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Original Research

Strength-Duration Curves of the Common Fibular Nerve Show Hypoexcitability in People With Functional Ankle Instability

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Abstract

Background: Some motor impairments, such as decreased reaction of peroneal muscles, altered kinematics, or poor postural control, have been described in people with functional ankle instability. Evidence shows a possible relationship between fibular nerve impairments and functional ankle instability.
Objective: To investigate the electrophysiologic excitability of the common fibular nerve, as measured by strength-duration curves, in subjects with functional ankle instability compared with a control group without ankle impairment.
Design: A cross-sectional study.
Setting: University Research laboratory.
Participants: Fifty subjects with functional ankle instability (35 men, 15 women; ages 24.36 ± 5.01 years) and 63 uninjured control patients (44 men, 19 women; ages 22.67 ± 4.85 years) were recruited by convenience sampling.
Interventions: Not applicable.
Main Outcome Measures: Strength-duration curves of the common fibular nerve were made in all participants. Rheobase, chronaxie, Bawen index, accommodation index, galvano-tetanic threshold, and intensity thresholds for different pulse durations were obtained and compared between the 2 groups.
Results: Subjects with functional ankle instability show increased values of chronaxie (0.58 ± 0.24 ms versus 0.47 ± 0.16 ms; $P = .004$), Bawen index (1.53 ± 0.24 versus 1.39 ± 0.21; $P = .002$), and intensity thresholds for pulse durations ≤2 ms both for rectangular and triangular pulse wave forms. The accommodation index was smaller in subjects with functional ankle instability than controls (3.7 ± 0.72 versus 4.05 ± 0.98; $P = .036$). The remaining parameters did not show significant differences between groups.
Conclusions: These findings suggest that subjects with functional ankle instability show a decreased excitability in their common fibular nerve when compared with subjects without ankle injuries.

Introduction

Ankle injuries are very common during sports activities. Fong et al [1] showed that ankle injuries were the most frequent injury in 34.3% of the 70 sports studied, and of these, ankle sprains were the most prevalent (76.7%). The incidence of these injuries in adolescent high school athletes during the period 2005-2006 in the United States was 22.6% [2]. It is estimated that between 20% and 40% of ankle sprains will cause chronic ankle instability (CAI), and this percentage can increase to 70% in specific sports such as basketball [3,4]. In a recent study [5], it has been shown that soccer, basketball, and volleyball were the sports with the greatest percentage of participants who reported recurrent ankle sprains (61%, 60%, and 50%, respectively).

Hertel [6] defined 2 aspects of CAI: mechanical ankle instability, characterized by deficits in the capsule-ligamentous system with joint hyperlaxity, and functional ankle instability (FAI), characterized by proprioceptive and balance deficits or weakness. When mechanical ankle instability and FAI coexisted, recurrent sprains appeared. This "pathophysiological" model has been modified in recent years to one more focused on the impairment associated with CAI [7]. In this new model, CAI is defined as the persistence of 1 or more of the following conditions after an acute ankle sprain: (1) perceived ankle instability (FAI); (2) mechanical ankle

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instability; and (3) recurrent ankle sprain [7]. The common symptoms associated with CAI are chronic pain, episodes of giving way, recurrent sprains, and swelling [8,9]; they may not only limit activity but also may lead to an increased risk of osteoarthritis and ankle joint degeneration [10]. In the new model of Hiller et al [7], FAI is related to the feeling of giving way or instability of the ankle, regardless of whether this subjective feeling is associated with mechanical instability [7,11].

Although the pathophysiologic mechanisms of FAI have not been completely clarified, some types of deficits have been described in people with FAI. There is some evidence of deficits in balance and postural control [12-14], altered kinematics during different activities [15-20], and altered response of the ankle pronator muscles [21-23]. In addition, recent studies have shown decreased afferent traffic from muscle spindle measured in the fibular nerve [24] and a gain modulation of the cutaneous reflexes measured in peroneus longus in subjects with unstable ankles [25]. Therefore, these deficits may be related to any kind of impairment of the fibular nerve, but there is a lack of prospective studies that can establish a causal relationship between fibular nerve impairment and ankle sprains or ankle instability.

