Time-varying patterns reveal foot loading changes after foot-ankle exercises for diabetic polyneuropathy

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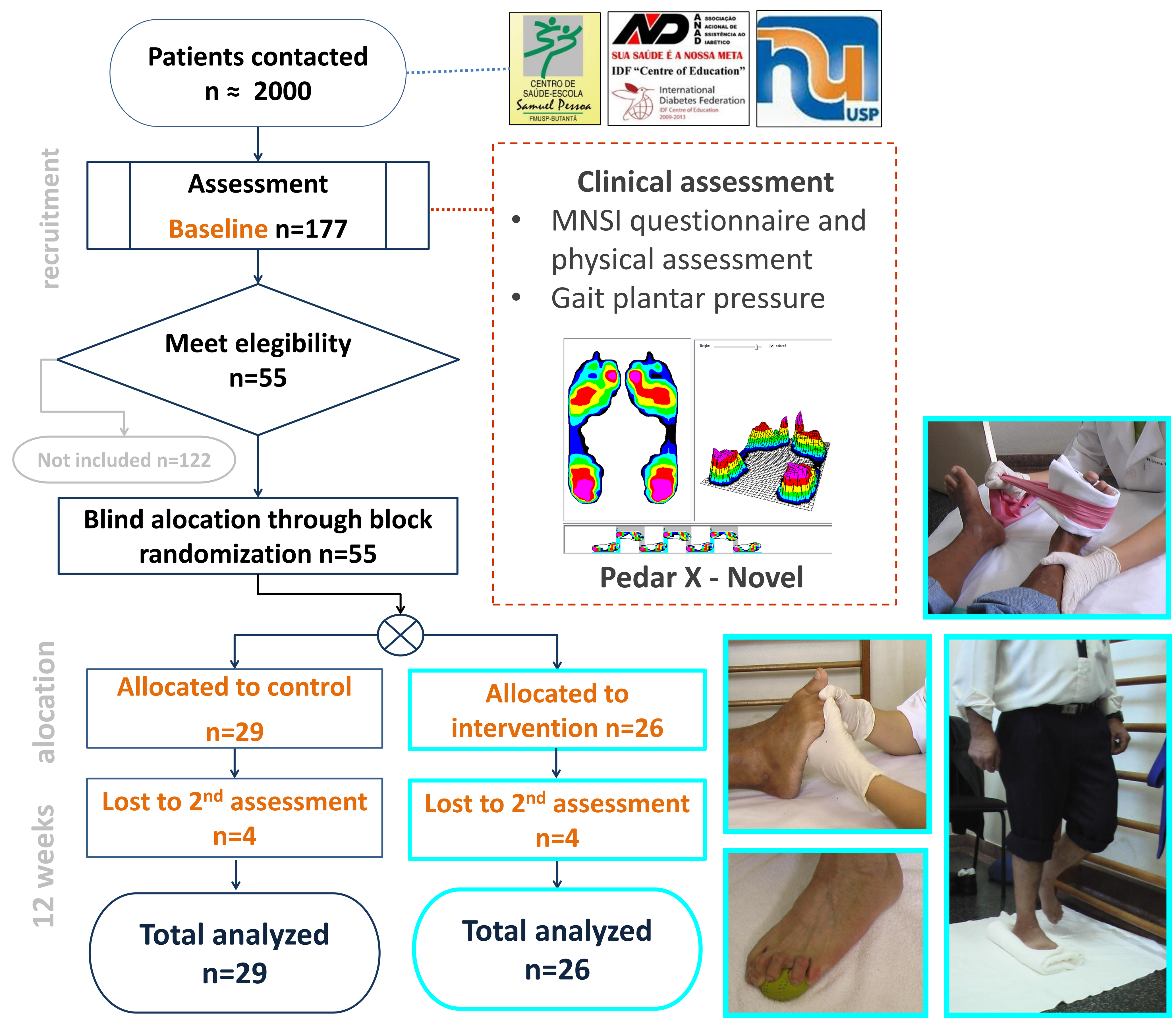
BACKGROUND

