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Balance and mobility assessment for ruling-out the peripheral neuropathy of the lower limbs in older adults

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ABSTRACT

The peripheral neuropathy of the lower limbs (PNLL) is an important cause of balance and mobility impairment in older adults. The nerve conduction study (NCS) is the *gold standard* for PNLL diagnosis. Aim of this work is to establish the sensitivity (Sn) and the specificity (Sp) of the balance and mobility examination for the PNLL in older adults.

This study consecutively recruited 72 participants (>65 years) who accessed to the clinical neurophysiology outpatient clinic for suspected PNLL. Participants were given the NCS and four clinical tests. Mobility was evaluated by the Timed Up and Go (TUG) test, the Performance Oriented Mobility Assessment (POMA) and the de Morton Mobility Index (DEMMI). In addition the Clinical Evaluation of Static Upright Stance (CELSIUS) scale was developed for a selective evaluation of static balance.

Based on the NCS, 36% of participants had PNLL. The CELSIUS scale (cutoff: 19.5/24), the TUG test (cutoff: 9.6 s) and the DEMMI scale (cutoff: 17.5/19) have high Sn (0.92 ÷ 0.96), but low Sp (0.28 ÷ 0.43) for the PNLL in the older adult. POMA scale (cutoff: 14.5/16) has low Sn (0.73), but acceptable Sp (0.85). In addition, CELSIUS, DEMMI and TUG negative likelihood ratios are 0.13, 0.17 and 0.12, respectively.

Balance and mobility examination have high sensitivity for PNLL. CELSIUS score > 19/24, DEMMI score > 17/19 or TUG time ≤ 9.6 s substantially reduce PNLL likelihood. These clinical measures are thus recommended for ruling-out PNLL in the older adult.

1. Introduction

Up to 15% of elderly people are affected by peripheral neuropathy of the lower limbs (PNLL [1]). The PNLL of the elderly often affects both sensory and motor fibers [2] and is often caused by diabetes [3].

Nerve conduction studies (NCS) are the most sensitive, specific and validated diagnostic tests for the diagnosis of PNLL [4]. However, NCSs are cost-intensive, time-consuming and require trained clinicians (both physicians and specialised technicians). For these reasons, different clinical tests have been developed to screen PNLL with a simple and cost-effective interview and/or bedside examination [5].

It is very well known that the damage of sensory and motor fibers due to PNLL causes balance and mobility impairment [6,7]. Several tests are available to quantify in a clinical setting the severity of the balance impairment and mobility restriction.

The Performance Oriented Mobility Assessment (POMA) scale is a task-oriented test that measures balance and gait abilities on an ordinal scale [8]. The POMA is widely adopted as a clinical measure of balance [9,10], even if its accuracy in predicting falls in elderly individuals has been debated [11]. The de Morton Mobility Index (DEMMI) is a newly developed clinical test, specifically created to measure the mobility status of older patients [12]. It consists of 15 items covering a broad spectrum of mobility levels and it has shown satisfactory clinimetrics properties [13,14]. In the Timed Up and Go (TUG) test, the time needed that a person to rise from a chair, walk three metres, turn around, walk back to the chair, and sit down is measured [15]. Also the TUG test is widely used for measuring mobility in the elderly [16].

Many clinical tests have been developed for balance assessments [17]. However, at our knowledge, each of these tests assesses both the static (e.g. the ability of standing feet toghether) and the dynamic balance (e.g. the ability to rise from a chair). To have a

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selective evaluation of the static balance (i.e. the physical equilibrium in the strict sense) we developed the Clinical Evaluation of Static Upright Stance (CELSIUS) scale (Appendix A of the Supplementary file). The CELSIUS scale comprises a set of 10 static balance tasks (each one scored on four categories, with score 4 indicating normal balance) and explores a wide range of static balance.

Despite poor balance and mobility restriction are key signs for the clinical diagnosis of PNLL, only a few studies have investigated their sensitivity and specificity for identifying a NCS-defined PNLL (e.g. [18]). Aim of the current work is to find the best cut-off scores in terms of sensitivity and specificity of the POMA, DEMMI and CELSIUS scales and of the TUG test for the identification of the PNLL, as diagnosed by a NCS.

2. Material and methods

2.1. Patients' selection

In the period October 2014–February 2015, 75 consecutive patients attending the clinical neurophysiology outpatient clinic of the Azienda Ospedaliera San Paolo in Milan were enrolled. Inclusion criteria were: i) age larger than 65 years, ii) living in the community and iii) referral to the clinical neurophysiology clinic because of suspected (first visit) or known (follow-up) PNLL. Exclusion criteria were: i) history of neurological disease (e.g. stroke, dementia, Parkinson disease) apart from polyneuropathy, ii) history of major orthopaedic disease (e.g. lower limb amputation, rheumatoid arthritis) and iii) need for oxygen therapy because of chronic obstructive pulmonary disease and/or late-stage heart failure. Patients with hip and/or knee prosthesis were not excluded.

