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Review

How far do stabilometric and clinical parameters correlate in peripheral neuropathies?

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ABSTRACT

Peripheral neuropathies are characterized by the impairment of motor and sensitive nervous fibers. We aimed to investigate the correlation between proprioception, force and the limits of equilibrium parameter (LOE), by assessing 38 patients diagnosed with characterized bilateral neuropathy and 11 healthy subjects. Clinical evaluation, based on a motor and pallesthesic score, enabled their classification into groups corresponding to motor, sensitive or mixed neuropathies. Balance measures *on* a stabilometric platform allowed differentiation between the patients and healthy subjects but not between the groups of patients. *The parameter limits of equilibrium* (LOE) calculated as percentage of foot length allowed not only the differentiation between patients and healthy subjects but also between patients showing motor and sensitive forms. *ROC analysis gave a threshold of 15% for LOE to discriminate between motor and sensory neuropathies with a 75% of sensitivity and 72% of specificity.* Consequently, *we propose a simple experimental procedure* to carry out an accurate assessment of balance disorders *in order to identify* future rehabilitation modalities recommended to these patients.

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1. Introduction

Peripheral neuropathies are characterized by the impairment of motor and sensitive nervous fibers. *They belong to* a heterogeneous group according to their etiology and clinical forms. Balance and gait control are common impairments.

Ongoing studies have adopted a genetic approach to inherited neuropathies or immunologic considerations in inflammatory neuropathies. Such studies contribute to a better understanding of the most common neuropathies [1,2]. Recent studies have focused on the respective roles of *motor and sensory functions* impairment and their relative contribution to imbalance. In this respect, some authors have pointed out the existence of a strong relationship between the role of distal muscles and the size of sensory fibers in static and especially dynamic balance [3–5]. More specific, subjects from the population with peripheral neuropathy may be more affected in terms of motor level than sensitive level, *or the opposite*.

The dissociation of motor impairment from sensory impairment in these patients could not only inform us about their direct influence on balance function, but also guide us to the most appropriate rehabilitation modalities. Indeed, balance rehabilitation has long been proposed for patients with common mixed sensory and motor neuropathy. Recently, interest has been focused on certain forms, such as ataxic neuropathies [6,7].

Several methods have been put forward to assess balance in subjects showing sensory or motor neurological impairments, including an instrumental approach in which center of pressure sway area is analyzed in static [8] or dynamic [3,5] conditions. Dynamic exploration methods that study the biomechanics of gait initiation [9], sit to stand performance [3] or lateral step-up [10] *are limited* because of their cost and complexity. *In daily clinical* practice the stabilometric platform remains the most commonly used tool for instrumentally characterizing static balance. The analysis of the sensory component through the assessment of the role of *visual inputs* is a long-established protocol (Romberg's test). *However, motor impairment is better assessed in dynamic conditions as proved by Owings et al. (2000)* [11] *suggesting the use of more adapted paradigms, such as the limits of equilibrium (LOE) parameter, which was proposed by Schieppati et al. (1994)* [12].

The aim of this study is to use a static stabilometric platform to assess the most relevant parameters for discriminating between specific behaviors in neuropathies with sensory or motor predominance. We formulate the hypothesis that the LOE parameter will be correlated to proprioception and muscle force

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and will contribute to a more accurate specification than simple stabilometry of the clinical characteristics of peripheral neuropathies.

We seek to answer this question in this study by comparing the results of equilibrium parameters collected from patients with Charcot-Marie-Tooth disease (CMT), chronic inflammatory demyelinating polyradiculoneuropathies (CIDP) and ataxic neuropathy from other etiology (AN), all of which are peripheral nervous system diseases that show sensory and/or motor impairments of different expression.

2. Methods

2.1. Participants

Thirty-eight patients with characterized bilateral neuropathy *were recruited* in two centers of reference on neuromuscular disorders (Paris-East and Paris-South Assistance Publique reference centers) and referred to the rehabilitation unit by neurologists for balance and gait training. All had clinical, electrophysiological, histological or genetic data corresponding to a well-defined polyneuropathy. The diagnoses of those patients were a hereditary neuropathy of CMT type, chronic inflammatory demyeliting polyradiculoneuropathy (CIDP) and ataxic neuropathy (AN).

The exclusion criteria were: cognitive impairment, proximal motor weakness, contractures, and other neurological or orthopaedic disorders that affect gait and balance. We excluded all patients taking medications that would affect balance or gait.

All patients and controls were informed of the aims of the *study* and gave their written consent for the anonymous analysis of the data.

