Static balance in patients presenting *diabetes mellitus* type 2 with and without diabetic polyneuropathy

Equilíbrio estático em pacientes com diabetes melito tipo 2 com ou sem polineuropatia diabética

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ABSTRACT

Objectives: To contrast the static balance in patients presenting *diabetes mellitus* type 2 (DM2) with and without polyneuropathy (DPN); and to correlate the rates from the scale *Diabetic Neuropathy Examination* (DNE) with the mean ratio of the center of pressure (CoP). **Subjects and methods:** Twenty patients, aged between 40 and 54, presenting DM2 and classified, according to DNE scale, in groups with (n = 10) and without (n = 10) DPN, were compared. Static balance was evaluated by means of the CoP mean ratio on a Wii Balance Board® under the conditions of open and closed eyes. After normality verification (Shapiro-Wilk), balance between both groups was compared by means of the Student *t* test and Mann-Whitney *U test,* as applicable. DNE rating was correlated with the mean ratio of CoP in the group with DPN, considering a significance level $p < 0.05$. **Results:** Significant differences ($p = 0.049$) were found under the condition of closed eyes, with greater CoP ratio in the group with DPN (0.548 cm *vs.* 0.442 cm). The group with DPN showed a tendency ($p = 0.059$) towards a greater CoP mean ratio under the open eyes condition (0.351 cm *vs.* 0.239 cm). There was a strong correlation (r = 0.751) between the DNE rating and the CoP mean ratio under the closed eyes condition ($p = 0.012$). **Conclusions:** Patients showing DPN demonstrated worse static balance than patients without DPN in the closed eyes condition. Furthermore, the higher the rating in DNE, the stronger the displacement of CoP, which may be associated with higher risk of falls. Arq Bras Endocrinol Metab. 2013;57(9):722-6

Keywords

Postural balance; diabetic polyneuropathy; *diabetes mellitus*, type 2; diabetic complications

RESUMO

Objetivos: Comparar o equilíbrio estático em pacientes com diabetes melito tipo 2 (DM2) com ou sem polineuropatia diabética (PND) e correlacionar os escores da escala de Exame da Neuropatia Diabética (EDN) com a média da relação do centro de pressão (CoP). **Sujeitos e métodos:** Vinte pacientes, com idades entre 40 e 54 anos, que apresentavam DM2 e classificados, de acordo com a escala EDN, em grupos com (n = 10) e sem (n = 10) PDN foram comparados. O equilíbrio estático foi avaliado segundo a média da relação do CoP em um *Wii Balance Board®* na condição com os olhos abertos e os olhos fechados. Depois da verificação da normalidade (Shapiro-Wilk), o equilíbrio entre os dois grupos foi comparado por meio dos testes *t* de Student e *U* de Mann-Whitney, como aplicável. O escore na EDN foi correlacionado com a média da relação do CoP no grupo com PND, considerando um nível de significância de $p < 0{,}05$. **Resultados:** Diferenças significativas ($p = 0{,}049$) foram observadas nas condições de olhos fechados, com uma maior média da relação do CoP no grupo com PND (0,548 cm *vs.* 0,442 cm). O grupo com PND mostrou uma tendência ($p = 0{,}059$) para maior média da relação do CoP na condição com os olhos abertos (0,351 cm *vs.* 0,239 cm). Foi observada uma forte correlação (r = 0,751) entre o escore EDN e a média da relação do CoP na condição com os olhos fechados ($p = 0{,}012$). **Conclusões:** Os pacientes com PND demonstraram pior equilíbrio estático do que os pacientes sem PND na condição com os olhos fechados. Além disso, quanto maior o escore no EDN, mais forte o deslocamento do CoP, o que pode estar associado com maior risco de quedas. Arq Bras Endocrinol Metab. 2013;57(9):722-6

Descritores

Equilíbrio postural; polineuropatia diabética; diabetes melito tipo 2; complicações do diabetes

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Received on Apr/26/2013
Accepted on Sept/29/2013

INTRODUCTION

Diabetes mellitus (DM) is one of the most common chronic diseases worldwide, affecting about 285 million people in 2010 (1). This high prevalence brings, as a consequence, an enhancement in macro-vascular complications linked to arteries that nourish the myocardium, brain and limbs; as well as micro-vascular complications, such as retinopathies, nephropathies, and neuropathies (2).

