The calcaneus of the tested limb was secured in a rubber heel cup mounted on a flat platform. Two EMG electrodes were adhered 1.75cm apart on the greatest bulk of the fibularis longus, approximately 2-3cm inferior to the fibular head. For corticomotor testing, a double cone coil was positioned over the vertex of the skull above the cortical neurons that corresponded with descending pathways that excited the contralateral fibularis longus muscle. The MagStim model 200 (MagStim Company, Ltd., Wales, UK) was used to deliver a single magnetic pulse with a possible strength of 2 Tesla, yet the double cone coil configuration only allows for a maximum of 70% of the stimulation (1.4 Tesla). This point was denoted on the swim cap with a felt tipped marker and used as the point for stimulation during active motor threshold testing. Participants performed a standardized plantar flexion contraction at 5% of their maximal voluntary isometric contraction while the investigator stimulated the motor cortex. The magnetic stimulation was decreased by 5% until no motor evoked potential could be elicited in the fibularis longus. Then the percentage of magnetic stimulation was increased by 1-2% until five out of ten consecutive stimuli produced a measurable motor evoked potential (≥100μV). The active motor threshold was expressed as a percentage of 2 Tesla. Lower active motor thresholds indicate increased corticomotor excitability. Spinal reflex excitability was assessed using Hoffmann reflex technique and expressed as a maximal Hoffmann reflex to maximal muscle response ratio (H:M Ratio). A higher H:M ratio indicates increased spinal reflex excitability. H:M Ratios were collected using a stimulating electrode placed over the common fibular nerve. A 1ms square-wave stimulus was administered to the common fibular nerve and the maximal Hoffmann reflexes and maximal muscle responses were elicited.

Means and standard deviations of pertinent variables are listed in Table 1. Prior to performing regression analyses, Pearson Product Moment correlations were used to determine simple relationships between spinal reflexive and descending corticomotor neural excitability and self-reported disability using the FADISport, individually. Next, a hierarchical multiple linear regression analysis was used to determine the capability of active motor threshold and H:M ratio to predict self-reported FADISport. Individual changes in R² (ΔR²) were calculated after inclusion of each predictor variable into the model. An alpha level of P ≤ 0.05 was determined a priori to evaluate the significance of both simple correlation analyses and the multiple regression model.

RESULTS:
There was a significant and negative, moderate correlation between fibularis longus H:M ratios and self-reported FADISport (r= -0.48, P=0.03), while a non-significant and positive, moderate correlation existed between fibularis longus active motor threshold and FADISport (r=0.43, P=0.06). H:M ratios (ΔR²=0.23, P=0.03) and active motor threshold (ΔR²=0.20, P=0.02) individually predicted a significant amount of variance in the overall regression model. Combined, H:M ratio and active motor threshold predicted 44% (R²=0.44, P=0.008) of the variance in self-reported FADISport (FADISport = -43.6 H:M + 0.82 Active Motor Threshold + 32.03).

DISCUSSION:
Excitability of both reflexive and corticomotor pathways account for 44% of the variance in self-reported disability during athletic activities in patients with chronic ankle instability. A moderate negative correlation between H:M and FADISport as well as a moderate positive correlation between active motor threshold and FADISport indicate that both spinal and corticomotor excitability increases as disability intensifies. This may be interpreted as an up-regulation of both spinal and corticomotor excitability in the fibularis longus muscle as disability intensifies in this patient population. An up-regulation of these influential neural pathways may be indicative of a neural excitability alteration needed to produce a motor control strategy that could protect against ankle inversion by activation of the fibularis longus, a muscle capable of ankle eversion. While 44% of the variance in self-reported disability can be explained by the combined spinal and cortical excitability of the fibularis longus, the current predictive model is limited to the excitability of a single muscle. Subsequently, future analysis may include related impairments such as muscle strength, pain, ligamentous laxity and postural control to better predict dysfunction in patients with chronic ankle instability.

SIGNIFICANCE:
Chronic ankle pain accounts for 20 percent of all joint related pain, and multiple ankle sprains may lead to joint degeneration and disability. The current study is the first to describe the influence of specific neural pathways on disability in patients with chronic ankle instability, which is a significant and fundamental step in developing interventions to target the neuromuscular factors that contribute to disability.

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Table 1. Means and Standard Deviations

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<th>Fibularis Longus H:M Ratio</th>
<th>Fibularis Longus Active Motor Threshold</th>
<th>FADISport</th>
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<tr>
<td></td>
<td>.30 ±.19%</td>
<td>55.76 ± 9.25%</td>
<td>64.5 ± 16.7</td>
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Active Motor Threshold + 32.03.