Balance control is compromised in patients with leprosy

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Summary

Objectives: To analyse the balance control of individuals with leprosy compared to healthy individuals.

Methods: Leprosy patients and healthy controls were recruited through the Universidade de São Paulo, Brasil. During the data collection process, individuals stood on a force plate (Pro Balance Master 8.1.0, Neurocom®, Inc, Oregon, USA) and received verbal instructions to remain motionless, with arms at their sides and feet positioned in a standard location on the plate, while movement in the subject’s Centre of Pressure (COP) was recorded.

Results: Significant differences were found for Area (A) of Centre of Pressure (COP) (area of an ellipse comprising 85% of the sampled COP) in conditions 2 (individual standing barefoot, with eyes closed on a stable force plate), 3 (individual standing barefoot, with eyes open on an unstable force plate), and 4 (individual standing barefoot, with eyes closed on an unstable force plate) ($P = 0.044$, $P = 0.001$, and $P = 0.001$, respectively), for Velocity of COP in side-to-side direction ($Vx$) in condition 3 ($P = 0.039$), and for Velocity of COP in forward-backward direction ($Vy$) in conditions 1 (individual standing barefoot, with eyes open on a stable force plate), 2, and 3 ($P = 0.023$, $P = 0.050$, and $P = 0.022$, respectively).

Conclusions: Balance control among individuals with leprosy presented greater Area and Velocity of COP oscillation especially in the forward-backward direction, when compared to healthy individuals.

Keywords: Leprosy, Postural Balance, Somatosensory Disorders
Introduction

Leprosy is an infectious disease that is also considered a public health problem.\textsuperscript{1,2} Although it is a disease easily diagnosed and treated, the epidemiological situation in the world is still alarming.\textsuperscript{2} Brazil has the second highest prevalence of leprosy in the world, according to the World Health Organization (WHO), with 26,395 new cases detected in 2015.\textsuperscript{3}

The bacillus \textit{Mycobacterium leprae}, the causative agent of leprosy, is characterised by slow evolution, high infectivity, and low pathogenicity.\textsuperscript{2,4} The bacillus is transmitted through the upper airways and long-term contact with a person who has the disease but has not been treated and causes changes in the skin and peripheral nerves.\textsuperscript{4,5} Although leprosy causes visual and skin changes in the infected person, the impairment of the peripheral nerves is the main feature of leprosy, which potentially compromises the subject’s physical capacity and often leads to the development of deformities.\textsuperscript{5,6} Approximately 10\% of individuals affected by leprosy in Brazil have some kind of disability, even after receiving medical treatment.\textsuperscript{6}

The maintenance of proper body balance requires the integration of the visual, somatosensory, and vestibular systems to generate adequate sensorimotor strategies for performing functional tasks.\textsuperscript{7,8} In a condition in which one of the sensorial systems is failing, the sensorial integration is reorganised in such a way that body balance is less compromised.\textsuperscript{8} For example, in a healthy individual standing on a firm base of support, it is expected that the somatosensory information is the most requested, followed by the vestibular and then visual input, to control his or her balance. For the same individual standing on an unstable base of support, there is an increased use of the vestibular and visual systems, and the dependency on somatosensory information decreases.\textsuperscript{7,8}

Once a patient with leprosy experiences peripheral sensory changes, he or she may present visual changes, and it is possible that balance control will be compromised. With this in mind, our objective was to analyse the balance control of individuals with leprosy compared to healthy individuals.

Material & Methods

This is a transversal analytical study approved by the ethics committee of the Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo – HCFMUSP, n° 448-675. Participants in the study are subjects with leprosy and gender- and age-paired healthy adults comprising the Leprosy Group (LG) and Control Group (CG), respectively. LG individuals were recruited from the Unidade de Atendimento Ambulatorial de Fisioterapia, Fonoaudiologia e Terapia Ocupacional do HCFMUSP. They were diagnosed with leprosy by the dermatologists of the Ambulatório de Dermatologia do HCFMUSP. LG and CG participants with amputation of the upper or lower limbs; neurological diseases unrelated to leprosy, such as stroke or Parkinson’s disease; peripheral neuropathy secondary to another disease; and/or wounds on the plantar region were excluded. CG participants with any alteration in the sensitivity of the feet were also excluded. The CG was recruited among relatives of students and hospital staff. All participants signed a consent form. The data collection was performed at the Laboratório de Investigação Médica, LIM-23.