Diabetic polyneuropathy (DPN) or peripheral diabetic neuropathy is one of the most common micro-vascular complications of DM (3,4), and appears mainly in *diabetes mellitus* type 2 (DM2) (5). DPN is defined as a neurological disorder producing a progressive loss of the functions of motor, sensitive, and autonomic nervous fibers, thus affecting the main divisions of the peripheral nervous system in patients presenting DM (6). Perkins and Bril (7) described that there are 2 types of tools to diagnose DPN: diagnostic methods, such as nerve conduction velocity and biopsies; and rating scales, which are characterized by being easy to use and highly reproducible. Asad and cols. (8) evaluated reliability and validity of the most commonly used rating scales, finding good psychometric properties for the *Diabetic Neuropathy Examination* (DNE) scale. DNE is a scale that incorporates assessment of strength, epicritic sensation, vibrating perception threshold and reflexes; all these factors become altered in the presence of DPN (9,10).

DPN has more integral complications in these patients. One of them is alterations in load distribution on the feet, which is connected to changes in balance (11). The latter may be quantified by measuring the center of pressure (CoP) with a force platform (12). It has been recently proven that the Wii Balance Board® (WBB) platform from Nintendo has the ability to emulate force platforms as a balance assessment method (13), which is an accessible, cheap, and easy-to-handle tool.

Balance alterations, together with sensory-motor disorders characteristic of DPN, generate an increase in the risk of falls and amputations (3), hence negatively impacting on the quality of life of those patients (14). A number of investigations has been carried out on the influence of DPN in the balance of subjects with DM. Higher CoP displacements have been observed in patients presenting DPN, in contrast with those presenting DM without DPN and healthy individuals (15-17). Furthermore, Ghanavati and cols. (18) have recently correlated DNE rates with Berg's balance scale, finding a strong negative correlation between both variables.

The objectives of this investigation were to compare static balance measured by means of a WBB platform, in individuals diagnosed with DM2 with and without DPN, and to analyze the relationship between the rates obtained in the DNE scale and the mean ratio of CoP.

SUBJECTS AND METHODS

Subjects

A descriptive, quantitative and transversal study was carried out. A convenience sampling was used with 20 patients from CESFAM "Dr. Jorge Sabat G." in Valdivia, Chile, aged between 40 and 54, diagnosed with DM2, and divided into groups with and without DPN, according to the score in the DNE scale. Exclusion criteria were: a) diabetic ulcers or deformations secondary to them, b) amputation, c) diabetic retinopathy and/or blindness, d) vestibular disorder, and e) body weight over 150 kg, since this weight is the maximum stand capacity of WBB. This study was approved by the Scientific Ethics Board of the Health Service of Valdivia, based on the Ethics Guidance from the Declaration of Helsinki of 1975, revised in 2000. All participants signed an informed consent form before the measurements were carried out.

Measurements

Both an interview and a general physical exam were carried out, in which age, gender, weight, size and years since DM2 diagnosis were recorded. DNE scale was applied to corroborate the presence of diabetic polyneuropathy. This scale contains two items related to muscle strength, one item related with reflexes, and five with sensitivity; in a total of 8 items. The highest score is 16 and a rating higher than or equal to 3 indicates DPN. The higher the score, the more severe the damage in each of the items (8-10). This scale was evaluated by a board of local experts to enable its use in the local population. To create this scale, a 128Hz Tuning Fork (Saehan medical™, South Korea), a 10 gram Semmes-Weinstein monofilament (Accu-chek, Roche diagnostics©, United States), and a Taylow reflex hammer were needed.

