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## Podometry: a critical evaluation of its use in Hansen's disease

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The aim of this paper is to evaluate the effectiveness of podometry to measure the pressure developed over the feet and the value of these findings to help in the prevention of the plantar neuropathic ulcer in patients bearing Hansen's disease. We evaluated 13 patients with impaired plantar pain and touch sensations and 17 normal patients. All the patients were submitted to static evaluation using the podometer. The system employed was the "Midcapteur" commercial podometer composed of a platform for acquisition of analogic data capable of registering the segmental pressures applied to the feet. These data are read by a 386 IBM/PC compatible computer that registers the graphic patterns obtained from the pressures developed and also calculates the modes of pressure distribution in the four quadrants of the foot. These data obtained by means of static podometry were compared to the clinical evaluation of pain and touch sensation of the feet in hansenian patients. The results demonstrate that podometry is an efficient method for evaluating the pressure in impaired feet in Hansen's disease and is a progression of neuropathic ulcer; it is sensitive in the identification of the spots of increased pressure in anesthetic and anomalous areas, asymmetries and in correlating the presence of ulcers with increased pressure.

**UNITERMS:** Hansen's disease, neuropathic ulcer, podometry.

**H**ansen's disease is caused by an acid-alcohol resistant bacilli classified as *Mycobacterium hansenica*, that causes a specific inflammatory response of slow evolution, that impairs peripheral nerves, especially sensitive fibers (6). Hansen's disease is an endemic illness, very common in spite of the effectiveness of the current treatments, many patients develop sequelae specially those related to the impairment of the peripheral nervous system. Foot involvement is very frequent, leading to neuropathic plantar ulcers that require a difficult long-term treatment. The prevention of these ulcers is still

long-term treatment. The prevention of these ulcers is still the best resource to avoid the onset of functional impairment in these patients.

Our aim is to evaluate the effectiveness of the podometry method, by means of digital analogic acquisitions, in order to prevent the onset of plantar "mal perforant" in the insensible feet of Hansen's disease patients.

### METHODS

We studied 13 patients (5 females and 8 males) with clinical and laboratory diagnosis of Hansen's disease that presented sensorial plantar alterations. The mean age was  $54.8 \pm 19.8$ , ranging from 21-81 years. Three of the patients had pressure ulcers.

We also studied 17 normal individuals with no past

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history on clinical complaints regarding impairment of the inferior limbs. These patients were used as control group (Ten females and seven males). The mean age was  $34.23 \pm 8.45$ , ranging from 22 to 49 years.

All the patients were submitted to static evaluation of the plantar pressure distribution, measured in both feet. The podometer of the "Midcapteur" system was used; it consists of a platform containing mechanical sensors, capable of registering the pressure variances applied to them. These data are entered and read by an IBM/PC 386 compatible computer that supplies a graphic chart to the pressures developed on the sole of the foot and the pressure distribution in the four quadrants of the feet. We performed two measurements on each patient. All patients were submitted to a previous clinical evaluation; leveling of touch and pain sensations of the plantar region were performed. The clinical data were compared with the data obtained from podometry (Figs. 1 and 2).

The control group was submitted to the same type of podometry evaluation. Sensation charts were normal in this group.

We also performed a qualitative analysis of the data obtained. The following variables were used: asymmetry between the two feet, verified by means of visual analysis of the printed plantar maps; confrontation of areas with observed clinical sensation impairment with areas of increased pressure and the findings of pressure increase in anomalous portions of the foot, by means of comparison with the control group; presence of the increased pressure concomitant with plantar ulcers and changes in foundation surfaces.



Figure 1 – Plataform and test performance.