For the characterisation of LG, the participants were evaluated according to the clinical classification of leprosy (multibacillary - MB or paucibacillary - PB); as well as investigated
trophic and/or traumatic changes in feet and defined degrees of physical disability for feet, according to the Brazilian Ministry of Health and recommendations of the WHO.

During the data collection process, individuals stood on a force plate (Pro Balance Master 8.1.0, Neurocom®, Inc, Oregon, USA) and received verbal instructions to remain motionless, with arms at their sides and feet positioned in a standard location on the plate (Figure 1).

Three 20-second trials were collected under four different sensory conditions: (1) eyes open on a stable plate, (2) eyes closed on a stable plate, (3) eyes open on an unstable plate, and (4) eyes closed on an unstable plate. In condition 1, all sensory information was available and accurate, while in condition 4, only the sensory information coming from the vestibular system was accurate, making this condition the most challenging for postural control. To prevent motor learning of the balance response, a pre-set evaluation sequence was adopted for the four conditions, and a sequence from easier to most demanding conditions, therefore from 1 to 4, was used to assess sensory conditions.

Primary data were transferred to a computer programme that transformed it to show the centre of pressure displacement (COP) through the duration of data acquisition. Three variables in each sensorial condition were calculated, such as area oscillation of the COP, which is the area of an ellipse comprising 85% of the sampled COP, and mean velocity of COP in the frontal (side-to-side direction) (Vx) and sagittal (forward-backward direction) (Vy) planes (Figure 2).

In each of the four sensory conditions, the variables’ average for the three trials was calculated for statistical analysis. The statistical analysis was performed using Minitab® Statistical Software Version 16.2.3 (Minitab, Inc., State College, Pennsylvania, USA) and IBM SPSS® Statistics for Windows Version 20.0 (IBM Corp., released 2011, Armonk, NY).

Figure 1. Data collection setting at the LIM-23.
Initially, the descriptive data analysis was done and the Kolmogorov-Smirnov test was performed to verify the normality of the data distribution. Once the variables presented a non-parametric distribution, the Mann-Whitney test was used to compare each variable (A, Vx, and Vy) in each condition between groups. A significance level of 5% ($P < 0.05$) was adopted.

**Results and Discussion**

The study included 34 subjects in the LG (43.21 ± 10.48 years old) and 34 in the CG (43 ± 10.47 years old), with 11 women (32.35%) and 23 men (67.64%) in each group.

In the LG, 31 (91.18%) subjects were diagnosed with multibacillary (MB) leprosy and three (8.82%), with paucibacillary (PB) leprosy. All LG subjects had normal toes and plantar region. However, two (5.9%) subjects presented absorption on the right foot and three (8.8%), on the left foot. Regarding the degrees of physical disability for feet, 28 (82.35%) subjects presented Grade I or II for the right foot and 29 (85.29%), for the left foot. And only six (17.65%) subjects presented Grade III for the right foot and five (14.70%) for the left foot.

The variables of LG and CG, and comparisons with the Mann-Whitney test, can be seen in Figure 3.

An area representation of one LG individual and one CG individual in condition 1 can be seen in Figure 4.

Changes in postural control have been reported in the literature in individuals with peripheral neuropathy, such as diabetic neuropathy$^9,10$ and elderly individuals.$^{11}$ Although leprosy is an antique yet still prevalent disease in many countries, there is a scarcity of studies that approach postural control in individuals with this disease.

