

# Hardware performance assessment recommendations and tools for baropodometric sensor systems

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**Summary.** Accurate plantar pressure measurements are mandatory in both clinical and research contexts. Differences in accuracy, precision, reliability of pressure measurement devices (PMDs) prevented so far the onset of standardization processes and of reliable reference datasets. The Italian National Institute of Health (ISS) approved and conducted a scientific project aimed to design, validate and implement dedicated testing methods for both in-factory and on-the-field PMD assessment. A general-purpose experimental set-up was built, complete and suitable for the assessment of PMDs based on different sensor technology, electronic conditioning and mechanical solutions. Preliminary assessments have been conducted on 5 commercial PMDs. The study lead to the definition of: i) an appropriate set of instruments and procedures for PMD technical assessment; ii) a minimum set of significant parameters for the technical characterization of the PMD performance; iii) some recommendations to both manufacturers and end users for an appropriate use in clinics and in research context.

**Key words:** baropodometry, pressure measurement devices, technical assessment, accuracy, COP estimation.

**Riassunto** (*Raccomandazioni e strumenti per assessment delle prestazioni hardware di sistemi di sensori baropodometrici*). Misure accurate della pressione plantare sono fondamentali in contesti clinici e nella ricerca. Differenze di accuratezza, precisione e affidabilità dei dispositivi di misura di pressione (PMD) hanno impedito fino ad ora la messa in atto di processi di standardizzazione e la costruzione di database di riferimento affidabili. L'Istituto Superiore di Sanità (ISS) ha approvato e condotto un progetto scientifico al fine di progettare, validare ed implementare metodi di test dedicati, per la valutazione tecnica di PMD sia in fabbrica che sul campo. È stato costruito un set-up sperimentale, completo e adattabile all'*assessment* di PMD basato su differenti tecnologie, condizionamento elettronico, soluzioni meccaniche. Valutazioni preliminari sono state condotte su 5 PMD commerciali. Lo studio ha portato alla definizione di: i) un appropriato set di strumenti e procedure per l'*assessment* tecnico dei PMD; ii) un set minimo di parametri significativi per la caratterizzazione tecnica delle loro prestazioni metrologiche; iii) raccomandazioni a fabbricanti e utilizzatori per un utilizzo appropriato dei PMD in clinica e in contesti di ricerca.

**Parole chiave:** baropodometria, dispositivi di misura di pressione, valutazione tecnica, accuratezza, stima centro di pressione.

## INTRODUCTION

Contrary to kinematic or force measurements, which gait analysis strongly relies on, plantar pressure measurement is hardly considered a powerful or meaningful diagnostic tool in clinics; even less consideration is deserved to pressure measurement devices (PMDs) in consolidated research contexts, although the potential of such measurements is highly recognized [1]. Reasons for such poor success may be found in a certain lack of accuracy and appropriateness of the existing PMDs. Differences in sensor technology, matrix spatial resolution, pressure range, sampling rate, calibration procedures, raw data pre-processing, lead to significant differences in the overall accuracy of PMDs response. In addition, critical potentially complicating practical problems interfere with the appropriate use of

PMDs, *i.e.* problems associated with patient behaviour/protocol, and problems associated with data post-processing. The whole set of the above problems have indeed played a role in preventing the definition of reliable reference databases. Clear examples of these concepts are found in the recent literature. In fact: i) not even interesting papers report the acquired absolute pressure values [2-5], which might help in understanding how much comparable different datasets are: rather, clinicians and investigators are often concerned about relative pressure values or relative pressure distribution changes, which come out as post-processing products and which should be treated with extreme care since they are greatly affected by differences in the PMD sensor response; ii) significant discrepancies are found among those which report such values, even when dealing with