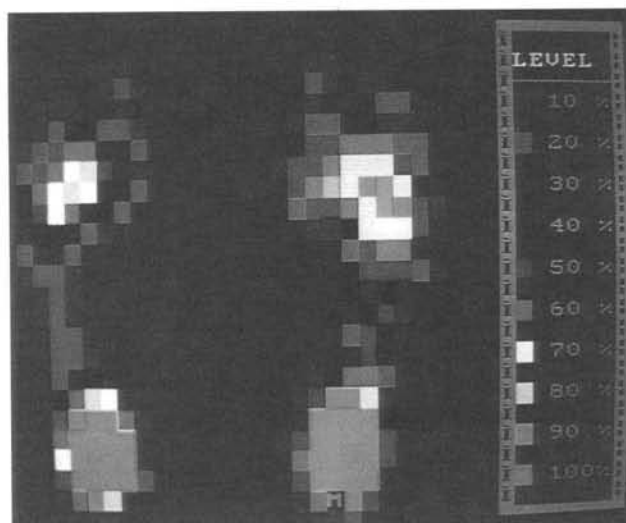


Figure 2 – Asimmetry between left and right foot - Hansenian patient.

## RESULTS

We observed a similar pattern of distribution in both groups relating to the pressures found in the anterior and posterior portions of the foot.

In the control group we observed a statistically significant difference between the values found in the right foot (dominant) in relation to the left one (non-dominant). In the dominant foot the difference between the values measured in the anterior and posterior regions was smaller than the difference obtained in the non-dominant foot. The statistical analysis was based on the chi-square test (Table 1).

In the group of Hansen's disease patients this difference was not observed in a significant manner (Table 2).

In Table 3 we correlated hansenian patients and controls. The measure utilized was the pressure obtained in the calcaneus region of the foot, that did not show a statistically significant difference. The analysis was performed based on the chi-square test.

Table 1  
Distribution of pressure: forefoot and hindfoot  
Control group (percentage)

|      | Left foot |       | Right foot |       |
|------|-----------|-------|------------|-------|
|      | Ant.      | Post. | Ant.       | Post. |
| Mean | 38.39     | 61.33 | 42.19      | 57.77 |
| SD   | 04.58     | 04.88 | 05.89      | 05.89 |

Chi-square: \*  $p < 0.005$

**Table 2****Distribution of pressure: forefoot and hindfoot Hansen's disease patients (percentage)**

|      | Left foot |       | Right foot |       |
|------|-----------|-------|------------|-------|
|      | Ant.      | Post. | Ant.       | Post. |
| Mean | 41.38     | 58.52 | 40.17      | 59.73 |
| SD   | 07.71     | 07.71 | 08.58      | 08.58 |

Chi-square: \*  $p < 0.005$  ns**Table 3****Pressure of the hindfoot Hansen's disease (HD) and control**

|      | Left foot |       | Right foot |       |
|------|-----------|-------|------------|-------|
|      | Contr.    | H.D.  | Contr.     | H.D.  |
| Mean | 63.33     | 58.52 | 57.77      | 59.73 |
| SD   | 04.88     | 07.71 | 05.89      | 08.58 |

Chi-square: \*  $p < 0.005$  ns

The qualitative analysis showed that asymmetry (the first parameter evaluated) was present in 10 (76.9%) and absent in three (23.11%) of the 13 patients studied. In the control group, asymmetry was absent in 14 (82.3%) and present in three (17.7%) of the individuals studied; this difference was statistically significant when analyzed by chi-square test.

Increased pressure development in anomalous regions was verified in three (17.7%) of the normal patients and in four (30.76%) of Hansen's disease patients. Although the phenomenon of increased pressure in anomalous regions of the foot is more frequent in hansenian feet, no statistical difference was observed, comparing the two groups (chi-square).

The correlation between points of increased pressure obtained by podometry and areas of pain and touch anesthesia evaluated clinically was coincident in 12 (92.3%) of the Hansen's disease patients. Only in one case this relation was not obvious.

Correlations between presence of the plantar ulcer points of increased pressure and absence of sensation were positive in the three cases (100%) evaluated that presented with neuropathic ulcer at the initial moment of evaluation.

Correlation between absence of pressure and anesthesia was observed in one (7.6%) hansenian patient, who showed a great anesthetic area of the foot (approximately 50%).

**DISCUSSION**

Very few results have been published in what refers to the value of methods for measuring segmental pressures and forces applied to the foot during orthostatism and gait (1, 2).

Clarke (3) demonstrated, during a dynamical study of gait that the pressure peaks correlate poorly to sex and age and that they did not vary with the gait speed in a significant way.

