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Effects of application of texture insoles on the balance of subjects with Multiple Sclerosis

Efeitos da aplicação de palmilhas com textura no equilíbrio de sujeitos com Esclerose Múltipla

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Abstract

Objective: The aim of this study was to evaluate the effects on static and dynamic balance after the use of textured insoles. **Method:** Fifteen subjects with multiple sclerosis were evaluated before using the insoles, after using them for 1 month, and after 2 months without using, them using the following measuring instruments: the Berg Balance Scale, Dynamic Gait Index, and 10-meter Walk Test, a means of functional gait assessment. **Results:** Improvement was observed in the Berg Balance Scale and Dynamic Gait Index scores, walking time, number of steps and step length after using the insoles for 1 month. The improvement in Berg Balance Scale score remained after two months without the insoles and there were no changes in gait speed. **Conclusion:** The use of textured insoles was effective as an intervention to improve static and dynamic balance in patients with multiple sclerosis.

Key words: Multiple Sclerosis; Postural Balance; Gait.

Resumo

Objetivo: O objetivo deste estudo foi avaliar os efeitos sobre o equilíbrio estático e dinâmico após o uso de palmilhas texturizadas. **Método:** Quinze indivíduos com esclerose múltipla foram avaliados antes de usar as palmilhas, após usá-las por 1 mês e depois de 2 meses sem usá-las, utilizando os seguintes instrumentos de medição: a Escala de Equilíbrio de Berg, Dynamic Gait Index e teste de caminhada de 10 metros, meios de avaliação funcional da marcha. **Resultados:** Houve melhora na pontuação Escala de Equilíbrio de Berg e Dynamic Gait Index, tempo de caminhada, o número de passos e comprimento do passo depois de usar as palmilhas. A melhora permaneceu após dois meses sem as palmilhas e não houve mudanças na velocidade da marcha. **Conclusão**: O uso de palmilhas texturizadas foi eficaz como uma intervenção para melhorar o equilíbrio estático e dinâmico em pacientes com esclerose múltipla.

Descritores: Esclerose Múltipla; Equilíbrio Postural; Marcha.

INTRODUCTION

Proper balance is dependent on the integration of visual input, the somatosensory system and vestibular system, and an appropriate motor response can often be impaired in patients with multiple sclerosis (MS)[1]. Commonly, these patients develop paresis, spasticity, ataxia, and sensory disturbances, resulting in pathological gait patterns followed by static and dynamic imbalance[2]. The balance changes in MS are problematic due to the association of MS with the difficulty in changing position, maintaining an upright posture, and performing functional activities such as walking and turning, going up stairs, in response to external perturbation and in the Functional Reach Test, predisposing to falls[3,]. Finlayson et al.[4] highlighted a decline in efficiency in activities that require loading of the feet and a high risk of osteoporosis and hip fractures after falls as a result of prolonged use of corticosteroids in MS patients.

Plantar sensitivity appears to be an important item in the regulation of stepping during the human gait and contributes to postural control aspects5. The afferent feedback from the feet is important for balance and locomotion, and it comes from specialized mechanoreceptors found in the feet skin layers6-8. Belanger and Patla9 showed that while walking and running, noxious and non- noxious stimuli occur, exciting the cutaneous nerve that innervates the foot, which might affect the alpha motor neurons and their activity in the leg muscles. Several studies have demonstrated changes in postural control through anesthesia and cooling10-12 of the foot, revealing an increased postural sway, decreased compensatory reactions and ankle and step strategies, and reduced soleus muscle response in a bipedal posture.

Sensory feedback from the feet may be influenced by changing the characteristics of a shoe sole or surface, and some studies have examined the effects of changes in sensory feedback during maintenance of a standing posture[13,14]. Watanabe and Okubo[15] provided evidence indicating that standing on different surfaces can alter the transmission of afferent signals from the sole of the foot. Increased activity of the tibial nerve was seen in subjects standing on textured surfaces with varied densities. Chiang and Wu[1] revealed a difference in muscle reflexes after standing on soft surfaces and concluded that the sensory feedback from the feet was altered when subjects stood on different surfaces. However, the effects were not examined during movements such as walking and running[16].

The foot mechanoreceptors can exhibit fast or slow adaptation, and 73% exihibit fast adaptation[7]. Merkel's cells are slowly adapting receptors that can be activated by more pronounced elevations or edges, and once stimulated, they provide accurate information about the dimensions of objects by means of the changes in their firing frequencies. If a surface is flat, Merkel's disks shoot continuously at a relatively low rate. The firing rate is increased by convexity, while concavities silence these receptors[17].