2.2. Procedure

The instrumental evaluation of balance was performed using a force platform (Satel, Blagnac, France). Balance was first evaluated in an upright standing position in two successive conditions on a rigid surface, first with the eyes open and then with the eyes closed. *The duration of recording (one for each condition) was 51.2 s* (sampling rate: 40 Hz). The sway area of center of pressure, corresponding to 95% of the confidence ellipse, was analyzed under each of the two conditions.

For the limits of equilibrium (LOE) evaluation, a recording of 12.8 s was carried out in which the subject held the maximum possible leaning posture (i.e. body straight, rotated at the ankle joints without lifting off the heels or the toes) successively in a forward and backward direction [12].

The retained parameter was the difference between the mean values of the CP according to the Y axis during the two leaning postures in a forward and backward direction (see Fig. 1). The foot length normalized the mean values of the CP displacement during the leaning postures for each subject.

2.3. Parameters

Muscle strength was evaluated using the following Medical Research Council (MRC) criteria[13], as proposed in both hereditary neuropathies and CIDP with a scale from 0 to 5 where: 5 = Normal power; 4 = Active movement against gravity and resistance; 3 = Active movement against gravity but not against resistance; 2 = Active movement with gravity eliminated; 1 = Flicker or trace contraction; 0 = No contraction. After evaluation we considered the lowest score of distal muscles. For all the three groups of patients the lowest score was from the *tibialis anterior* muscle.

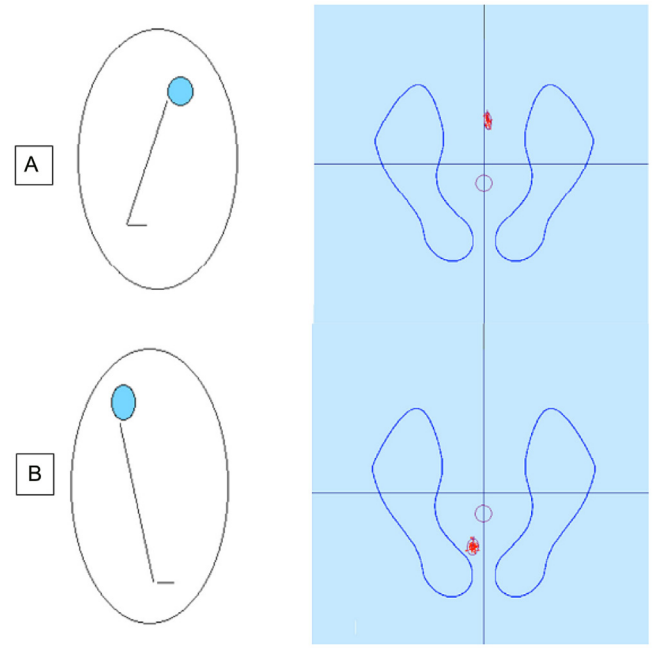

Fig. 1. Experimental setup and stabilograms in leaning forward (F) and backward (B) postures of a healthy subject.

Vibration perception was assessed with a 256 Hz tuning fork and a pallesthesic score (PS) was determined, as proposed by Merkies et al. (2006) [14] for CIDP, from no change (=0) to decreased vibration at big toe (=1), at lateral malleolus (=2), at patella (=3) or at greater trochanter (=4). A total score (0–8) was obtained when scoring the bilateral impairment of lower limbs.

At the end of the clinical evaluation, the neuropathy subgroups were clinically defined as follows:

Sensory neuropathy (SN): sensitivity abolition of the tuning fork with a pallesthesic score superior or equal to 2 and motor force preservation (motor score of 4–5), allowing the patient to walk on heels and tiptoes as needed with a walking aid.

Motor neuropathy (MN): motor score inferior to 4 and pallesthesic score inferior or equal to 2.

Sensorimotor neuropathy (SMN): Motor score between 2 and 4 and pallesthesic score between 2 and 6.

2.4. Data analysis

Data were analyzed using non-parametric tests after Komogornov–Smirnov test, tested distribution. Differences between groups were compared using a Kruskal-Wallis analysis followed by a post-hoc Mann-Whitney test. The correlations between clinical scores and the LOE parameter were performed using a simple regression. Receiver Operating Characteristic (ROC) analysis was performed in order to determine the best threshold for LOE. The threshold of significance was established at $p < 0.05$.

3. Results

The characterization of the sample, means of instrumental tests and confidence interval (CI) for each group are represented in Table 1.

The Kruskal-Wallis test revealed a group effect between the CTL group and the three groups of patients for all the three parameters tested (Fig. 2).

In respect to the evaluation of the CP sway area of each group in the eyes open condition (EO) the post-hoc Mann-Whitney test

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