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Effect of proprioceptive training among diabetic women

Efeito do treinamento proprioceptivo em mulheres diabéticas

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Abstract

Background: *Diabetes mellitus* is a common disease among the elderly and represents one of the principal public health problems worldwide. Individuals who suffer from *diabetes mellitus* present a predisposition to develop neuropathies. These problems can be diagnosed by means of the detection of points with greater pressure and diminished tactile sensitivity. **Objective:** To evaluate the center of pressure oscillatory amplitude in the bipedal position with eyes open and the plantar tactile sensitivity after 12 weeks of proprioceptive training. **Methods:** Thirteen diabetic volunteers of mean age 61.77±7.55 years were recruited. Baropodometric and sensitivity evaluations were performed before the physical therapy intervention and after six and 12 weeks of therapy. The therapy was applied twice a week and consisted of a circuit composed of 13 stations with different textures. The tactile sensitivity values were subjected to the Friedman analysis of variance test. The data on the anteroposterior and mediolateral oscillation of the center of pressure were analyzed using the Wilcoxon rank test. **Results:** For the anteroposterior oscillation of the force center, there were significant differences ($p<0.05$) between the values before and after six and twelve weeks of physical therapy intervention. However, there were no significant differences ($p>0.05$) regarding mediolateral oscillation between the groups over the course of time. The results also showed significant improvement ($p<0.05$) in the tactile sensitivity of the points analyzed. **Conclusions:** It can be concluded that the training undertaken was effective in increasing the plantar tactile sensitivity and reducing the anteroposterior oscillation of the center of pressure in the studied sample.

Key words: diabetes; peripheral neuropathy; physical therapy.

Resumo

Contextualização: O *diabetes mellitus* é uma doença comum na população idosa e representa um dos principais problemas de Saúde Pública em todo o mundo. Os indivíduos acometidos pelo *diabetes mellitus* apresentam predisposição a desenvolver neuropatias, que podem ser diagnosticadas pela detecção de pontos de maior pressão e sensibilidade tátil diminuída. **Objetivo:** Avaliar a amplitude da oscilação do centro de pressão na posição bipodal com olhos abertos e sensibilidade tátil plantar após 12 semanas de treinamento proprioceptivo. **Materiais e métodos:** Foram recrutadas 13 voluntárias diabéticas, com idade média de 61,77 (±7,55 anos). A avaliação sensitiva e baropodométrica foi realizada antes e após seis e 12 semanas de intervenção fisioterapêutica. Esta foi aplicada duas vezes por semana e constou de um circuito composto por 13 estações com diferentes texturas. Os valores referentes à sensibilidade tátil foram submetidos ao teste de análise de variância de Friedman. Dados quanto à oscilação ântero-posterior (AP) e médio-lateral (ML) do centro de pressão foram analisados pelo teste rank de Wilcoxon. **Resultados:** Em relação aos valores referentes à oscilação AP do centro de força, houve diferença significativa ($p<0,05$) entre os valores antes, após seis e 12 semanas de intervenção fisioterapêutica, porém não houve diferença significativa ($p>0,05$) quanto à oscilação ML entre os grupos ao longo do tempo. Os resultados também apontam melhora significativa ($p<0,05$) na sensibilidade tátil dos pontos analisados. **Conclusões:** Diante dos resultados obtidos, pode-se concluir que o treinamento utilizado foi efetivo para incremento da sensibilidade tátil plantar e redução da oscilação AP na população estudada.

Palavras-chave: diabetes; neuropatia periférica; fisioterapia.

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Introduction

Diabetes mellitus (DM) is a prevalent disease considered to be a Public Health problem, with high social and economic costs[1]. Among the clinical complications of DM there are blindness, renal insufficiency, nephropathy and peripheral neuropathy (PN)[2,3]. PN seems to develop as an autonomic and sensorial disturbance and as a progressive and irreversible motor disease[4]. It can interrupt the afferent and efferent functions of the lower extremities that are responsible for maintaining normal posture and normal walking[5]. As a consequence, proprioception is lost.

Proprioception is the ability to perceive position and movement. This ability allows for the monitoring of the progression of any movement sequence and makes later movements possible. It is a sensory modality mediated by mechanoreceptors, which are receptors found in muscles and neurotendinous organs. The function of mechanoreceptors is to discriminate between temporal and spatial information about pressure of contact on the feet[6,7].

When the sensitivity in the sole of the foot and the information coming from mechanoreceptors is decreased, there is a decline of balance in the elderly and in individuals with diabetes. Within this context, physical activities directed at improving proprioception and balance can reduce morbidities related to ageing and diabetes, with significant effects observed after 12 weeks of training[9,10].

The measurement of the amplitude of oscillations of the center of pressure during upright posture has been used to assess postural stability. This measure is important because there is a strong inverse correlation between the oscillations of the center of pressure and postural control, with greater values of oscillation being indicative of poorer balance control[11,12].