Mechanical stimulation of the sole of the foot during the stance phase can evoke postural reactions that are strongly correlated with the cutaneous stimulus. Chiang and Wu[1] conducted a study using a soft surface under the sole of the foot, and the results showed that standing on this surface could affect the input of joint receptors and cutaneous mechanoreceptors. In a study conducted by Nurse et al.[11] using normal subjects, the texture of the subjects' insole was changed without altering their shape, and they found changes in gait patterns, which supports the theory that sensory feedback of the feet cutaneous receptors is important in determining movement strategies during human locomotion.

Patel et al [18,19], showed that the mechanical properties of a foam surface, the foam surface density, and the extent to which the foam material compresses under a given force are significantly related to the resulting stability challenge. Mantovani et al.[20] conducted evaluations of plantar pressure and the body's pressure center shifts in 15 subjects with postural changes. The evaluations were conducted in two different situations: first without and then with proprioceptive insoles. The results showed that, after one minute of insole use, there was postural realignment of the scapular plane and hip, as the insoles tended to reduce the sharp values of each curve with cervical, occipital, and lumbar significance. It can be seen that there was no significant difference in plantar pressures; however, the results support the hypothesis that the foot is strongly adaptive to changes and imbalances of the upper segmental levels, such as trunk misalignments (static and dynamic). These insoles promoted an adequate postural realignment, possibly due to a better adaptation of muscular and postural tone

Shoes, orthotics, sports surfaces, and the construction of insoles can act as a filter, changing the sensory input from receptors of the foot and therefore the motor response, which can generate an increase or decrease in response to loading of the feet[2, 14, 21]. Nurse et al.[13] revealed that, in normal individuals, changes in the plantar sensory feedback using textured insole (TI) result in decreased activity of the soleus and tibialis anterior muscles during the period these muscles are usually active and suggested that these changes can be applied as a sensory intervention to alter gait patterns.

There are no findings in the literature about the use of textured insole in patients with multiple sclerosis. Due to the low cost and easy access to textured insole, we consider the need for studies that demonstrate the benefit of using IT on the balance and gait of individuals with MS and propose a treatment that is effective for rehabilitation. Therefore, to address the gap in literature and clinical practice, we conducted a study to analyze to evaluate the effects on static and dynamic balance after use of textured insole in patients with multiple sclerosis.

Subjects and methods

This was a longitudinal and prospective study, approved by the Ethics and Research Committee of the Medical Sciences Faculty, State University of Campinas (protocol number 1724/2005), and conducted in accordance with Resolution 196/96 of the National Health Council.

We recruited 38 patients, who had defined clinical diagnoses of MS, from the physical and occupational therapy outpatient clinic at the Clinics Hospital (CH), UNICAMP. The inclusion criteria were patients between 18 and 60 years old (both genders) who were in the remission phase of relapsing-remitting MS and, able to walk without the aid of another person. The exclusion criteria were primary or secondary progressive forms of MS, relapse during the use of textured insole, cognitive impairments that would preclude the patient from understanding the research stages, diabetes, associated neurological disorders, diseases that can alter exteroceptive or proprioceptive sensitivity, and musculoskeletal comorbidities that limit the upright position. After analyzing the criteria, we selected 16 patients who agreed to participate in the research and signed a consent form.

All subjects were evaluated with the following scales: the Expanded Disability Status Scale (EDSS), Berg Balance Scale (BBS), Dynamic Gait Index (DGI), and the 10-meter Walk Test, wich was performed as a functional gait assessment. The EDSS has a total score of 10 points and aims to measure the maximal function and limitations imposed by neurological deficits by grading 8 functional systems[22]. The BBS is composed of 14 ordinary tasks involving functional balance performance, with a maximum score of 56[23]. The DGI was developed to quantify gait disorders in patients with alterations of the vestibular system[24]. Scoring ranges from 0 to 24, and for scores below 19, the risk of falls is considered high. The 10-meter Walk Test in this study included four items: walking time (seconds), number of steps, step length (cm) and velocity (meters/second). The test was performed three times, with the mean of values recorded[25]. The walking time was measured by chronometer, the number of steps were counted and the average speed calculated by calculator.

The materials used for this study included textured insoles made of expanded polyurethane (antiallergic) with a thickness of 10.28 mm and weight of 3800 g/m^2 (Figure 1), 4 cones (12 cm high), a regular shoe box, one adhesive tape, one measuring tape, and two ordinary chairs. The insole was adjusted to the shoes participants had at the time of evaluation.