Based on these data we opted for a static evaluation of foot segmental pressure, because we were interested in the detection of points where greater pressures ensued and in their correlation with anesthetic areas. This measure proved to be reliable and reproducible, although the examiner chose the best moment for data acquisition based on visual evaluation of the monitor's screen. The double acquisition improved reliability.

Shorten (8) demonstrated that during walking the highest pressure develops in the posterior foot (heel) and at the base of the hallux, in distinct moments of walking: heel-strike and toe-off, respectively. In the statistical analysis the highest pressures prevailed slightly in the heel. Our findings coincide and show greater pressures at the heel, in both groups studied.

Orlin (7) demonstrated, through statistical analysis, of the segmental pressures developed in children's feet, that the highest pressures are found in the posterior region of the foot, at the heel. The numerical values show prevalence of static forces at the heel when compared to our findings.

Hennig (4) studied patterns of pressure distribution in feet of adults and children and demonstrated that the lower pressure peaks obtained in the children's group were due to body weight and to the greater amount of soft tissue and that the method is highly reliable.

Hughes (5) measured the reliability of the computerized podometry method in relation to clinical applicability and to research, he concluded that this method was highly credible and reproducible and could, therefore, be used safely for clinical analysis and research.

Rose (8) refers that using a system of measurement placed in shoe plantar sensors it is possible to measure the pressures developed inside the shoe and to study the effects of shoe modifications.

Our studies show that the highest pressures, in the control group are present in the heel and in the head of the first metatarsal, similar to descriptions in literature, confirming the credibility and reliability of the method employed.

Computerized podometric evaluation of the insensible feet of hansenian patients showed a close relation between points of increased pressure and areas with deficient sensation. It also proved useful in demonstrating points of in-

creased pressure in the anomalous regions, that is, in areas where usually no high weight loads are observed.

The use of this type of evaluation may be an important instrument in preventing plantar "mal perforant", because we can see the exact point of increased pressure. This fact is confirmed by qualitative analysis that demonstrates the coincidence between plantar ulcers and points of increased pressure.

The inconsistent results obtained by comparing qualitative and quantitative analysis of the asymmetry between the left and right foot is probably due to the type of calculations made by the computer, which utilizes mean values. The qualitative analysis of the printed image demonstrates the presence of points of increased pressure and the lesser pressure and even lack of foundation, with evident asymmetry when the two sides are compared.

The absence of pressure observed in one of the cases is probably due to the presence of a great anesthetic area on the sole of the foot causing the suppression of this area as a support region due to the loss of proprioceptive stimuli. Proprioceptive control, is probably impaired also, in patients that present increased pressure points in anomalous regions more frequently.

## CONCLUSIONS

1. Static podometry is a good method for evaluating points of increased pressure in patients with Hansen's disease and the use of this kind of equipment may be helpful in preventing the onset and progression of plantar "mal perforant".
2. The impairment of the deep touch sensation alters the pressure distribution of the foot.

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## RESUMO

O objetivo deste trabalho é avaliar a eficácia da podometria na prevenção do mal perforante plantar em pacientes hansenianos. Foram avaliados 13 pacientes hansenianos com comprometimento da sensibilidade tátil e dolorosa da planta do pé e 17 pacientes normais. Todos os pacientes foram submetidos à avaliação estática através do podômetro. O sistema utilizado foi o podômetro comercial Midcaptureur, constituído de uma plataforma para aquisição dos dados analógicos, capaz de registrar as pressões segmentares aplicadas nos pés. Estes dados são lidos num computador IBM/PC 386 compatível, que registra o mapeamento gráfico das pressões desenvolvidas assim como calcula a distribuição desta mesma pressão nos 4 quadrantes do pé. Estes dados obtidos através da podometria estática foram comparados com a avaliação clínica da sensibilidade tátil e dolorosa dos pés, nos pacientes hansenianos. Os resultados mostraram que o podômetro é um bom método para se avaliar os pés com deficiência de sensibilidade em hanseníase e também como um método de avaliação que ajuda na prevenção do desenvolvimento do mal perforante plantar: foi sensível na identificação dos pontos de hiperpressão nas áreas anestésicas e em regiões anômalas, das assimetrias e na correlação entre a presença de úlceras e hiperpressão.