MINIMAL DETECTABLE CHANGE IN FOOT-PRESSURE MEASUREMENTS IN TYPICALLY DEVELOPING CHILDREN

Tim Niiler, Chris Church, Nancy Lennon, John Henley, Ameeka George, Daveda Taylor, Angelica Montes, Freeman Miller

Gait Laboratory, A.I. duPont Hospital for Children, Wilminton, DE, USA
E-mail: tan13@psu.edu

INTRODUCTION: Pedobarography is extensively used to evaluate foot deformities. Unfortunately, little is known about the uncertainty and sources of uncertainty in the pedobarographic data. We need this information to evaluate if observed differences originated from treatment something else like processing. The purpose of this study is to determine the minimal detectable change (MDC) in a variety of foot pressure measures. The MDC is the sum of the net uncertainties ($\delta_{\text{net}}$) for each of the two measures being compared plus any inter-rater uncertainty ($\delta_{\text{inter}}$) if different raters reduced the data. For a given measure, the net uncertainty is determined by the step-to-step uncertainty ($\delta_{\text{step2step}}$), the day-to-day uncertainty ($\delta_{\text{day2day}}$), and the intra-rater uncertainty ($\delta_{\text{intra}}$). The purpose of this study was to quantify variability in segmented pedobarograph data and thereby estimate the MDC and its component uncertainties as a function of age.

CLINICAL SIGNIFICANCE: Understanding the uncertainty inherent in these measurements allows for better planning of interventions and evaluation of their outcomes.

METHODS: In this IRB approved study, we analyzed data from a convenience sample of data from 46 males and 62 females aged 2 to 17 years with no identified abnormalities in gait, foot deformities, or pain. At each visit three pedobarograph measurements were taken per subject per foot while they walked at a self-selected pace. Six subjects returned at least three days after their first pedobarograph measurements for repeat measurements so that we could assess day-to-day variability. Preliminary processing of the data involved dividing the foot into five segments: the medial forefoot (MMF), lateral forefoot (LFF), medial midfoot (MMF), lateral midfoot (MMF), lateral midfoot (LMF), and heel. Additionally, the coronal plane pressure index (CPPI) was calculated to assess varus/valgus foot posture [1]. Standard errors of these parameters were then calculated on a per-subject basis to represent the session uncertainty [2]. Day to day uncertainty was calculated based on the average differences between parameters from two different days.

The intra-rater uncertainties for each parameter were determined by having a single engineer process 10 subjects' data five times each in random order so as to minimize any memory-related processing effect. For each parameter, the standard deviation per subject was then averaged across the 10 subjects to estimate the uncertainty. For the inter-rater analysis, three lab personnel processed data from the same 20 subjects (3 foot-prints x 2 sides) totaling 120 foot prints. The standard deviation per subject across the three raters was averaged across the 20 subjects to determine the inter-rater uncertainties.

Session uncertainties ($\delta_{\text{session}}=\delta_{\text{intra}}+\delta_{\text{step2step}}$) for each parameter were grouped by age in order to determine if their variability changed with growth. Seven age groups were ultimately used as shown in Figure 1. One way analysis of variance was carried out to
determine if there were significant differences between age groups, raters, and day-to-day measurements.

RESULTS: Average session uncertainties for each age group as estimated from average standard error are presented in Figure 1. The largest are for the heel whereas the smallest are for the medial mid foot. Age-based CPPI uncertainties are very much larger, although the range of CPPI is twice that of percent impulses. No significant difference in uncertainties with age was found except between the two year olds and all other age groups for the uncertainty in the medial midfoot measures. Inter-rater and intra-rater uncertainties in percent impulse for each of the regions of the foot were similar ranging between a fraction of a percent up to about 2.5%. Day-to-day uncertainties in percent impulse were much larger ranging up to 7.2%. Figure 2 presents the composite uncertainties in a relative manner in order to highlight their magnitudes compared to the average values for 12-17 year olds.

DISCUSSION: This study presents the first quantification of uncertainties in normative segmented foot-pressure data. In comparing foot pressure data one must consider which variable is being compared, whether or not it’s from the same person, the same day, and whether the same person processing the data. Results indicate that session and daily variability in foot-pressure norms is more important than processing error, and that while there is little variability of uncertainties with respect to age, there is much more regional variability. Additionally, as CPPI is a composite measure based on medial and lateral segmental impulses, its relative uncertainty is much higher. This suggests that composite measures may be too variable for meaningful clinical use.

REFERENCES:

DISCLOSURE STATEMENT:
None of the authors have any conflicts of interest to report.