Information Return Device Concept: Baropodometric Biofeedback Application

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Topics: Biomechanics; Handicap; Materials; Measurement Systems.

Abstract: Numerous studies on new biofeedback devices conception development were undertaken. They are used for some compensation methods of the data lost on sensors set. The aim of the study was carried out for introducing several approaches of investigations and test of the biofeedback device that support a plantar pressure analysis, for foot unloading processes implementation. The healthy man is walking in normal conditions first; on a walkway. The recorded load on 6 sensors has to be reduced next in a specified area. The pressure was considered at the beginning on metatarsal head, in time of 100 steps. The visual and auditory signals were then adjusted to a specific plantar pressure threshold setting. Peak and pressure time integral were evaluated for each condition. The Results showed that the subject performed 65% of success unloading steps. In the present case, the biofeedback device enabled us to modify the plantar support to prevent possible foot complication. In general, Biofeedback systems could show their interests in many applications: rehabilitation process, sport or to assist active-assistive orthotic devices.

Key words: "Biofeedback", "plantar pressure", "sport", "rehabilitation", "assistive device".

1- Introduction

The term Biofeedback refers to the use of an external device to increase an individual's awareness of sensory events that accompany performance.

The biofeedback device can be considered as an interesting therapeutic method when a self-regulated system is disturbed (André *et al.* 1986). Electromyographic biofeedback has mostly been used to correct simple motor tasks involving not more than one segment (Ingersoll and Knigh, 1991). However biofeedback methods are applicable, to correct complex abilities mobilizing several segments, if the feedback is based on a mechanical resultant of the movement such as the external force (White and Lifeso 2005, Dozza *et al.*

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2005). The recent progress was achieved for the development of the measuring conception, using force and pressure recording sensors, providing the user with biofeedback interfaces. Previous studies have demonstrated different methods to m plantar pressure (Pataky *et al.* 2000, Femery *et al.* 2004). Such systems use different se as well as different acquisition systems, from the portable plantar pressure measu system we have developed. Our plantar biofeedback provides both visual and audio back in order to correct the plantar pressure distribution, when local pressure exc maximum determined threshold. These devices use a signal-warning system that may particularly appropriate to the patient's disease, when suffering from lost nocic perception subsequent to metabolic diseases, infectious disorders or traumatic lesions.

2- Methods

2.1-Population

A 23-yr-old healthy man, weighing 80kg, without foot or gait abnormalities, took in this trial after providing written informed consent in accordance with a pro approved by an institutional review board.

2.2 Instrumentation

The whole biofeedback system is called B.I.R.D for Baro-Paedometric Informa Return Device.

Previous studies used FSR sensors which detect normal force acting on the si revealed a very simplified action of the foot on the sensor area whereas plantar ulcer linked to normal and sheer stress (Pataky *et al.* 2000, Femery *et al.* 2004). The hyd from Paromed (Gmbh, Germany) consists of an inbuilt Wheatstone bridge, inserted a capsule filled with incompressible fluid, which results in a pressure from the differ components of the ground reaction force. This implies that the cells are sensitiv mechanical stress which has three components, pressure acting normally on the s anterio-posterior and medio-lateral shear stress acting tangential to the surface. The revealed more realistic measures of pressure acting under the foot. The sensors are brated by the manufacturer and a calibration file is provided for each sensor. An i dual calibration for each sensor was performed to ensure that statements of the ab pressure at different regions of the foot could be substantiated. Our bench testing of the sensors confirm previous data (Femery *et al.* 2004, Chesnin *et al.* 2000) (table

Dimensions (mm)	
Diameter	22
Active sensing diameter	18
Thickness	3
Measurement range	0 to 625 kPa
Uncertainty	± 1%
Stability	± 2% (at 400 kPa, deviation ± 2

2.3 Customized Insole development

The Footscan plate [b] was used to detect the peak locations and to determine the sensor distribution of a customized insole. Two insoles (right and left) were thus customized comprising 6 Paromed hydrocells in each, distributed under the lateral heel (LH) and medial heel (MH), metatarsal heads 5 (M5), 3 (M3), and 1 (M1), and the Hallux. The insoles were connected to an amplifier and linked with a personal computer via a telemetrically joined data recorder. The metrological process and its feedback were organised for the biofeedback customised software package.

2.4 Visual and Auditory Feedback

The feedback from this device is intended to cue the subjects to initiate a new walking gait strategy. The visual feedback, which was returned to the subject through two control screens by video projection, consists of plantar footprint visualisation scenes that correspond with localisation of the insole sensor setting (fig. 1). On the left of the plantar footprint there is a scale of colours, from blue, green to red; illustrating pressure intensity at each of the sensors localisation point. A "scorer" was placed on the left side of the foot print, informing the user about the performances considered. The peak plantar pressures were recorded during a diagnostic walking trail (PP_{dt}) performed at preferred walking speed. The peak pressures under each footprint location were then defined and serve as reference. A 5% reduction in peak pressure would be sufficient to prevent foot ulceration at its most affected area (Descatoire *et al.* 2007). This threshold level is considered as PP_{CR} max value. The 20% reduction in peak pressure, considered as PP_{CR} min, enabled us to limit excessive relief resulting in dangerous plantar pressure redistribution (Descatoire *et al.* 2007). For the case study, the peak plantar thresholds ($PP_{CR\ Max}$ and $PP_{CR\ Min}$) of the sensor located under the first metatarsal head (M1) were determined as 5% and 20% reduction in plantar pressure recorded during "Diagnostic test (dt)", respectively (i.e. $PP_{CR\ Max} = 0.95\ PP_{dt}$ and $PP_{CR\ Min} = 0.80 PP_{dt}$). The auditory feedback was implemented as an alarm trigger, combined with the visual feedback. It indicated the local pressure overload, at the selected area where the $PP_{CR\ Max}$ was noticed. On the contrary, only the visual feedback informed the subject when excessive relief occurred. Thus step-by-step, the subject concerned was informed of dynamic events at the foot-ground interface, and remained aware of the overall foot condition.