To assess balance, the mean ratio of CoP was obtained through a static balance test carried out on the

WBB platform (Nintendo®, United States). Prior to the test, patients were informed about it and were asked to stay as quiet as possible in two conditions: bipodal support with open eyes, and bipodal support with closed eyes. The test was applied twice, and the best attempt was recorded for each condition. Patients were positioned standing with their arms relaxed hanging at the sides of the body, and with their feet forming a 30° angle between the mean foot line and the antero-posterior axis of the platform. Distance between both feet was 10 centimeters between both heels (19). The test started with 10 seconds for adaptation, followed by 60 seconds for bipodal support with open eyes. Afterwards, patients were asked to close their eyes; 10 seconds were permitted for adaptation to this condition to finally shift to the last 60 seconds of bipodal support with closed eyes. A 30-second resting period was allowed between both attempts (20).

CoP data were sent from the WBB platform to a computer via Bluetooth™. Data collected in the computer were codified by a modified version of the "Wiimote test" software. This software is unrestricted and provides all the coordinates of the CoP in a .csv extension file. Different variables were obtained from this file through the program Microsoft Excel 2010. First, the average axis of CoP was obtained by means of the mean value of the coordinates of the X and Y axes. Afterwards, the present CoP ratio was obtained by calculating the distance between the average CoP and the present CoP of the patient. All this is summarized by means of the following equations:

$$\bar{x} = \frac{\sum_{n=1}^{n}(x_n)}{n} \quad \bar{y} = \frac{\sum_{n=1}^{n}(y_n)}{n}$$

$$r = \sqrt{[(x-\bar{x})^2 + (y-\bar{y})^2]}$$

$$\bar{r} = \frac{\sum_{n=1}^{n}(r_n)}{n}$$

Where $\bar{x}$ is the mean value of the horizontal axis; x_n are all values belonging to the horizontal coordinate; n is the total number of data; $\bar{y}$ is the mean value of the vertical axis; y_n are all the values of the vertical coordinate; r is the present CoP ratio; x is the present value of the horizontal axis; y is the present value of the vertical axis; $\bar{r}$ is the mean CoP ratio; and r_n are all the values belonging to the CoP ratio.

Statistical analysis

Statistical analysis was carried out using the software SPSS Statistics v.19. Shapiro-Wilk test applied to verify data normality. The Student *t* test and Mann-Withney *U test* for independent samples were used to establish differences between groups, as applicable. The Rho Spearman index was used to establish associations between variables. Associations were classified as mild (< 0.3), moderate (0.3-0.6), and strong (> 0.6). A significance level of $p < 0.05$ was considered for all analyses.

RESULTS

The general characteristics of subjects with and without DPN are shown in table 1. Notably, there were no significant differences in the assessed variables between the study groups.

Table 1. Descriptive characteristics of participants

Characteristics	With DPN	Without DPN	P-value
Age (years)	49.4 ± 3.44	50 ± 3.05	0.732
Gender (M:F)	9:1	8:2	-
Weight (kg)	77.7 ± 19.72	73.18 ± 17.77	0.734
Height (m)	1.53 ± 0.90	1.52 ± 0.79	0.880
Duration of diabetes (years)	8.94 ± 6.55	5 ± 5.58	0.171

DPN: distal sensorimotor polyneuropathy; M: male; F: female.

Figures 1 and 2 show the behavior of CoP displacements under the conditions of open eyes and closed eyes respectively. A tendency ($p = 0.059$) to significant differences appeared as evident in the first case, whereas in the closed eyes condition, discrepancies reached statistical significance (0.548 cm *vs.* 0.442 cm; $p = 0.049$).

Regarding associations between DNE scale and CoP behavior, there was a remarkable correlation between the above mentioned variables under the open eyes condition for patients with DPN. Statistical significance was not reached by the rest of the associations (Figures 3 and 4).

DISCUSSION

The objectives of this study were to compare static balance, as measured by means of the WBB platform, between patients with and without DPN and, at the same time, to assess the correlation between DPN and the DNE scale in the group presenting DPN.

