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

Diabetes Care 2017;40:e51–e52 | DOI: 10.2337/dc16-2183

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People with diabetic peripheral neuropathy (DPN) exhibit marked unsteadiness during gait (1), increasing their risk of falling 20-fold compared with their matched counterparts 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, because 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 with people without diabetes and to investigate how self-perceived unsteadiness influences gait and balance control.

Three groups were investigated: patients with DPN (DPN group; neuropathy disability score [NDS] $\geq$6, vibration perception threshold [VPT] $\geq$25 V), patients with diabetes but no neuropathy (DM group; NDS $\leq$3, VPT $\leq$15 V [5]), and matched control subjects without diabetes (Table 1). Self-perceived unsteadiness was assessed using two items from the neuropathy-specific quality of life questionnaire (Neuro-QoL) 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 center of mass and the center of pressure under the feet in both anterior-posterior and mediolateral planes was defined as "dynamic sway," as we have previously described in patients with diabetes (1).

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

The novelty of the current 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 forward, away from their base of support, during each step.

Consistent with previous reports (3), we found that self-perceived unsteadiness increases with advancing severity of DPN; 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 control subjects without diabetes. These findings are consistent with our gait laboratory study showing that significant unsteadiness was only present in patients with DPN (1). Therefore, participants' perception of unsteadiness appears to match that of gait laboratory measurements of balance impairment. Indeed, we show almost identical group mean values for maximum mediolateral dynamic sway, a key indicator of balance impairments, as we did in a previous study with the same group allocations (DPN, DM, and control) during level walking (1). The current study 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

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Received 11 October 2016 and accepted 28 January 2017.

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

	Between-group comparisons				Correlations	
	Control	DM	DPN	*P* value	Spearman 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 out of 10)	1 (1)	1 (0)	8 (1)+‡	0.0002	0.66**	0.0001
VPT (V)	6 (3)	8 (1)	28 (2)+‡	0.0001	0.61**	0.0001
Self-perceived unsteadiness						
Walking (score out of 5)	1.2 (0.3)	1.3 (0.7)	2.3 (0.9)+‡	0.0002	—	—
Standing (score out of 5)	1.3 (0.7)	1.1 (0.4)	2.4 (1)+‡	0.0001	—	—
Dynamic sway						
Anterior maximum (cm)	31.3 (2)	25.5 (0.9)+	24.7 (1.9)	0.132	–0.31*	0.029
Posterior maximum (cm)	20.2 (2.3)	18.7 (0.8)	16.1 (2.1)	0.425	0.36*	0.010
M-L maximum (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)+‡	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 with the control and DM groups are indicated by + and ‡, respectively; *P* values shown are for the outcome of the nonparametric one-way ANOVA. Control ($n = 19$): people without diabetes or peripheral neuropathy; DM ($n = 15$): people with diabetes but without neuropathy; DPN ($n = 15$): people with moderate-severe DPN. Correlations: correlation between participants' self-perceived unsteadiness and key neuropathy and gait variables for all groups combined ($n = 49$). M-L: mediolateral; A-P: anterior-posterior. * and ** indicate significance at $P < 0.05$ and $P < 0.01$ levels, respectively.

provided a deeper insight, and its lack should be acknowledged as a limitation. Centrally acting medication associated with diabetes may have an impact upon gait and balance and is being analyzed as a covariate as part of a larger ongoing study. The question that remains is to what extent the psychological factors, such as self-perceived unsteadiness and fear of falling, 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 behavioral 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.

Acknowledgments. The authors thank the staff of the Manchester Diabetes Centre and the Help BEAT Diabetes campaign (Research for the Future campaign).

Funding. Funding for this research was provided by the Dowager Countess Eleanor Peel Trust in the U.K., minor medical research grant ref. SEK.1064.2.SEG(14/83).

Duality of Interest. No potential conflicts of interest relevant to this article were reported.

Prior Presentation. Part of this work was presented in abstract form at the 76th Scientific Sessions of the American Diabetes Association, New Orleans, LA, 10–14 June 2016.

Author Contributions. N.D.R. wrote the manuscript. S.J.B. and M.P. conducted the data collection. S.J.B. processed gait data. N.D.R. and S.J.B. performed data analysis and statistics. S.J.B., M.P., and A.J.M.B. conducted participant recruitment. L.V. conceived the study idea and guided psychological assessment. All authors reviewed and edited the manuscript. N.D.R. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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