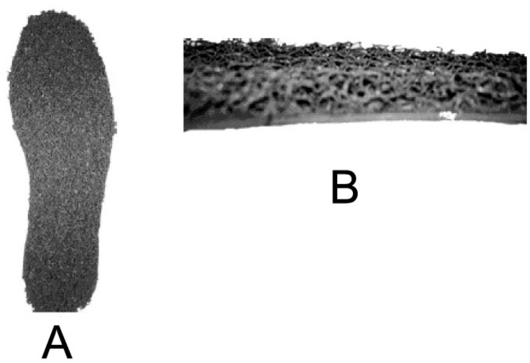

Figure 1: Insole texture, superior view (A) and lateral view (B).

The subjects were assessed with all measuring instruments without the TF (assessment 1). On the same day, the patients were reassessed with the BBS, DGI, and 10-meter Walk Test while using the TF (assessment 2). The patient was instructed to use the TF, replacing the original insoles of their shoes, 5 hours per day during activities of daily living or instrumental activities of daily living for a period of 30 days. After this first month using the TF, the individual was reassessed by the same instruments (post treatment) without the TF (assessment 3) and with the TF (assessment 4). Next, the individual stopped using the insoles and was reassessed after 2 months (follow-up) with the same measuring instruments without the insoles (assessment 5).

A descriptive analysis of numeric and categorical variables of the sample was performed. We did not find a normal distribution of variables (Shapiro-Wilk Test). For analysis of continuous variables, we used the Wilcoxon test, and the significance level of was set at $p < 0.05$. We used SPSS for Windows, Version 20.0.

Results

The total sample consisted of 14 patients because one withdrew from the study. The results of demographic, clinical data and the scores of the measuring instruments in the five assessments are in tables below respectively (See table 1 and 2 respectively).

Table 1: Demographic data (n=15)

Variables	median or frequency	1st quartile; 3rd quartile
Age (y)	40	32; 49
Gender (F/M)	14/1	---
Symptoms duration (months)	90	45; 123
EDSS score	3.5	2.5; 4

Y: years; F: female; M: male; EDSS: Expanded Disability Status Scale.

Table 2 shows that after a period of 30 days using the TF, the post-treatment assessments (assessments 3 and 4 compared with assessments 1 and 2, respectively) showed significant improvement ($p<0.05$) in the BBS and DGI, taking into consideration the time required to perform the 10-meter Walk Test; in assessment 3, significant improvement was observed in the number of steps (reduction) and step length (increase). Also, after two months without using the TF, the assessment at follow-up showed that the increase in BBS score remained ($p <0.05$), as did the changes in gait speed.

Discussion

Therapeutic strategies have been employed for recovery or maintenance of postural control and mobility in MS patients[1, 2, 4], highlighting the use of different surfaces for walking[1, 17, 18]. In our study, the use of a TF optimized the standing and dynamic balance scores. Regarding the insoles, mechanoreceptors respond to mechanical stimuli, including recesses and stretching of the skin that provide information about texture

Table 2: Variables in pretreatment, posttreatment and follow-up time points

	Pretreatment median (1st quartile; 3rd quartile)		Post treatment median (1st quartile; 3rd quartile)		Follow-up median (1st quartile; 3rd quartile)
Variables	Without TF (1)	With TF (2)	Without TF (3)	With TF (4)	Without TF (5)
BBS	49 (44; 51)	49 (47; 52)	51 (49; 54) *	51 (48; 55) **	51.5 (48.5; 55) §
DGI	18 (16; 20)	20 (16; 21)	20 (18; 22) *	21 (16; 22)	18.5 (16.3; 20.8)
Gait assessment					
Time (s)	12.5 (9.1; 17.5)	12 (8.2; 14.9)	9.9 (8.3; 12.9) *	9.9 (8.2; 13) **	12.3 (9.7; 29)
Number of steps	19.3 (15.2; 22.8)	17.6 (15.3; 20)	16.8(16.1; 19.8) *	17 (15.7; 19.8)	19.3 (16.6; 52)
Step length (m)	0.51 (0.47; 0.65)	0.58 (0.5; 0.68)	0.59 (0.5; 0.62) *	0.59 (0.5; 0.62)	0.53 (0.51; 0.59)
Velocity (m/s)	0.88 (0.7; 1.23)	0.97 (0.74; 1.3)	1.02 (0.82; 1.3)	1.04 (0.82; 1.24)	1.02 (0.75; 1.03)

(N=15) Bbs: Berg Balance Scale; Dgi: Dynamic Gait Index; S: Second; M: Meter; M/S: Meters Per Second; Tf: Textured Insoles
* $p<0.05$ comparison between assessments 1 and 3.
** $p<0.05$ comparison between assessments 2 and 4.
§ $p<0.05$ comparison between assessments 3 and 5.

which allows detection of the spacing, roughness, and direction of the texture pattern. Thus, the aim when using textured surfaces is to increase the sensory input[26-27].

