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Evaluation of a neuropathic ulcers prevention program for patients with diabetes

Avaliação de um programa para prevenção de úlceras neuropáticas em portadores de diabetes

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Abstract

Background: Neuropathic foot ulcers are among the major health problems faced by patients with diabetes mellitus. **Objective:** To evaluate the preventive efficacy of a therapeutic education and protective footwear program in the incidence and recurrence of neuropathic ulcers due to diabetes. **Methods:** Fifty-three patients with diabetes and neuropathy from a public healthcare unit in Porto Alegre, Rio Grande do Sul, took part in a clinical trial for two years. The participants were randomly allocated to an intervention group (n=30) or a control group (n=23). Therapeutic education was provided in group sessions, and protective footwear was supplied in accordance with individual prescriptions. The nonparametric Mann-Whitney test was used to determine differences in incidence and recurrence of ulceration between the groups. Life-table analysis and the Kaplan-Meier method were used to measure the duration of ulcer-free survival. **Results:** In the intervention group, the ulcer incidence rate was 38.1% compared to 51.1% in the control group. Among the participants who presented ulcers, 83% were in the control group and 16.7% in the intervention group. After one year, the participants in the intervention group had a 75% chance of being ulcer-free, compared with 61% in the control group, and these percentages reduced to 60% and 52% respectively after two years. There was a tendency toward shorter survival among the control group participants. **Conclusion:** Although the proposed program lowered recurrence rates and increased the duration of ulcer-free survival, it was unable to prevent occurrence and recurrence of neuropathic ulcers due to diabetes.
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Key words: diabetic foot; primary prevention; health education; shoes.

Resumo

Contextualização: Úlceras neuropáticas nos pés são um dos grandes problemas de saúde enfrentados por portadores de diabetes mellitus. **Objetivo:** Avaliar a eficácia preventiva de programa de educação terapêutica e de calçados para proteção dos pés quanto à incidência e recorrência de úlceras neuropáticas por diabetes. **Métodos:** Um total de 53 pacientes de uma unidade de saúde pública de Porto Alegre/RS, portadores de diabetes e neuropatia, participaram de um ensaio clínico durante dois anos. Os sujeitos foram alocados aleatoriamente em grupo de intervenção (GI) (n=30) ou controle (GC) (n=23). A educação terapêutica foi realizada em grupo, e o calçado para proteção fornecido conforme prescrição individual. Utilizou-se o teste não paramétrico de Mann Whitney para determinar a diferença de incidência e recorrência de ulceração entre os grupos. A análise da tábua de vida e o método de Kaplan-Meier foram usados para medir o tempo de sobrevida sem úlcera. **Resultados:** A incidência de lesão no GI foi de 38,1% versus 57,1% no GC. Dos sujeitos que apresentaram úlcera, 83% pertenciam ao GC e 16,7% ao GI. Em um ano, os participantes do GI o mostraram 75% de probabilidade de se encontrarem sem lesão, contra 61% do GC, reduzindo para 60% e 52%, respectivamente, em dois anos. Há uma tendência de menor sobrevida em participantes do GC. **Conclusão:** Embora com índices menores de recorrência e maior sobrevida sem lesão, o programa proposto não foi capaz de prevenir a ocorrência e recorrência de úlceras neuropáticas por diabetes.
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Palavras-chave: pé diabético; prevenção primária; educação em saúde; sapatos.

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Introduction

Diabetes mellitus (DM) is a metabolic disorder of multiple etiologies characterized by chronic hyperglycemia resulting from impaired production and/or use of insulin. The disease can be classified into two major groups: type 1 diabetes (autoimmune or idiopathic) and type 2 diabetes, which is characterized by a defect in insulin secretion and action[1]. A serious health problem in diabetic patients is foot ulcers. An otherwise simple lesion can lead to functional losses[2,3] and culminate in loss of the limb or even death[4]. Several factors are involved in the development of foot ulcers in diabetic patients: neuropathy, peripheral vascular disease, limitation of joint motion, trophic skin disorders and abnormal distribution of mechanical forces in the feet[5-7]. Among them, the most important etiologic factor is diabetic peripheral neuropathy[5,8-10].

