How Does Self-Perceived Unsteadiness Influence Balance and Gait in People with Diabetes? – Preliminary Observations

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People with diabetic peripheral neuropathy (DPN) exhibit marked unsteadiness during gait (1), increasing their risk of falling 20-fold compared to their matched counterpart without diabetes (2). Unsteadiness and associated restrictions in activities of daily living predict depressive symptoms in patients with DPN (3), highlighting the negative spiral between DPN, unsteadiness, falls and psychological distress (4). However, since unsteadiness has been assessed by self-report in most previous studies, it remains unknown whether a person's perception of unsteadiness actually correlates with objective measures of balance and gait. This study aimed to assess self-perceived unsteadiness in patients with and without DPN as compared to people without diabetes and to investigate how self-perceived unsteadiness influences gait and balance control.

Three groups were investigated: Patients with diabetic peripheral neuropathy (***DPN group***; neuropathy disability score [NDS] $\geq$6, vibration perception threshold [VPT] $\geq$25V), patients with diabetes but no neuropathy (***DM group***; NDS $\leq$3, VPT $\leq$15V (5)) and matched controls without diabetes (Table 1). Self-perceived unsteadiness was assessed using two items from the Neuropathy-Specific Quality of Life Questionnaire (NeuroQoL) asking about problems with balance experienced during walking and standing (6). Participants underwent gait analysis using a 10-camera motion analysis system and force platforms, while walking at their self-selected speed in standardized footwear. Separation between the body's centre of mass and the centre of pressure under the feet in both anterior-posterior and medio-lateral planes were defined as 'dynamic sway' as we have previously described in diabetes patients (1).

The DPN group reported more self-perceived unsteadiness compared to DM and control groups ($P<0.0001$). Body center of mass movement was significantly altered in the DPN group compared to the control group ($P<0.05$; Table 1). Gait velocity and step length were significantly reduced in the DPN group compared to controls ($P<0.0001$). The strongest correlations with participant's self-perceived unsteadiness were with gait velocity, step length and severity of DPN (Table 1).

The novelty of the present study is in showing that DPN patients are not only aware of themselves as being unsteady but actually attempt to self-regulate their unsteadiness by walking more slowly and taking shorter steps. These gait adjustments reduce the extent to which DPN patients need to move their body forwards away from their base of support during each step.

Consistent with previous reports (3), we found that the self-perceived unsteadiness increases with advancing severity of DPN and hence, diabetic neuropathy and self-perceived unsteadiness seem inextricably linked to fall risk. Interestingly, self-perceived unsteadiness in the DM group was actually no different from that of controls without diabetes. These findings are consistent with our gait laboratory study showing that significant unsteadiness was only present in patients with DPN (1). Therefore, participant's perception of unsteadiness appears to match that of gait laboratory measurements of balance impairment. Indeed, we show almost identical group mean values for maximum medio-lateral dynamic sway, a key indicator of balance impairments, as we did in a previous study with the same group allocations (DPN, DM and Controls) during level walking (1). The present study has also found a significant correlation between the anterior-posterior dynamic sway and self-perceived unsteadiness, further supporting our expectations that subjective perceptions of unsteadiness would correlate with the objective, laboratory measures of balance.

Some study limitations and opportunities for future work should be acknowledged. Information on fear of falling, depression and fall history would have provided a deeper insight and should be acknowledged as a limitation. Centrally-acting medication associated with diabetes may impact upon gait and balance and is being analysed as a covariate as part of a larger ongoing study. The question that remains to be answered is to what extent do the psychological factors, such as self-perceived unsteadiness and fear of falls actually drive changes in gait characteristics, or whether the experienced problems with gait and balance largely determine the patient's subjective appraisal of feeling unsteady. Although no psychosocial interventional studies to date have been performed in people with DPN-related unsteadiness, some positive effects on reducing falls have been achieved in high-risk older adults. These studies used multifactorial interventions that involved education and cognitive behavioural therapy approaches (4). Such interventions may therefore offer potential for modifying psychosocial factors associated with unsteadiness in DPN patients with the aim of reducing fall risk.