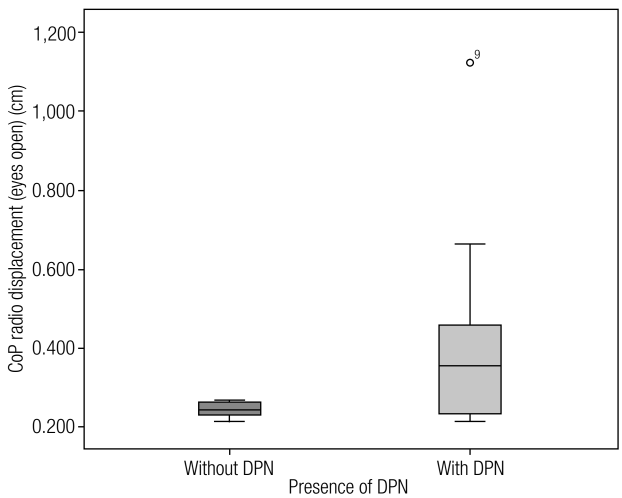

Figure 1. Boxplot of the CoP ratio displacement (cm) under the open eyes condition in the groups with and without DPN.

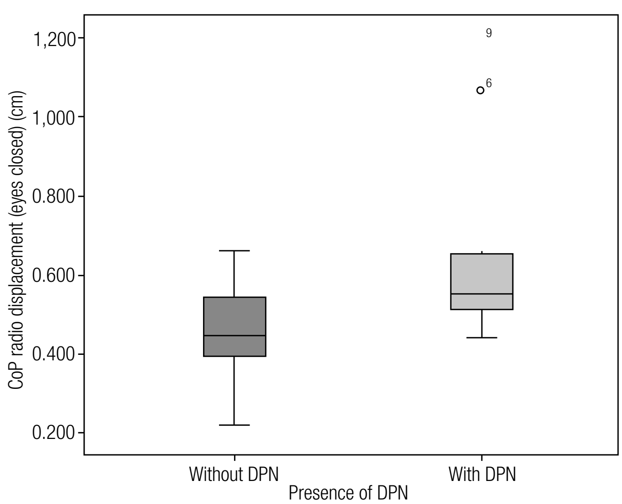

Figure 2. Boxplot of the CoP ratio displacement (cm) under the closed eyes condition in the groups with and without DPN.

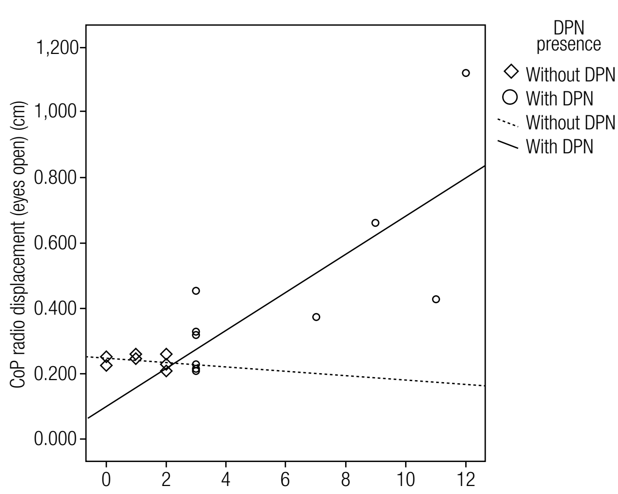

Figure 3. Correlation between DNE score and the CoP ratio displacement (cm) under the open eyes condition. DNE *vs.* ratio (without DPN) = -0.171 (p = 0.637); DNE *vs.* ratio (with DPN) = 0.751 (p = 0.012).