The International Consensus on the Diabetic Foot reinforced reports of several studies on the amputation of diabetics by recommending multi-professional actions to achieve the 50% reduction in amputations proposed in the St. Vincent Declaration[11]: inspection of patients' feet during clinic visits, use of appropriate footwear, education for self-care and continuous follow-up of those who have already had foot injuries[12]. Therefore, the role of the physical therapist within the multiprofessional team is to educate the diabetes patients and to prescribe and follow-up the use of orthoses[13].

Therapeutic education and foot protection with footwear are two of the five crucial points defined by the Consensus[12] for the care of diabetic patients at risk of neuropathic injuries due to insensitivity. These interventions, which are complementary, have been identified as strategies that can reduce the incidence and recurrence of neuropathic injuries in diabetic patients[14-18]. The Consensus[12] recommends that these interventions be targeted specifically at patients at high risk of injury, however as essentially preventive actions, they should be also targeted at patients with less severe neuropathy because it is a complication that worsens with the development of diabetes[5,9,10,16]. Therefore, the purpose of the present study was to evaluate the effectiveness of a program of injury prevention for patients with diabetic neuropathy, consisting of patient education for self-care and use of special protective footwear.

Methods

This was an experimental study performed through a clinical trial in a convenience sample with duration of two years. The participants were selected from a unit of the National Health System (SUS) in Porto Alegre, Rio Grande do Sul. At the time, the unit offered follow-up consultations and non-systematic instruction on the prevention of diabetic foot. An initial sample of 563 patients was tracked to identify those who were at risk of foot injury due to neuropathy. To identify the degree of risk, monofilament testing was performed using the monofilament Semmes-Weinstein 5.07 (10g)[19,20]. Fifty-three individuals that were followed-up clinically and through laboratory testing were identified with the condition of interest: neuropathy caused exclusively by DM. The ethical approval for this study was obtained from the Municipal Health Department of Porto Alegre, Rio Grande do Sul (approval number 1279/00), and the study was conducted according to the human research guidelines put forward by Resolution 196/96 of the National Health Council.

Procedures

Monofilament Testing

Cutaneous sensitivity was evaluated using the Semmes-Weinstein 5.07 monofilament (GWLHDC, Carville, Louisiana, USA). The test was conducted with the participant in the supine position, after familiarization with the test. The test sites were: the digital pulp of the hallux and the head of the first and fifth metatarsal[12]. The forced-choice protocol described by Boulton et al.[21] was followed. The inability to feel the filament in two of the three evaluated points was considered an indication of risk of ulceration.

Plantar pressure measurement

The dynamic footprints were obtained in the standing position with bare feet and semi-weight bearing, using the Harris and Beath footprinting mat[22] (Apex Foot Products Corporation, Englewood, NJ). For the measurement of the natural stride length and for familiarization with the equipment, the participant walked along a regular five-meter path three times before the test. The result was used to identify the presence of overpressure and as a reference for determining the size of the footwear that would be delivered to the participant.

The selected participants agreed with the conditions of the study and signed an informed consent form. The participants who composed the final sample (n = 53) were randomly allocated to the control group (n = 23) and to the intervention group (n = 30). Both the participants and the examiners were blinded to group allocation. The following data was recorded for all participants: age, type of DM, time of diagnosis of the disease, recent glycohemoglobin values, history of neuropathic foot injury or fracture, and complaints related to diabetic neuropathy. All participants underwent a clinical foot examination to verify skin conditions (color, temperature, presence of hyperkeratosis, cracks, blisters, areas of redness and injuries), the presence of pulses (anterior and posterior

tibial arteries) and deformities (claw toe, hammer toe or bone protuberances). These data, together with the results of the monofilament testing and the plantar pressure measurement were used to classify the risk of foot injury[23], namely: risk 1 (insensitivity), 2 (insensitivity and plantar overpressure or deformity), 3 (insensitivity and previous ulcers), 4 (insensitivity, previous ulcers and plantar overpressure) and 5 (neuropathic fracture).