The increased risk of plantar ulceration in patients with diabetic polyneuropathy (DPN) is often associated with an heterogeneous plantar pressure distribution characterized by overloading the anterior regions, unloading the toes and hallux, and a reduced role of lateral forefoot and toes. he most studied loading variables in this population are mean and standard deviation of peak pressure and pressure-time integral, that **reduces the complex and interdependent foot segments dynamics to a simple average value of many steps, that is also represented by only one sensor**. Therefore, they are not optimal variables for describing time changes during the whole process of foot-floor interaction. Our aim is to propose a method for identifying plantar areas that **most discriminate the overall changes through time** in the plantar pressure distribution during gait, after an exercise intervention protocol for DPN patients (Sartor et al, 2014).

METHODS

Study design



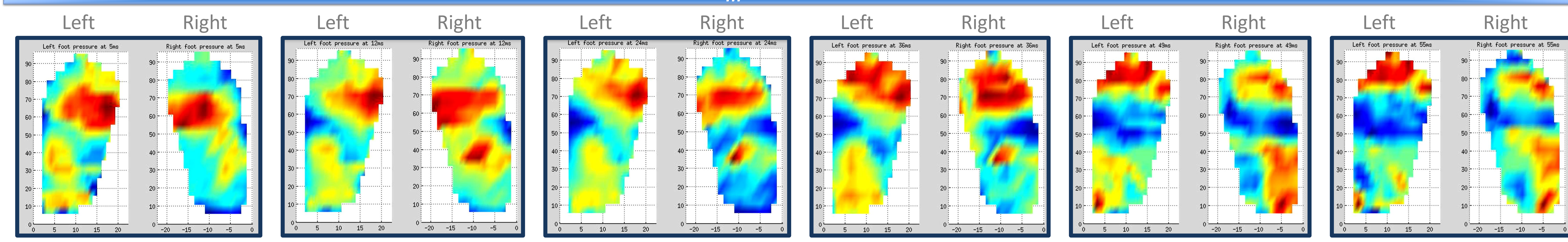
Data analysis

1. Quantification of the feature importance (FI)[2].
2. Pixel-wise statistics for the analysis of variance[2] - identify the set of pixels whose patterns separate classes and sub-classes of pixels.
3. Map the foot on a grid of 99 pixels (sensors of Pedar-X insoles).
4. Footsteps were normalized on the same duration (60Hz) and then compared pixel by pixel between groups.
5. The potential for discrimination capabilities of each pixel m increases with D_m. The features with larger D_m correspond to the large inertia.
6. This experiment can be interpreted as a region of interest (ROI) selection experiment.

$$D_m = \frac{|\mu_{IG}^m - \mu_{CG}^m|}{\sqrt{1+\sigma^{2m}_{IG}+\sigma^{2m}_{IG}}}$$

μ_{IG}^m, μ_{CG}^m, σ^{2m}_{IG} and σ^{2m}_{IG} are the estimated mean and variance of the m^th^ pixel for **both groups after intervention**

Results – DISCRIMINATION (D_m) between IG and CG after the exercises



8% stance phase | 20% stance phase | 40% stance phase | 60% stance phase | 81% stance phase | 92% stance phase

CONCLUSIONS

- The method was efficient in **eliciting the differences** between the groups after an exercise intervention, and also it was possible to identify which sensors discriminate better the difference between the groups in each instant of stance phase.
- It **preserves the time series** and **does not limit the peak pressure information to only one sensor** (usually the peak pressure of only one sensor is reported).
- It was possible to identify **more participation of toes** during the push off phase, that is accompanied by an increase in forefoot pressure at early stance. The toes function are known to be reduced in this population and is associated to a shorter COP excursion (Giacomozzi et al, 2002) and with the proeminence of metatarsal heads.

PRESS PLAY IN THE IPAD TO VISUALIZE THE VIDEO

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