The objective of this study was to assess the oscillations of the center of pressure during bipedal stance with eyes open and the plantar tactile sensitivity after 12 weeks of proprioceptive training to minimize complications caused by diabetes.

Materials and methods

This research was conducted according to the resolution number 196/196 of the National Health Council and was approved by the Research Ethics Committee of the Universidade Metodista de Piracicaba (Unimep), under the protocol number of 98/04. All volunteers signed an informed consent form.

Participants

A total of 21 possible participants were invited to take part in the study. The following exclusion criteria were used: having cognitive deficits, PN of other etiologies or blindness. Participants who missed two intervention sessions were also eliminated. Thus, a total 13 female volunteers with diabetes, whose ages varied between 50 and 70 years (62±7.55), took part in this study. They were sedentary and were taking oral antidiabetic drugs.

All volunteers were received medical treatment and were assessed by physical therapists at the beginning of the study. The assessments included measures of body mass (71.15±8.98kg), height (1.51±0.06m), body mass index (BMI, 30.99±4.70kg/m^2), the ratio between waist and hip circumferences (RWH, 0.87±0.13), and blood pressure.

Experimental procedure

The physical therapy intervention was structured into two 45-minute sessions every week, for 12 weeks. Sessions were divided into three phases: warm-up (15 minutes), proprioceptive training and cool down, with assessment of blood pressure.

Balance training was based on adapted Frenkel techniques[14] and was modified for diabetic individuals with sensory deficits in the sole of the foot. The exercises demanded high levels of concentration and visual control of movements and repetitions with the objective of promoting the acquisition of functional movements[15]. Exercises were organized in circuits where participants had to coordinate gait by stepping with alternate feet on markers placed on the ground and the progression was manipulated through modifications of speed and direction.

The proprioceptive training protocol included gait, balance and proprioception exercises with the objective of stimulating the sole of the foot. A circuit with different floor textures composed of 13 stations was used. The activity time at each station was two minutes and the rhythm of the exercises was determined by alternating slow-paced and fast-paced songs. Materials used to build the circuit were used in the following sequence: a ten-cm thick foam, a wood box with beans, a two-cm thick mat with a density lower than the foam, a wood box with cotton, and again a similar two-cm thick mat.

A balance board was then used to train the lateral balance reactions. At the seventh station, volunteers sat on a bench and trained feet flexors by grasping with the toes a towel put on the floor. At the eighth station, there was again a ten-cm thick foam. Two proprioception balls with an eight-cm diameter with external projections resting on the floor were on the next station. At the tenth and 11th stations, there was a box with grains and a two-cm mat. Balance and hip movements were trained at the 12th station with medicine balls (diameter

75cm). At the last station, sandpaper was placed on the ground and volunteers had to alternately slide their feet on it. The cool down sequence included breathing exercises, slow active movements and stretching of the upper and lower extremities and low back muscles.

Baropodometry was performed with the Matscan (Tekscan®) pressure plataform, with 2.288 sensors, with a resolution of 1,4 sensor/cm^2 and dimensions of 436 x 369mm. Data collected by the Matscan was transferred and analyzed online with Windows software installed in a standard desktop computer. For the determination of the center of mass, participants stood on the platform with their eyes open for six seconds, three times in sequence. Data were collected before the physical therapy intervention and six and 12 weeks later.

Sensory function of the sole of the foot was assessed with Semmes-Weistein 10-gr monofilaments (Sorri®) according to the criteria adopted by the American Diabetes Association (ADA)[16]. The tips of the first, third and fifth toes and the corresponding projections of the metatarsal heads were touched with the filaments for two seconds. Results of this assessment were considered negative when the volunteer did not report feeling the touch of the filament in one or more of the assessed areas.

Data reduction

Data regarding anterior-posterior (AP) and medial-lateral (ML) oscillation amplitude were converted into the ASCII language with the software Research Foot 5.72 (Matscan®) and then analyzed with the Excel software (Microsoft Windows®). For purposes of normalization, the data were multiplied by the distance between sensors (0.8382).

Statistical analyses

The sample size was calculated with the Graphpad Statemate 2.0 software (Power test). Calculations were based on means and standard deviations of the oscillations of the center of pressure in elderly diabetic women obtained in a pilot study with an α=0.05 and power of 80%, and the estimated sample size was 13 individuals.

Normality of the data was determined with the Shapiro-Wilk for all statistical variables and the Bartlett's test was then applied to assess the homoscedasticity. Data referring to AP and ML oscillations of the center of mass were analyzed with the Wilcoxon-Rank test and the Friedman analysis of variance (ANOVA) was used to analyze the sensory function data. For all analyses, the BioEstat software version 4.0 was used and the significance level was 5%.

Results

Significant differences in sensory function of the sole of the foot were found ($p<0.05$) when the assessments were performed before the intervention, after six and after 12 weeks of training were compared, in spite of the presence of the outliers. In the test of plantar sensitivity, only 15% of the participants could feel all the 12 tested points. After six weeks of proprioceptive training the percentage increased to 46% and after 12 weeks the percentage reached 85% (Figure 1).

