Gait & Posture 41 (2015) 852–856

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

A color-code based method for the interpretation of plantar pressure measurements in clinical gait analysis

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ARTICLE INFO

Article history:
Received 5 August 2014
Received in revised form 7 November 2014
Accepted 14 December 2014

Keywords:
Plantar pressure
Foot
Color-coding

ABSTRACT

Comparing plantar pressure measurements (PPM) of a patient following an intervention or between a reference group and a patient-group is common practice in clinical gait analysis. However, this process is often time consuming and complex, and commercially available software often lacks powerful visualization and interpretation tools. In this paper, we propose a simple method for displaying pixel-level PPM deviations relative to a so-called reference PPM pattern. The novel method contains 3 distinct stages: (1) a normalization of pedobarographic fields (for foot length and width), (2) a pixel-level *z*-score based calculation and, (3) color coding of the normalized pedobarographic fields. The methodological steps associated to this novel method are precisely described and clinical output illustrated. We believe that the advantages of the novel method cover several domains. The strongest advantage of the novel method is that it provides a straightforward visual interpretation of PPM without decreasing the resolution perspective. A second advantage is that it may guide the selection of a local mapping technique (data reduction technique). Finally, it may be easily used as education tool during the therapist–patient interaction.

1. Introduction

Currently, clinicians and researchers are facing considerable challenges when analyzing and interpreting plantar pressure measurements (PPM). Comparing (PPM) of a patient following an intervention or between a reference group and a patient-group is common practice in clinical gait analysis. However, this process is often time consuming and complex, and commercially available software often lacks powerful visualization and interpretation tools. In fact, researchers and clinicians are often obliged to follow the following three steps for the interpretation of PPM: (1) subsampling, (2) selection of physical quantities and, (3) conduction of descriptive or inferential analyses. Unfortunately, this

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http://dx.doi.org/10.1016/j.gaitpost.2014.12.013
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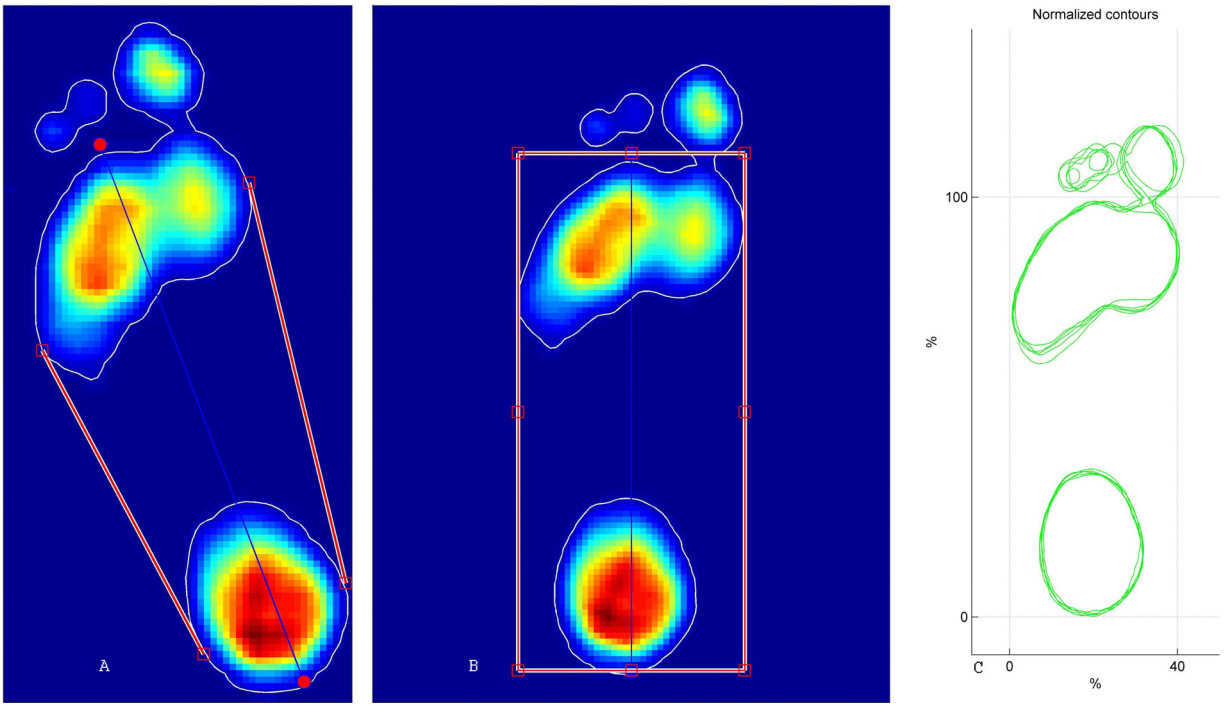

