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The Effect Of Peripheral Neuropathy Severity On Gait Characteristics In Diabetic Patients

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SUMMARY

Diabetic peripheral neuropathy (DPN) disrupts the nerve function at the extremities resulting in loss of sensory information. Alterations in gait pattern such as reduced walking speeds, increased double support have been observed with DPN patients when compared to healthy individuals. However within the DPN population, the effect of severity of neuropathy on gait characteristics is still uncertain.

Using validated wearable sensor technology, spatio-temporal parameters were collected when patients were walking at their habitual speed. Fear of falling questionnaire were also administered using FES-I. A total of 33 patients were recruited whose age ranged from 52 to 88 years. Severity was classified into 4 groups based on resulting Vibratory Perception Threshold (VPT) scores: <15 as no neuropathy, 15 to 24 as mild, 25 to 50 as moderate and >50 as severe neuropathy groups.

Significant increase ($p < 0.05$) of stance and double support percentages were observed with increased level of neuropathy. DPN patients seem to walk with reduced stride length, stride velocity and knee angle with increased severity. No correlation was observed between FES-I scores and VPT or with gait characteristics. Results suggest increasing lack of foot sensation doesn't increase fear of falling (FES-I), but increases the risk of falling in patients suffering from diabetes.

INTRODUCTION

Peripheral neuropathy is highly prevalent in patients with a history of Diabetic Mellitus (DM) [1, 2]. The annual direct and indirect costs associated with Diabetic Peripheral Neuropathy (DPN) were around 10.9 billion dollars in 2001 alone [3]. Within the DPN population, it was observed that with an increase of severity of neuropathy resulted in a 6-10% increase in medical costs [4, 5]. Severity of neuropathy has been clinically assessed commonly using Vibration Perception Threshold (VPT) test [6].

Previous studies have focused on the variation in gait characteristics of DPN patients when compared to a healthy population. However, there is limited research on the effect

of severity of neuropathy on gait characteristics within DPN population. Moreover, recent study [7] has shown foot orthoses to significantly improve the number of steps to reach steady state (gait initiation). The current study would also look at the overall variation of gait initiation with the severity of neuropathy.

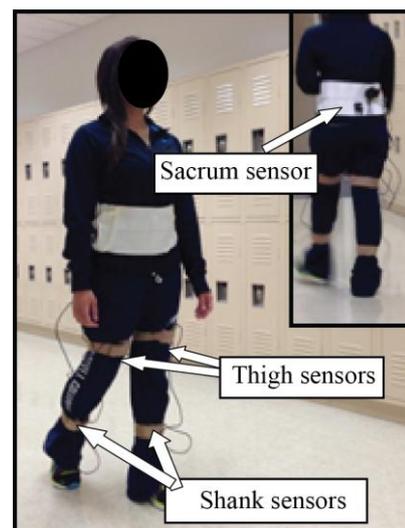


Figure 1: LegSys™ portable wearable system with sensors attached via straps

METHODS

Participants were recruited from Rosalind Franklin University Health Systems in North Chicago, IL and from the Annual Diabetes Exposition event held in Chicago, IL. All participants were provided with informed consent approved by the IRB at Rosalind Franklin University.

The participants were included if they were medically diagnosed with type 1 or type 2 diabetes and were able to walk greater than 60 feet without any assistive devices. Participants were excluded if they had neurological pathologies other than DPN, orthopedic/general surgical conditions or amputation that would influence gait. Patient demographics were collected and the severity of neuropathy was assessed via VPT test [6]. Patients with a VPT score less than 15 volts were considered to have no neuropathy.

16-24 VPT score was considered mild, 25-50 moderate and >50 was considered to be severe.

Spatio-temporal parameters of gait such as stride velocity, stride length, swing percentage and double support percentage of the gait cycle along with gait initiation were collected using a validated [8,9] wearable sensor system named LegSys (Biosensics LLC, MA, USA). In addition, balance during walking was quantified using the motion of sacrum in medial-lateral (COM_{ML}) and Anterior-posterior (COM_{AP}). Patients were instructed to walk 20 feet at their habitual speed (Figure 1).

A Fall Efficacy Scale (FES-I) questionnaire was administered after the gait assessments. Participants were also asked about the history of falls in the past one year and classified as either fallers or non-fallers. A general linear regression and ANOVA were used to determine the significance of association between level of neuropathy and gait parameters. A two tailed student's t test was used to test the significance of variability between each group of neuropathy. All statistical analysis was performed using Minitab software with an alpha value of 0.05.

RESULTS AND DISCUSSION

Thirty-three patients were recruited whose mean age was 67.6 (9.2) years. The mean BMI was 31.2 (5.6). Gait parameters such as stance and double support percentages displayed positive correlation ($r=0.6$) with VPT score and significantly increased ($p<0.05$) by 11%, 13% and 42% with increasing severity of neuropathy. DPN patients seem to walk at lower stride velocity, knee angles and stride lengths as the severity increases which in turn results in increased double support percentages.

A pattern of 25% increase in number of steps to get to steady state phase was observed when mild and no neuropathy groups were compared to moderate and severe groups. However, no significant changes were observed due to high variance when compared among each group. On the same note, the gait initiation phase was almost doubled in the fallers group compared to non-fallers (4.56m in falls vs. 2.22m in non-fallers). However, results didn't achieve statistically significant level. High variation might be due to footwear type not being controlled, although patterns in gait parameters were still observed.

No correlation was observed between severity of neuropathy and FES-I scores. Moreover, no correlations were observed

between FES-I scores, falls reported and resultant gait parameters. On the same note, although DPN fallers have poorer gait and more severe neuropathy than non-fallers, no significant difference was found among fallers and non-fallers for neuropathy severity and all tested gait parameters except the range of motion of sacrum in medial-lateral direction during walking ($p=0.01$).

CONCLUSIONS

Increase in lack of foot sensation due to peripheral neuropathy complication increases double support and stance phase, while reduces stride length and stride velocity in patients with diabetes. These results are in agreement with previous reports that compared DPN subjects with healthy individuals [10]. However, it seems severity of neuropathy doesn't have association with fear of falling and history of falls among diabetes population. Interestingly, the range of motion of sacrum in medial-lateral direction during walking seems to be the most sensitive parameter to identify fallers from non-fallers. Results need to be confirmed in a larger sample size and within a prospective study, to identify whether gait deterioration combined with severity of neuropathy could be predictor of fall among patients with diabetes.

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