2.5 Walking test

The non-disabled subjects performed the walking tests on a 25 m walkway. The subject concerned was equipped with the customised insoles inserted in neoprene shoes to match the form of the insoles. After a brief explication of the device, the subject performed the diagnostic walking test at his self selected walking speed. The plantar pressures of more than 100 steps were recorded. Then the subject used the

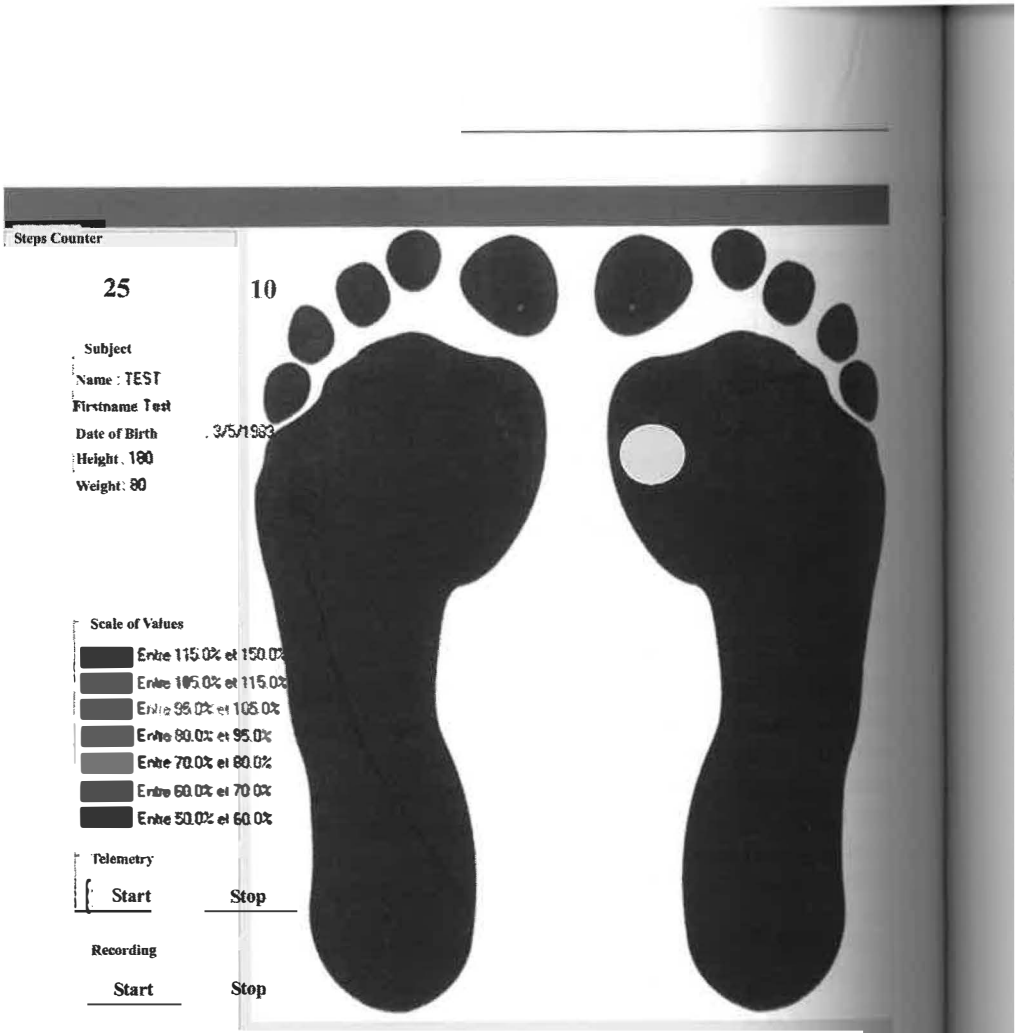

Figure 1 - B.I.R.D software interface: 65 Success Steps, 25 Moderate Steps, 10 Faulty Steps.

ration in neuropathic diabetic subjects (Lavery *et al.* 1997). The test enabled us to n the peak plantar pressure in unloaded conditions over 100 (50 right and 50 left st consecutive steps.

3- Results

Table 2 contains the results recorded during the diagnostic walking and the unloa processes. One step under BIRD condition was considered successful when the pressure value remained between $PP_{CR\ Max}$ and $PP_{CR\ Min}$. If the peak pressure reco under M1 was greater than PP the relief was excessive and the step

	diagnostic Condition	Unloaded Condition		
		Success steps 20%<PP<5%	Moderate Success steps PP>20%	Failure steps PP<5%
% of step		65	25	10
PP mean	116.7	103.2	75.5	124.8
SD	22	11.8	8.1	5.8
PP min	96.1	97.7	63	116.3
PP max	176.8	110.1	87	133.2

Table 2 - Peak Pressure values measured under M1 during the diagnostic and the unloaded ndition. Values are in kilopascals. PP min: minimum peak pressure, PP max: maximum peak pressure.

5- Discussion

ecent technologies have allowed us to modify and optimise existing biofeedback systems, in order to develop some additional diagnostic devices and/or to develop new rehabilitation methods based on "on-line" detection of abnormal walking parameter alues. In the present case, the subject has relieved the first metatarsal with facilities (90% of the steps). Moreover, he performed 65% of success steps that would avoid dangerous plantar pressure redistribution. Our visual and auditory biofeedback provides a warning system that may play a valuable role in preventing injuries or ulceration by changing the walking pattern

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