Fig. 1. (A) Mean left PPM of a person with the 5 kPa contour line (white line). The red lines represent the tangent lines, whereas the middle blue line indicates foot length. (B) Same footprint following rotation (around foot progression angle) and normalization (with respect to foot length). (C) Superimposement of contour lines of five trials of the same subject following normalization. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

approach is characterized by a high degree of subjectivity and a low-resolution perspective [1,2]. Researchers have not only quantified these limitations [3], they have also provided so-called 'high-resolution' methods [1,2]. The theoretical concept behind these methods is that descriptive and inferential comparison of entire pedobarographic fields is afforded. To our best knowledge, commercially available software from RSscan® (Footscan 7 software), Tekscan® (Mat-Scan and F-Scan clinical software), BTS® (BTS P-Walk and BTS G-studio software) and Medicapteurs® (win-pod-, S-pod-, and Win-track software) do not provide this kind of high-resolution comparison. On the contrary, Novel® plantar pressure software provides a sensor-level visualization tool which binary codes 'differences' between pedobarographic fields using red and blue color.

Next to the qualitative method proposed by Nove®, the literature provides also two other methods, namely statistical parametric mapping [3] and nonparametric statistical testing [4,5]. Both methods have powerful features, especially in the field of inferential analysis (e.g. analysis on patient-level and group-level). However, a drawback of these approaches is that it involves complex statistical calculations on one hand and that a considerable number of trials must be collected in order to avoid type I error. The latter aspect may cause some problems in clinical gait analysis especially in patients with antalgic gait or neuropathy.

We propose an alternate method of visualizing pressure deviations between two normalized plantar pressure patterns (NPPP). In this paper we describe the preprocessing and color-coding method as well as some clinical visualization on patient data.

2. Methods

2.1. Experimental dataset

Dynamic PPM of 33 control subjects (mean age 51.7 years ± 6.3, mean BMI 24.6 kg/m^2 ± 3.5) and 97 diabetic patients (mean age

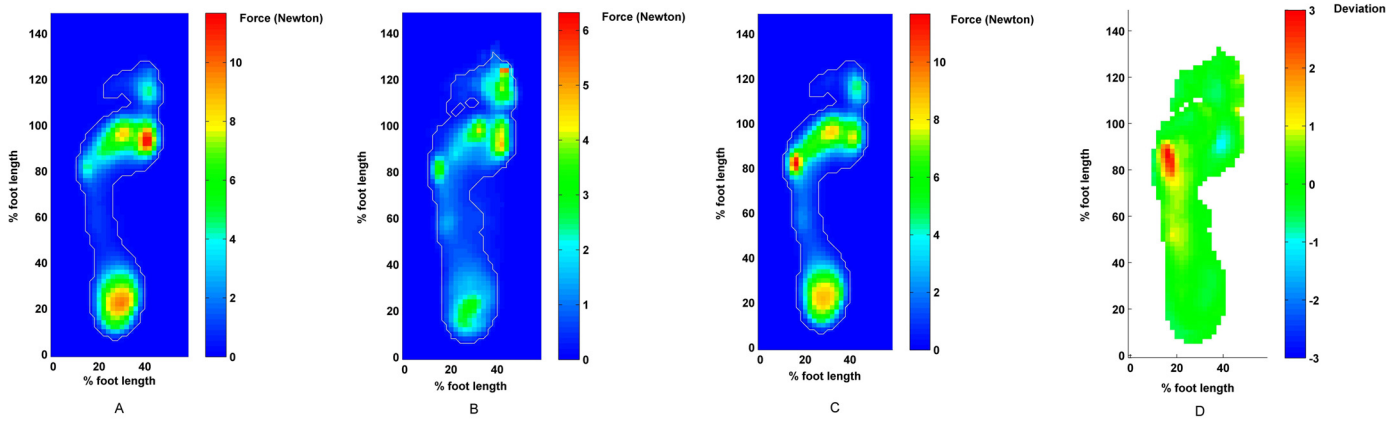

Fig. 2. (A) Illustration of a so-called reference NPPP, (B) standard deviation of the reference NPPP, (C) mean NPPP of a so-called observation-group (another group of subjects), (D) 2-dimensional color-coded array representing the deviation between both groups using pixel-level standard deviation of the reference group.