The participants in the control group maintained the routine care assistance offered by the unit where the study was conducted, and those in the intervention group underwent the prevention program. Both groups were monitored by the researcher through foot inspection to survey the incidence and recurrence of neuropathic injury. This dichotomous information was used to evaluate the effectiveness of the proposed program. Individual consultations were held quarterly in the first 18 months, with a total of seven consultations referred to as "times" (from 0 to 6). At the end of the two-year study period, the participants were evaluated for the last time (time 7). The control group received instructions on foot care and use of footwear when requested during individual consultations with the researcher. The participants who had neuropathic injuries during the study received medical and nursing care and instructions on how to reduce loads on the affected limb.

Intervention

The intervention consisted of a preventive program, implemented by the researcher, composed of therapeutic education (weekly group meetings) and provision of two pairs of special protective shoes. The therapeutic education was conducted in four meetings of 90 minutes in groups of up to eight participants. The focus group technique was employed to address and discuss issues that are suggested internationally for prevention programs of diabetic foot complications: DM complications, disease treatments, inspection and foot hygiene or choice and use of footwear[14]. Specially prepared games were used as teaching aids[24], with questions on the issue at the end of each meeting. The participants received the footwear only after the completion of the educational program, one pair at the beginning of the study and another pair after the fourth re-evaluation (time 4), with the recommendation of daily use. The researcher monitored the first time the shoe was worn and the two-week adaptation phase. The footwear was designed to meet the demands of this study, respecting the characteristics of a therapeutic shoe[18,25,26]. Two models, one open and one closed, were created in three different widths and different colors, using the Brazilian reference for standard footwear measures (French point), and the values of the perimeter of a section of the shoe were resized to proportional increases in height and width, following the same logic used in the American point. The width of the shoe was defined by the distance from the head of the first to the head of the fifth metatarsal, and the size, by the greatest longitudinal length of the foot. The participants could choose the color and model (open or closed). Adherence to the footwear was evaluated by its use: not daily, daily use for up to six hours a day, or for more than six hours a day.

Statistical analysis

Descriptive analysis and normality tests (Shapiro-Wilk) were performed using the statistical package SPSS for Windows, version 14.0 (Chicago Illinois Software). A level of 5% (α value=0.05) of statistical significance was considered in all tests. For comparison between groups, the nonparametric Mann-Whitney U test was used for the quantitative variables. We chose to use nonparametric tests due to the size of some samples and the asymmetric nature of the tested variables. Categorical variables, because they are proportions, were compared using the Pearson chi-square test or Fisher's exact test for samples with low frequency.

To study the time until the occurrence of injuries and compare it between groups, we used the method of survival analysis[27], employed when one wants to study the time until the occurrence of events of interest (neuropathic injury). This method allows the inclusion of information contained in the censored data. Censures (loss due to incomplete observation time) occurred due to withdrawal, death or completion of the study before the occurrence of injury. The life table technique was used to obtain an estimation of the survival function, and the Kaplan-Meier method was used to construct the survival curve. To test the difference in survival time between groups, the log-rank test was used. A significance level of 5% was considered.

Results

The descriptive data of the study population are shown according to group in Tables 1 and 2. Of the 53 participants of the total sample, 51 (96.2%) had type 2 DM. The time of diagnosis of DM was more than 10 years (mean 14.5±10.2). The mean age was 62 years, and 33 (62.3%) participants were male. The differences between groups were not statistically significant ($p<0.05$) in any of the demographic and clinical variables collected at the beginning of the evaluation (time 0).

The sample distribution according to risk category is shown in Table 2. There was a higher number of participants classified

into the lower risk categories (risk 1 and 2) in both groups, 21 (70%) in the intervention group and 17 (74%) in the control group. Among the participants classified as risk 4, six (66.7%) were in the intervention group. The differences between the two groups, regarding the distribution into categories of risk of injury, were not significant (p=0.256).

The censure (loss of follow-up) in the total sample was 14 participants, seven of each group. Therefore, the 24 months of follow-up were completed by 21 participants in the intervention group and 14 in the control group. One participant in the intervention group withdrew from the study before completing the educational program and, therefore, did not receive the footwear. The other 29 participants completed the therapeutic education program, received the shoes and wore them: 34.5% daily for up to six hours, alternating with other shoes and 37.9% daily for more than six hours. The others (27.6%) did not wear the shoes daily. Table 3 shows data of the occurrence (first episode) and recurrence of neuropathic foot injuries recorded in the two groups at the end of the study. Sixteen participants had the first episode of neuropathic injury, 38.1% from the intervention group and 57.1% from the control group, which was not a significant difference (p=0.317). Of these 16 participants, 12 (75%) had high risk for injury (risk 3 or 4). Of those who were at risk 4, the occurrence of injury was detected in two participants (100%) in the control group and two (50%) in the intervention group. Of the six participants who had recurrence of injury during the study, five (83.3%) belonged to the control group and one (16.7%) to the intervention group; the difference was not significant (p=0.119).