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Author Contributions

NDR wrote the manuscript and is the guarantor of the work. SJB and MP conducted the data collection. SJB processed gait data. NDR and SJB performed data analysis and statistics. AJB, SJB and MP conducted participant recruitment. All authors reviewed/edited the manuscript. LV conceived the study idea and guided psychological assessment.

Conflict of Interest

None of the authors has any conflicts of interest to declare relating to this work.

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Table 1. Participant demographics, peripheral neuropathy and gait measurements: between-group analysis and correlations with self-perceived unsteadiness.

Between group comparison					Correlations	
	Control	DM	DPN	P value	Spearman's coefficient	P Value
Demographics						
Age (years)	56 (2)	56 (2)	62 (3)	0.227	-	-
Body mass (kg)	***79 (3)***	***78 (3)***	***91 (4)+***	0.016	-	-
Height (m)	1.72 (0.02)	1.7 (0.02)	1.7 (0.03)	0.687	-	-
Peripheral neuropathy						
NDS (score/10)	***1 (1)***	***1 (0)***	***8 (1)+, ǂ***	0.0002	**0.66****	**0.0001**
VPT (V)	***6 (3)***	***8 (1)***	***28 (2)+, ǂ***	0.0001	**0.61****	**0.0001**
Self-perceived unsteadiness						
Walking (score/5)	***1.2 (0.3)***	***1.3 (0.7)***	***2.3 (0.9)+, ǂ***	0.0002	-	-
Standing (score/5)	***1.3 (0.7)***	***1.1 (0.4)***	***2.4 (1)+, ǂ***	0.0001	-	-
Dynamic sway						
Anterior Max (cm)	***31.3 (2)***	***25.5 (0.9)+***	***24.7 (1.9)***	0.132	**-0.31***	**0.029**
Posterior Max (cm)	20.2 (2.3)	18.7 (0.8)	16.1 (2.1)	0.425	**0.36***	**0.010**
M-L Max (cm)	7.9 (0.8)	8 (1.1)	9.8 (0.8)	0.288	0.22	0.068
M-L range (cm)	3.1 (0.4)	2.5 (0.3)	4 (0.6)	0.160	0.11	0.44
Temporal-spatial gait characteristics						
Gait velocity (m/s)	***1.49 (0.04)***	***1.45 (0.05)***	***1.17 (0.06)+, ǂ***	0.0002	**-0.57****	**0.0001**
Step length (cm)	***77.2 (1.7)***	***72.7 (1.7)***	***64.4 (2.9)+***	0.004	**-0.58****	**0.0001**
Step width (cm)	11.4 (0.7)	11.3 (0.7)	12.7 (0.6)	0.234	0.10	0.49
Center of mass						
M-L Range (cm)	3.8 (0.3)	4 (0.4)	4.6 (0.4)	0.302	0.11	0.466
A-P Range (cm)	***94.1 (1.7)***	***91.7 (1.6)***	***82.6 (3.2)+***	0.013	**-0.47****	**0.0010**

Group comparisons: values are means (SD); significant differences in the DPN group compared to the control and DM groups are indicated by + and ǂ, respectively. P values shown are for the outcome of the non-parametric one-way analysis of variance. Controls (*n*=19): are people without diabetes or peripheral neuropathy; DM: (*n*=15): are people with diabetes but without neuropathy; DPN: (*n*=15): are people with moderate-severe diabetic peripheral neuropathy. NDS: neuropathy disability score; VPT: vibration perception threshold; M-L: medio-lateral; A-P: anterior-posterior. Correlations: Correlation between participant's self-perceived unsteadiness and key neuropathy and gait variables for all groups combined (*n*=49). * and ** indicate significance at $P<0.05$ and $P<0.01$ levels, respectively.