Significant differences were found for the AP oscillations of the center of pressure ($p<0.05$) when the assessments were performed before the intervention, after six weeks and after 12 weeks of training were compared (Figure 2).

There were no significant differences for the ML oscillation ($p>0.05$) between assessments performed before and after intervention (at six and 12 weeks).

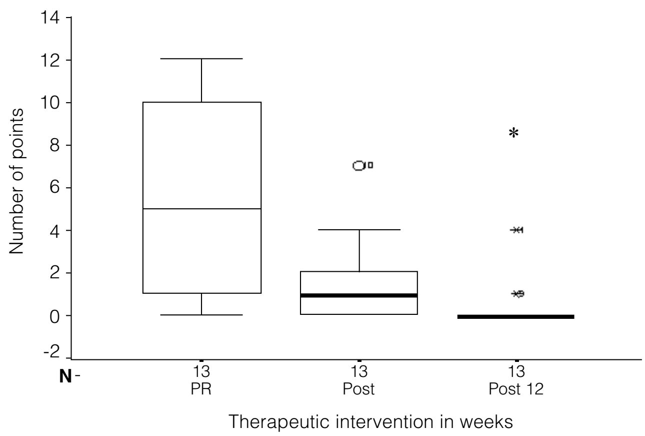
Discussion

DM afflicts 7.6% of the Brazilian population aged 30 to 69 years. Approximately 50% of the individuals with DM are not aware of their condition and are not diagnosed, and 24% of the individuals who are diagnosed do not undergo any kind of treatment[17].

The sensory component of the PN causes gradual loss of sensitivity to pain, perception of plantar pressure, temperature and proprioception[18] and can lead to postural instability[19,20]. This can induce an increase in the number of falls and consequently in the number of fractures, in addition to causing plantar ulcers in the population with DM[21-23].

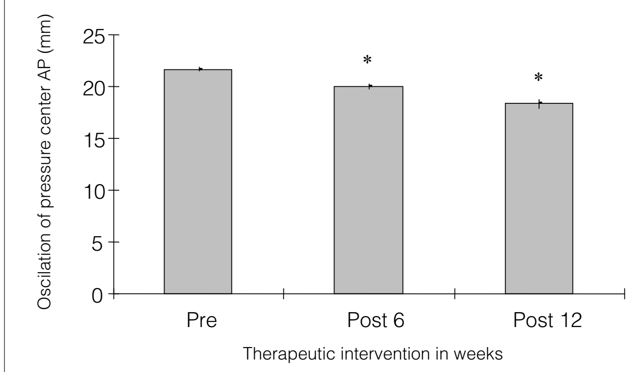
Similarly to the present study, Tilling, Darawil and Britton[24] observed postural instability in diabetic women. The greater latency period for postural responses observed in individuals with PN demonstrates that this condition predisposes the individual to postural instability[25]. The greater AP oscillations found in the present study could be explained by the proprioceptive deficits found in individuals with diabetes.

Physical activity is being considered as a therapeutic intervention to ameliorate postural instability. Studies that analyzed the effects of proprioceptive exercise programs for individuals with diabetes[26,27] report that balance and postural stability can be improved, probably by means of an increase in peripheral afference, leading to a reduction of falls related to sensory deficits. Postural control is the resultant from the interaction of the vestibular, visual and sensory systems, and any alterations in one or more of these systems, such as sensory deficits on the feet, can result in postural instability The improvement of



*p<0.05 related to pre and post6; pre and post12 (n=13).

Figure 1. Number of insensibility points monofilaments (10g) in plantar surface, bilaterally, in diabetics in period before (pre) and after six (post6) and 12 (post12) weeks of physical therapy.



*p<0.05 related to pre and post6; pre and post12 (n=13).

Figure 2. Medium values±standard deviation of the anteroposterior oscilation (AP) of the pressure center in bipodal positions with opened yes, before and after six and 12 weeks of therapeutic intervention.

tactile sensitivity and the reduction of AP oscillations observed in this study after the training protocol could be attributed to the multisensory nature of the stimulation provided by the intervention.

The reduction of plantar tactile sensitivity of individuals with PN is more evident in the sole than in the dorsum of the foot when the individual is tested with Semmes-Weinstein monofilaments[28]. McGill et al.[29] demonstrated that the 10-g monofilament has sensitivity and specificity rates of 88 and 68%, respectively. Results of this study also demonstrated the efficacy of the monofilament to assess foot sensitivity in patients with diabetes.

The feasibility of a low cost intervention protocol to prevent morbidities in individuals with diabetes was investigated[30]. The present study also contemplated the social aspect of treatment as it proposed low cost, viable procedures. Results of this study demonstrated that the therapeutic intervention provided patients with multisensory stimulation and contributed to the improvement of postural stability in the studied sample.

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