Table 4 shows the survival data of the total sample, considering the censures since the start of the study (time 0) until the time of occurrence of the event (neuropathic injury). The percentage of survival concerns each moment (time) of follow-up, and the cumulative percentage of survival is the time without the event over the length the study. At the end of the study (time 7), 19 participants of the total sample remained free of injuries. Of these, 13 participants belonged to the intervention group and six to the control group, therefore the cumulative survival was 60% and 52% respectively.

Figure 1 shows the graph of the survival function of both groups, with a trend toward shorter survival time, i.e. shorter

Table 1. Characteristics of the studied population.

Variable	Group		p-value
	Intervention (n=30)	Control (n=23)	
Diabetes diagnosis (years)	14±10	15±10.5	0.602**
Type of Diabetes n (%)			
1	1(50)	1(50)	0.999*
2	29(56.9)	22(43.1)	
Male n (%)	21(63.6)	12(36.4)	0.255*
Age (years)	64.4±9.2	59.8±9.0	0.074**

Data are means ± SD; * Significant difference at p<0.05 (Fisher's Exact Test); ** Significant difference at p<0.05 (Mann-Whitney Test).

Table 2. Foot risk categories in the two groups.

	Intervention n (%)	Control n (%)	p-value*
Risk 1	6(37.5)	10(62.5)	0.256
Risk 2	15(68.2)	7(31.8)	
Risk 3	3(50)	3(50)	
Risk 4	6(66.7)	3(33.3)	

* Significant difference at p< 0.05 (Fisher's Exact Test).

Table 3. Occurrence and recurrence of neuropathic foot ulcerations in the two groups after 24-month follow-up.

Foot ulceration	Intervention n(%)	Control n (%)	p-value*
Occurrence			
No	13(61.9)	6(42.9)	0.317
Yes	8(38.1)	8(57.1)	
Recurrence			
No	7(70)	3(30)	0.119
Yes	1(16.7)	5(83.3)	

* Significant difference at p<0.05 (Fisher's Exact Test).

Table 4. Survival time in the population studied: time until foot ulceration.

Time	Participants without an event (ulceration)	Number of censored participants	Number of events (ulcerations)	% of survival	Cumulative % of survival	SD
0	53	3	0	1.00	1.00	0
1	50	5	5	0.89	0.89	0.05
2	40	5	5	0.87	0.77	0.06
3	30	2	1	0.96	0.75	0.07
4	27	3	2	0.92	0.69	0.07
5	22	0	1	0.95	0.66	0.08
6	21	0	1	0.95	0.63	0.08
7	20	19	1	0.90	0.57	0.09

Time 0=first evaluation; Times 1 to 6=quarterly reevaluations; Time 7=final evaluation.

time until the occurrence of the event (neuropathic injury) among participants in the control group. However, the test for comparison of the curves of the two groups did not provide a significant difference (p=0.362).

Discussion

The present study included participants with insensitivity only (risk 1) up to larger losses (risk 4) caused by diabetic neuropathy. The success in preventing the recurrence of ulcers in diabetic patients, in response to the combination of footwear and therapeutic education, was discussed by Maciejewski et al.[18] in a review of the literature published between 1980 and 2003. The authors emphasized that these multifactorial interventions are directed to patients at high risk of injury due to neuropathy and ischemia caused by diabetes. According to the International Consensus on Diabetic Foot[12], the interventions of therapeutic education and foot protection should be directed especially to high-risk patients, given that they are more likely to have complications. However, those with a milder neuropathy condition should not be excluded, due to the risk of deterioration. The data from the present study confirm the priority of assistance to patients at higher risk. Of the participants with injuries, 75% were risk 3 or 4, which is equivalent to 80% of the initial sample of participants at risk 3 and 4. Of the 38 participants classified as risk 1 and 2, only four (10.5%) had the event. Considering the findings of Calle-Pascual et al.[16], it can be inferred that the profile of the sample may have influenced the results of this study. These authors studied DM patients at different stages of neuropathy undergoing a prevention program and found that the reduction in the incidence of neuropathic injury is lower in patients with milder neuropathy. Calle-Pascual et al.[16] studied the patients for 4.6 years; therefore, to verify preventive effects in patients with mild neuropathy even, with deterioration, it is necessary to monitor them for longer period than those monitored by Calle-Pascual et al.[16].

