# Falls risk and the diabetic foot



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Falls in people with diabetes are a major problem, with feelings of unsteadiness, associated psychosocial effects and direct physical consequences. Sensory and motor neuropathy affecting the foot and lower limb are major contributory factors to gait impairments, subsequent unsteadiness and increased falls risk. Patients' perception of their unsteadiness measured using a sensitive scale matches well with gait laboratory assessment of unsteadiness, with clinical implications. A patient with an active foot ulcer has an increased risk of falling compared to a comparable patient without an active ulcer, with offloading footwear likely implicated. Podiatry and footwear interventions may help to reduce falls risk, with neuropathy and foot screening being particularly important for patients with diabetes.

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Falls are a major problem in developed nations around the world, with one in three adults aged over 65 years falling every year. In the general population, falls are associated with ageing-related declines in physical capabilities, frailty and a range of other risk factors. Falls are perhaps less well-recognised in diabetes, however, a person with diabetic peripheral neuropathy is actually up to ~20 times more likely to fall compared to their counterpart without diabetes (Richardson et al, 1992). Diabetic peripheral neuropathy is an independent risk factor for falls and a number of more recent research studies have shown the potential importance of the diabetic foot and lower limb in contributing to this heightened falls risk (Richardson and Hurvitz, 1995). The presence of a diabetic foot ulcer also increases the risk of falls. It is not only the direct injurious effects of falls that are of concern, but the psychological distress and depressive symptoms that are associated with unsteadiness and falls in people with diabetes (Vileikyte et al, 2009). The fear of falls associated with unsteadiness can also lead to restriction of activities of daily living and in reducing physical activity levels, which is a particularly undesired consequence for people with diabetes when physical activity plays such an important role in helping to regulate glycaemic control.

## Falls and diabetic peripheral neuropathy

People with diabetes may have to manage any number of complications associated with their condition and it is perhaps not surprising that falls have been traditionally overlooked as an important complication of diabetes. However, unsteadiness and falls associated with diabetic peripheral neuropathy has been shown to be one of the main triggers for depression and anxiety in these patients (Vileikyte et al, 2009). People with diabetes have a greater fear of falling compared to people without diabetes, which is also associated with poor physical performance and depression (Hewston et al, 2018).

Many patients might incorrectly attribute their feelings of unsteadiness and balance problems to the natural ageing process, with feelings of helplessness and an associated sense of inevitability. The majority of people with diabetes experiencing unsteadiness and falls are in fact much younger than the age where falls become prominent in the general population and this is because the underlying aetiology of unsteadiness is different in people with diabetic peripheral neuropathy and very closely linked to the diabetic foot and lower limb.

Diabetic peripheral neuropathy has long been recognised as a risk factor for diabetic foot ulcers because of the important role sensory deficits play in the generation of high cumulative plantar pressures (Boulton et al, 1983). The importance of sensory deficits in the diabetic foot were recognised in an early survey of patients with and without diabetic neuropathy for their role in contributing to falls risk, with an adjusted odds ratio for reported injuries in the neuropathic group of 15.0 compared to controls (Cavanagh et al, 1992). Early work from

the same group also identified compromised postural control during quiet standing in patients with diabetic sensory neuropathy (Simoneau et al, 1994).

These early studies provide useful insight to the role of diabetic sensory neuropathy in unsteadiness and falls risk, but balance challenges presented by quiet standing with two feet in contact with the floor are much lower compared to that presented by gait and other daily locomotor activities where there is a constant transition between single and double leg support.

More recent studies are now recognising diabetic sensory neuropathy as an important contributory factor in unsteadiness and falls during gait (Brown et al, 2015; Reeves et al, 2017). Diabetic motor neuropathy affecting the foot and lower limb is another prevalent complication of diabetes, but has not until recently been linked with unsteadiness and the risk for falls (Handsaker et al, 2014). A number of recent studies are showing how motor neuropathy affecting the foot and lower limb may well be closely linked to unsteadiness and falls, but that the independent effects of sensory and motor neuropathy are often difficult to 'disentangle' in human studies of this nature.