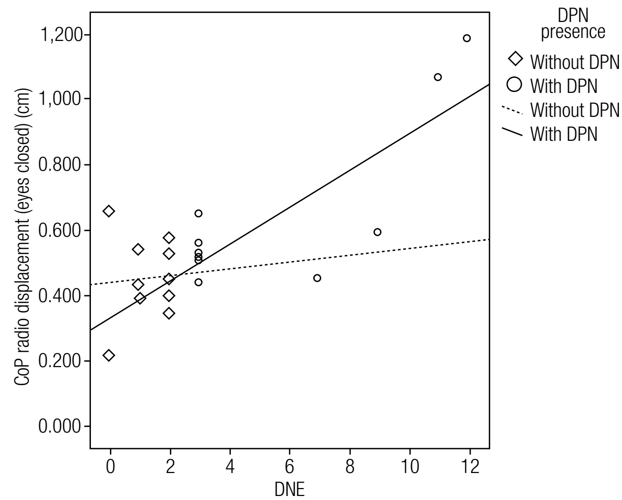

Figure 4. Correlation between DNE score and the CoP ratio displacement (cm) under the closed eyes condition. DNE *vs.* radio (without DPN) = 0.026 (p = 0.942); DNE *vs.* radio (with DPN) = 0.587 (p = 0.074).

Our results revealed that patients with DPN showed worse statistical balance under both conditions, with statistical significance in the closed eyes condition. This finding is similar to what was discovered by other authors, who stated that patients presenting peripheral neuropathy or DPN show balance alterations when contrasted with healthy subjects (15-18,21-25) and with subjects presenting DM without DPN (17,18,21,23,25). This statement is based on the fact that the tactile sensorial system is the main mechanism for balance (26); hence, when influenced by DPN, balance control is affected. Furthermore, higher CoP displacement under the closed eyes condition has also been evidenced by other authors (15,17,23,25), who stated that eliminating the visual stimulus affects postural control.

Concerning the correlation of DNE rating and the ratio of CoP displacement, a strong positive correlation between both variables was found under the open eyes condition. This indicates that, as the severity of the neuropathy increases, CoP displacement is greater. Therefore, a stronger presence of factors belonging to the peripheral neuropathy, such as sensory decline, a decline in muscular strength and diminution of muscular reflexes, would be related with worsened balance. Only one study correlating DNE rating and balance (18) was identified, which reported a strong negative correlation between neuropathy severity and balance, similar to what was discovered in our study.

Former studies objectively appraise static balance through force platforms (15,21-23). We used the WBB platform and have found results that agree with what is suggested by the literature. This may indicate that WBB may be a valid instrument to assess balance, as stated by Clark and cols. (13). Within the limitations of our study is the reduced sample size, which makes data extrapolation difficult; hence, our suggestion is that further studies should be carried out with more participants to seek a correlation between DNE rating and balance. Finally, there is little literature using DNE scale in our local population; thus, a stronger use of it appears as necessary in oder to diversity its use.

In conclusion, patients presenting DPN show worse static balance under the closed eyes condition when contrasted with patients presenting DM without DPN. Furthermore, the higher the rating in the DNE, the stronger the CoP displacement, which could be associated with a higher risk of falls, even in low complexity situations, such as being able to stand statically.

Disclosure: no potential conflict of interest relevant to this article was reported.