The forward-backward postural control mainly occurs in the ankle, while the side-to-side postural control occurs especially in the hip and trunk.$^7,12,13$ In our study, we found higher mean velocity of COP in the forward-backward direction (Vy) in the LG in conditions 1, 2, and 3. We believe that, no matter the sensory manipulation in our study, such as visual, somatosensory, or vestibular, the individuals with leprosy rely on ankle postural adjustments,
mainly in the subtalar joint, to keep their balance. On top of that, hip and trunk adjustments were also required to maintain the balance in the LG as an additional resource for postural control when the ankle adjustments were not effective.

The area of displacement of COP of individuals with leprosy was higher in conditions 2, 3, and 4, following similar results in velocity of COP in forward-backward displacement.

Figure 3. Area (cm²) and velocities Vy and Vx (cm/s) of centre of pressure displacement under all sensory conditions for LG (red) and CG (blue). [*]p ≤ 0.05. Legend: LG, Leprosy Group. CG, Control Group. COP, Center of Pressure. A, area oscillation of COP. Vy, velocity of COP in side-to-side direction. Vx, velocity of COP in forward-backward direction. [*]p ≤ 0.05 (Comparisons using Mann-Whitney U-test).

Figure 4. Area representation of a LG individual (red) and a CG individual (blue) in condition 1. Legend: COPx, Center of Pressure in side-to-side direction. COPy, Center of Pressure in forward-backward direction.
Condition 1 was the only one in which we did not find significant differences. In this condition, the findings were similar between groups.

The mean velocity of COP in the side-to-side direction (Vx) did not, in general, show any differences from the control group, only when somatosensory was disturbed in condition 3. We believe that, once an individual with leprosy in our sample (LG) has a peripheral sensory deficit when their balance is threatened by sensory conditions, higher activation is elicited in the hip and trunk muscles to achieve better balance control, since probably the ankle, especially the subtalar joint, was not effective for maintaining the side-to-side balance alone.

Similar results regarding the deficit in postural control were previously found by Boucher et al.\textsuperscript{9} and by Lafond et al.\textsuperscript{10} in patients with diabetic peripheral neuropathy when compared to healthy individuals.

In our sample, we had three diabetic individuals in the LG. Since the diabetes can lead to peripheral neuropathy we have also repeated all the analyses excluding them. The results were maintained for A and Vx; for Vy we found significant differences only for conditions 1 and 3. We believe that individuals with diabetes and leprosy may have a greater somatosensory alteration, evidenced by condition 2, since in this condition they need more of the somatosensory system to keep the balance. In other words, in the group including the three diabetic individuals, the LG presented higher Vy with eyes closed and stable plate. When excluding the three diabetic individuals, the LG became equal to the CG.

We also had three individuals with PB leprosy in the LG. Although PB leprosy causes fewer changes in the nerves of individuals affected with leprosy when compared to MB leprosy,\textsuperscript{14} we did not exclude the individuals with PB leprosy, since even though there are fewer nerve changes in PB, there is the possibility of peripheral nerve changes, through demyelination of these nerves, with a dominant pattern of mononeuropathy.

In our study, we used a mobile force plate (Pro Balance Master 8.1.0, Neurocom\textsuperscript{®}, Inc, Oregon, USA) when we assessed conditions 3 and 4 following the motions of the individuals in the forward-backward direction. We believe that the experimental setting, following the body movement only in the forward-backward direction, may have influenced the findings of this study. Perhaps if the challenge in the somatosensory system was carried out with a 3-D system, different results could be found.

This study was able to verify differences in the postural control between leprosy patients and healthy adults. However, further investigation is needed with a larger sample and specific assessments for somatosensory changes (e.g., assessing the sensitivity of the feet), in order to gain a deeper understanding of leprosy patients’ balance changes and to treat them adequately.

We conclude that the balance control of individuals with leprosy has a greater area oscillation of the COP and greater velocity of the COP, especially in the forward-backward direction, when compared to healthy individuals.

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