The follow-up losses by withdrawal or death were similar in both groups, indicating that the proposed procedures did not interfere with the adherence to the study. These high levels of sample loss often occur in studies on patients with DM. Polonsky[28] attributes this to the difficulties and frustrations regarding the management of chronic diseases such as diabetes. The author describes this behavior as diabetes burnout.

The adherence to the proposed intervention is a positive point of the present study, considering its importance to the result of preventive actions[16,18]. Protective footwear was given only to the participants who completed the therapeutic education program. Of the 30 participants, 29 completed the program. Of the participants who received the shoes, 72.4% wore

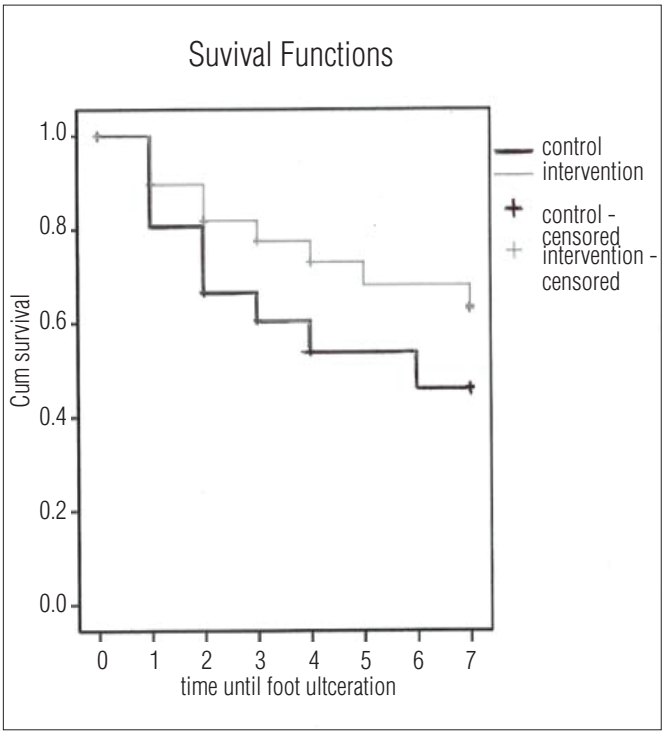

Figure 1. Survival function using Kaplan-Meier analysis to compare groups.

them daily, alternating with or without other footwear. This is a good result, considering the difficulties shown by Johnson, Newton and Goyder[29] in their study on the prospects of the diabetes patients in relation to therapeutic footwear. According to these authors, patient involvement in choosing the model and color of the footwear may motivate the use, which could explain the good adherence observed in this study. This information on adherence was not used for analysis of association with the occurrence of injuries, because the intent of the study was to evaluate the two interventions, education and protection of the feet, applied in conjunction. To evaluate individual effects of each intervention, a design with two other groups would be required to isolate the effects of therapeutic education or of the protective footwear.

The size of the sample (39, at the end of the study) may have affected the results of this study because it is insufficient to evaluate a prevention program. The magnitude of effect of preventive interventions, such as education of patients, is small. According to a systematic review by Valk, Kriegsman and Assendelft[14], a sample of at least 430 participants is required to detect clinically relevant differences between groups. For n = 39 (sample at time 7), considering 20% of effect, the statistical power is 0.24[30]. This value indicates a high probability of type II error in the results obtained in the present study. To confirm the null hypothesis of differences between the groups, a larger sample would be required.

Conclusion

Despite lower rates of recurrence of injury and a greater probability of remaining without injury, no significant difference was found as a result of the implementation of the therapeutic education program combined with the use of protective footwear in diabetic patients.

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