REFERENCES

1. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Res Clin Pract. 2010;87(1):4-14.
2. Fowler MJ. Microvascular and macrovascular complications of diabetes. Clinical Diabetes. 2008;26(2):77-82.
3. Boulton AJ, Malik RA, Arezzo JC, Sosenko JM. Diabetic somatic neuropathies. Diabetes Care. 2004;27(6):1458-86.
4. Boulton AJ, Vinik AI, Arezzo JC, Bril V, Feldman EL, Freeman R, et al. Diabetic neuropathies: a statement by the American Diabetes Association. Diabetes Care. 2005;28(4):956-62.
5. Edwards JL, Vincent AM, Cheng HT, Feldman EL. Diabetic neuropathy: mechanisms to management. Pharmacol Ther. 2008;120(1):1-34.
6. Davies M, Brophy S, Williams R, Taylor A. The prevalence, severity, and impact of painful diabetic peripheral neuropathy in type 2 diabetes. Diabetes Care. 2006;29(7):1518-22.
7. Perkins BA, Bril V. Diabetic neuropathy: a review emphasizing diagnostic methods. Clin Neurophysiol. 2003;114(7):1167-75.
8. Asad A, Hameed MA, Khan UA, Ahmed N, Butt MU. Reliability of the neurological scores for assessment of sensorimotor neuropathy in type 2 diabetics. J Pak Med Assoc. 2010;60(3):166-70.
9. Meijer JW, van Sonderen E, Blaauwwiekel EE, Smit AJ, Groothoff JW, Eisma WH, et al. Diabetic neuropathy examination: a hierarchical scoring system to diagnose distal polyneuropathy in diabetes. Diabetes Care. 2000;23(6):750-3.
10. Meijer JW, Bosma E, Lefrandt JD, Links TP, Smit AJ, Stewart RE, et al. Clinical diagnosis of diabetic polyneuropathy with the diabetic neuropathy symptom and diabetic neuropathy examination scores. Diabetes Care. 2003;26(3):697-701.
11. Giacomozzi C, D'Ambrogi E, Uccioli L, Macellari V. Does the thickening of Achilles tendon and plantar fascia contribute to the alteration of diabetic foot loading? Clin Biomech (Bristol, Avon). 2005;20(5):532-9.
12. Duarte M, Freitas SM. Revision of posturography based on force plate for balance evaluation. Rev Bras Fisioter. 2010;14(3):183-92.
13. Clark RA, Bryant AL, Pua Y, McCrory P, Bennell K, Hunt M. Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. Gait Posture. 2010;31(3):307-10.
14. Van Acker K, Bouhassira D, De Bacquer D, Weiss S, Matthys K, Raemen H, et al. Prevalence and impact on quality of life of peripheral neuropathy with or without neuropathic pain in type 1 and type 2 diabetic patients attending hospital outpatients clinics. Diabetes Metab. 2009;35(3):206-13.
15. Lafond D, Corriveau H, Prince F. Postural control mechanisms during quiet standing in patients with diabetic sensory neuropathy. Diabetes Care. 2004;27(1):173-8.
16. Najafi B, Horn D, Marclay S, Crews RT, Wu S, Wrobel JS. Assessing postural control and postural control strategy in diabetes patients using innovative and wearable technology. J Diabetes Sci Technol. 2010;4(4):780-91.
17. Turcot K, Allet L, Golay A, Hoffmeyer P, Armand S. Investigation of standing balance in diabetic patients with and without peripheral neuropathy using accelerometers. Clin Biomech (Bristol, Avon). 2009;24(9):716-21.
18. Ghanavati T, Shaterzadeh Yazdi MJ, Goharpey S, Arastoo AA. Functional balance in elderly with diabetic neuropathy. Diabetes Res Clin Pract. 2012;96(1):24-8.
19. Yelnik A, Bonan I. Clinical tools for assessing balance disorders. Neurophysiol Clin. 2008;38(6):439-45.
20. van der Kooij H, Campbell AD, Carpenter MG. Sampling duration effects on centre of pressure descriptive measures. Gait Posture. 2011;34(1):19-24.
21. Kanade RV, Van Deursen RW, Harding KG, Price PE. Investigation of standing balance in patients with diabetic neuropathy at different stages of foot complications. Clin Biomech (Bristol, Avon). 2008;23(9):1183-91.
22. Nardone A, Grasso M, Schieppati M. Balance control in peripheral neuropathy: are patients equally unstable under static and dynamic conditions? Gait Posture. 2006;23(3):364-73.
23. Oppenheim U, Kohen-Raz R, Alex D, Kohen-Raz A, Azarya M. Postural characteristics of diabetic neuropathy. Diabetes Care. 1999;22(2):328-32.
24. Richardson JK, Hurvitz EA. Peripheral neuropathy: a true risk factor for falls. J Gerontol A Biol Sci Med Sci. 1995;50(4):M211-5.
25. Simoneau GG, Ulbrecht JS, Derr JA, Cavanagh PR. Role of somatosensory input in the control of human posture. Gait Posture. 1995;3(3):115-22.
26. Menz HB, Lord SR, St George R, Fitzpatrick RC. Walking stability and sensorimotor function in older people with diabetic peripheral neuropathy. Arch Phys Med Rehabil. 2004;85(2):245-52.