The BBS seems to indicate the response to changes in weight transfer in the lower limbs, because standing balance showed a significant improvement in terms of total score after 1 month of TF use and the improvement was retained. According to Shumway-Cook [25], when the BBS score is between 46 and 54 points, a decrease of 1 point is associated with an increase of 6 to 8% for the risk of falls. In the present study, there was an increase of 2 points in the median BBS score between the pre- and post-treatment periods. Probably contributing to the improvement of the static balance and reduction of the risk of fall in this group.

Perry et al.[12] studied ten healthy subjects subjected to cooling of the entire sole of the foot and found that cutaneous mechanoreceptors contribute significantly to the detection of posterior stability limits and that the absence of these effects on the lateral and anterior directions pointed to the information available from toes proprioceptors. A the decrease in plantar exteroceptive sense is less important than the proprioceptive deficits when maintaining balance in a standing posture, with unipedal support, or with eyes closed[13]. Thus, the plantar afferent feedback is important in maintaining balance when vision is absent. It is known that proprioceptive deficits are prevalent in MS patients, and use of textured insoles is aimed at enhancing the conscious proprioceptive information, compensating for vestibular and cerebellar losses.

The sensory input from cutaneous afferents of the foot is important in changing gait patterns[14]. The dynamic balance as measured by the DGI showed an increase, especially from the first to the third assessment. This may be due to the evaluation of gait activities with vertical and horizontal rotations of the head (inaccuracy of vision), overcoming obstacles and going up stairs, with the requirement of proprioceptive and vestibular information. Nurse et al.[14] reported that the Golgi tendon organ and the skin receptors act as load sensors and can adjust the motor response during static and dynamic movements in individuals with altered plantar sensitivity. These load receptors promote a phasic transition between the stance and swing phases of the gait cycle, and the TF stimulus is probably involved in this process.

Changes in muscular activation resulting from TF use can be observed by changes in the functional gait assessment. The findings show that between the first and third assessment, there was reduction in walking time and, number of steps and an increase in step length during the 10-meter Walk Test. Corroborating our findings, Maki et al.[16] observed that cutaneous stimulation at the edges of the sole of the with a strip of polyethylene (1 mm thick and 3 mm wide) can improve the stability of single support during the swing phase in normal young and elderly subjects.

In the randomized, controlled and blind clinical trial of Hatton et al[28], using 12-week textured insoles in 176 individuals with multiple sclerosis to observe gait efficacy on uneven surfaces, balance and sensory measurements in which experimental group used textured insoles And the control group used smooth insoles that were adapted and to the shoe size of each participant. Better sensory motor sensibility was observed in the plantar region, besides being presented as tactile stimulation and assisting in the discharge of weight, therefore the textured insoles present the capacity to improve the gait pattern and to provide greater stability, besides increasing the length of the step and Decrease time if double support during walking. In another study conducted by Dixon et al[29], whose the objective of this study was to investigate the immediate effects on balance and gait in 46 individuals with MS able to walk with or without ancillary devices, mean age 49 ± 7 years, being allocated Randomly in the control group (smooth insole) and experimental group 1 and 2 (insole with texture 1 and texture 2, respectively) and used them for two weeks. There was no significant difference between the groups, the textured insoles did not present immediate effects on the balance and gait, however the groups that used the textured insole presented improvement in the space-time parameters of the gait and increase of the length of step, suggesting that perhaps a time greater than two weeks of use is required. For Kalron, et al[30], in his experimental intra-subject study used the textured insole to evaluate the immediate effects and maintenance of these long-term effects on postural control and spatiotemporal gait parameters. The 25 individuals who participated, being 16 women and 9 men with average age of 49.6 ± 6.5 years, used the insole during 4 weeks. Kalron, et al. Corroborating with Dixon et al[29], there was no significant improvement between the initial and final evaluation for gait parameters, but there was improvement on the center of pressure displacement and oscillation rate when subjects with MS used the textured insole in comparison to Wearing casual shoes without the insole, impacting on better balance.

The present study had some limitations, namely the withdrawal of one patient and possible withdrawal, not informed of the insoles use by the patients. The absence of a control group does not allow the comparison and generalization of retention of gains in the MS group, which occurred only for the BBS scores. The variability of the time of MS symptoms and the EDSS score may have influenced the results. However, all participants were able to walk without the aid of another person, characterizing similar functions and limitations imposed by neurological deficits.

Conclusion

Given the evolution of the scores of the measuring instruments, the use of textured insoles was effective as an intervention for improving static and dynamic balance in patients with MS, and can be established as affordable and low-cost complementary therapy. We suggest further studies with larger sample sizes, longer use of the TF, and use of other instruments for measuring mobility and balance with different types of textured insoles.

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