All participants gave their written informed consent to participate in the study.

2.2. Nerve conduction study

In the current study, the PNLL of the Elderly was defined similarly to the diabetic sensorimotor polyneuropathy [19]. PNLL was defined by the presence of at least one symptom (pain, numbness, tingling, weakness, ataxia) or sign of polyneuropathy (absence of knee and/or ankle reflexes, deficit of position sense and sensation to vibration) and at least one electrophysiologic abnormality in both one sural and one peroneal nerve.

In each patient, the nerve conduction study (NCS) of the right sural, right peroneal and left tibial nerves was completed. Latency (ms) of the sural sensory action potential (SAP) peak, conduction velocity (m/s) along the peroneal and tibial nerves and peak to peak amplitude of both SAP (uV) and compound muscle action potential (CMAP, mV) were measured. Motor velocity of the peroneal nerve and of the tibial nerve was computed in the tract fibular head-ankle and popliteal fossa-ankle, respectively.

Nerve conduction data were referred to normative values on healthy control subjects, 20–60 years old [20]. To note is that these values are fully comparable to the normative values established in the population of patients attending our outpatient clinic (unpublished results).

Limit values are given below:

1. sural nerve SAP latency (negative peak): 3.8 ms;
2. peroneal nerve conduction velocity: 41.6 m/s;
3. tibial nerve conduction velocity: 40,6 m/s;
4. sural nerve SAP peak to peak amplitude: 6 μV;
5. peroneal nerve CMAP peak to peak amplitude: 4 mV;
6. tibial nerve CMAP peak to peak amplitude: 5 mV.

All nerve conduction studies were performed by a neurologist (CC) with an expertise in clinical neurophysiology, assisted by a clinical neurophysiology technician. All NCS were conducted in the clinical neurophysiology outpatient clinic of the Azienda Ospedaliera San Paolo in Milan. Electromyographic activity was recorded using conventional surface electrodes in a belly-tendon montage. Signals were amplified, digitized (ISA 1004, Micromed, Treviso, Italy) and stored on a PC for offline analysis. Electrical stimuli (squared pulses) were delivered using a surface bipolar electrode placed on the expected course of the nerve. The stimulus intensity was adjusted, in each participant, to elicit the maximum action potential. Finally, the standards laid down by the American Association for Neuromuscular (1999) [21] about limb temperature control, distance measurement and measurement of action potentials onset and amplitude were complied with in full.

2.3. Balance and mobility assessments: the CELSIUS, POMA and DEMMI scales and the TUG test

The CELSIUS scale consists of eight static balance tasks (each task lasting 15 s) which evaluate the physical equilibrium in the strict sense, that is the ability of an individual to maintain a standing position over time. Each CELSIUS item (i.e. each balance task) is scored on four categories, with score 3 indicating normal balance. Details on the CELSIUS scale (Appendix A of the Supplementary file) and its statistical development are given in Appendix B of the Supplementary file.

The POMA scale [8] is actually made of two scales, the POMA – balance and the POMA – gait. In the POMA – balance scale, items assessing static balance are intermingled with dynamic balance items and thus POMA – balance score reflects both participants' equilibrium and mobility. The POMA – gait scale, which was not administered in the current study, is a checklist of normal gait qualities. Since in the current study only the POMA – balance was administered, the POMA acronym will be referred to the POMA – balance scale from here on out. In the current work the POMA scale with a maximum total score of 16 was chosen [11].

The DEMMI scale is a mobility assessment originally developed for measuring the mobility of community-dwelling older people [12]. It is a recent scale, developed using modern clinimetric techniques (i.e. the Rasch analysis).

The TUG test [15] is widely adopted for measuring mobility in the older people [16]. In the current study the TUG test was administered as follows. Participants were asked to get out of the chair, walk to the 3 m mark on the floor, turn around, walk back to the chair and sit down. Participants were explicitly asked to wait for the go signal from the examiner. Seconds from the time the participant's buttocks released the chair to the time the participant's buttocks touch the seat again were measured by means of a conventional stopwatch. An ordinary office chair was used (seat height: 44 cm; no wheels; no armrests; rigid and fixed back). To avoid falls during the test, patients were instructed to use a comfortable and safe walking speed. For all participants, the TUG test was repeated two times and the second measure was included in the final analysis.

2.4. History collection and fall risk assessment

All the participants were interviewed to collect their medical history, including use of medicines, need for assistance in activities of daily living (ADL) and outdoor walking, need for gait aid and number of falls in the preceding year. Fear of falling and how a person perceived his/her standing balance were also recorded. Fall risk was also assessed [22]. Upon NCS, patients' history, balance and mobility assessment were collected by a physiatrist (AC). AC was blind to the results of the NCS and CC (i.e. the neurologist who