Although there are some studies that have described lesions of fibular nerve in subjects suffering from inversion injuries in their ankles [26-31], most are reports of isolated cases and case series. However, some of these researchers have shown an association between ankle injuries and the fibular nerve impairment caused by mechanical traction of the nerve. Nitz et al [32] obtained a prevalence from mild-to-moderate severe denervation (1−2+) of 17% in subjects with grade II (defined by authors as an injury of lateral and medial ligament complex rupture) and 86% in grade III (defined by authors as the injuries of grade II plus the distal anterior tibiofibular ligament injury) acute ankle sprains. These alterations have been observed in subacute ankle sprains, with a normalization of the values 5 weeks after injury [33]. Additionally, Jazayeri et al [34] found a significant decrease of nerve conduction velocity (NCV) and increased distal latency in the peroneal and tibial nerves in a sample of football players with FAI. Therefore, the evidence indicates that the evaluation of the fibular nerve function in patients with unstable ankles may be interesting.

A way to study the involvement of the common fibular nerve in FAI subjects could be the use of a traditional test of nerve excitability such as the strength-duration curves (S-D curves) [35-43]. They are based on the relationship between the intensity of an electric monophasic rectangular pulse and its duration in provoking a motor response when a motor nerve is electrically stimulated. This relationship describes a hyperbolic function [37]. In denervation processes, this curve has a particular path, with increased stimulation thresholds and a lack of response to shorter duration pulses [35,37,43] S-D curves have shown good reliability indexes both for their thresholds path [38,39] and for the known parameters obtained from them [43].

Several authors have studied the applicability of S-D curves for areas such as the detection of the level of disk injury and lumbar radiculopathy [44,45], evaluation of chronic hemiparetic muscles in patients with central nervous system injury [46], and diagnosis of pelvic floor dysfunction [47-50]. No previous studies have investigated the application of S-D curves to evaluate the excitability of the common fibular nerve in subjects with FAI. A change in excitability could explain the patient reported symptoms used for defining FAI (as feeling of giving-way, weakness, or recurrent sprains). Because the test is objective, noninvasive (the technique is transcutaneous, nor percutaneous), safe, economic, and easy [40,42,43,48,50], it can be used in rehabilitation and physical therapy consultations. Therefore, the aim of this study was to investigate the electrophysiologic excitability of the common fibular nerve, as measured by S-D curves, in subjects with functional ankle instability compared with a control group without ankle impairment.

Methods

Study Design and Participants

The subjects were recruited for this descriptive cross-sectional study by convenience sampling from a university campus (volunteer recruitment). Table 1 shows demographic characteristics of both groups.

Sample size was calculated by considering the main parameters from S-D curves. For detecting differences of 1 mA in rheobase, 3 mA in galvanic-tetanic threshold, and 0.1 ms in chronaxie, and assuming

Table 1
Demographic characteristics for both groups*

	FAI Group	Control	*P* Value	95% CI
Gender (% men)	70%	69.8%	.99	—
Age, y	24.36 ± 5.01	22.67 ± 4.85	.07	−3.54 to .15
Weight, kg	73.5 ± 11.64	69.15 ± 11.56	.05	−8.70 to .003
Height, cm	175.1 ± 8.46	172.61 ± 9.21	.14	−5.83 to .84
BMI, kg/m^2	23.89 ± 2.86	23.1 ± 2.65	.13	−1.82 to .25
CAIT-Sv	19.6 ± 4.15	29.21 ± 0.77	<.001†	8.41 to 1.80
Predominance (% right hand)	84.1%	78%	.53	—
Physically active‡ (%)	42.8%	38%	.70	—

FAI = functional ankle instability; CI = confidence interval; BMI = body mass index; CAIT-Sv = Spanish version of the Cumberland Ankle Instability Tool.

* Data are expressed as mean ± standard deviation for quantitative data and percentages for qualitative data.

† Statistical difference between groups.

‡ A physically active person must practice any physical activity at least 3 h/wk.