## Unsteadiness and falls in diabetic peripheral neuropathy: key role of the foot and lower limb

There is a relatively large and growing body of literature highlighting how diabetes and diabetic peripheral neuropathy alter many aspects of gait. A number of studies also show how many of these aspects are altered by diabetes even before the onset of measureable diabetic peripheral neuropathy (Savelberg et al, 2009; Sawacha et al, 2009; Brown et al, 2014). In a recent gait study, however, it was highlighted that marked unsteadiness was only evident in patients with moderate-severe diabetic peripheral neuropathy (defined by a vibration perception threshold [VPT] ≥25 V and a modified neuropathy disability score [NDS] of ≥6) and that people with diabetes but with no neuropathy, were actually comparable to controls without diabetes in terms of their balance control during gait activities (Brown et al, 2015). These findings are further supported by a study involving both laboratory measurements of gait and balance, in addition to capturing patient's perception of their unsteadiness using relevant items on the neuropathy-specific quality of life questionnaire (Neuro-QoL).

As with the previously mentioned gait study, this study involved three groups of people: people with moderate-severe diabetic peripheral neuropathy, people with diabetes, but no neuropathy and age-matched controls without diabetes. Self-perceived unsteadiness was highest in people with diabetic peripheral neuropathy, but actually similar between people with diabetes, but no neuropathy compared to controls without diabetes (Reeves et al, 2017). This previous research shows the agreement between laboratory-based measures of unsteadiness and falls-risk and subjective feelings of unsteadiness.

From a clinical point of view, this is actually very important, since if clinicians can ask their patients to rate how unsteady they feel with a relatively sensitive scale, such as the Neuro-QoL, this may provide a very useful insight to falls risk. Recent research, therefore, highlights two important points: 1) although many changes to gait can be seen before the onset of significant peripheral neuropathy, marked unsteadiness during gait is only present in people with diabetic peripheral neuropathy; 2) objective gait laboratory measures and subjective feelings of unsteadiness agree very well in terms of unsteadiness and falls risk.

The evidence is clear, therefore, that diabetic peripheral neuropathy is a major contributory factor for unsteadiness and heightened fallsrisk. Testing for diabetic peripheral neuropathy using appropriate sensory assessments is, therefore, an important part of screening, not only for diabetic foot ulcer risk, but also for falls risk. Diabetic peripheral neuropathy, encompasses both sensory and motor components and disentangling these aspects to understand, which might be relatively more important in falls risk, is much more challenging. Research from the gait laboratory has shown how people with diabetic peripheral neuropathy display an altered lower-limb muscle activation pattern and coupled with this are much slower to generate the forces in lower-limb muscles that help to stabilise the lower limbs and body during gait tasks (Handsaker et al, 2014).

The feedback experienced when the foot touches the ground during 'normal' gait is important for helping activate lower-limb muscles at the right time so that the lower limbs work to stabilise the body and ensure forward movement. The insensate diabetic foot means that this feedback is completely lacking and causes a delayed reaction from lower-limb muscles after the foot contacts the ground leading to unsteadiness and heightened falls risk (Handsaker et al, 2014). Slower and impaired lower-limb muscle responses evident during gait may also be caused by motor impairment in people with diabetic peripheral neuropathy. Diabetic neuropathy is associated with a slowing of motor neuron conduction velocity and weakness, particularly of more distal lower-limb muscles (Andersen, 2012).

In gait studies involving people with diabetic peripheral neuropathy, both sensory and motor impairments will be present and, therefore, both of these aspects (sensory deficits and motor impairments) will likely contribute to unsteadiness and heightened falls risk. Nevertheless, the importance of screening for clinical signs of sensory neuropathy should be considered an important aspect of falls prevention in people with diabetes.

## Diabetic foot ulcers and falls risk

A diabetic foot ulcer has been shown to increase the risk of falls compared to people with diabetes, but without a foot ulcer (Allen et al, 2017). In a study involving retrospective analysis on over 40,000 people with diabetes, those with an active foot ulcer (mean ± SD age: 63.5 ± 10.6 years) were twice as likely to fall (odds ratio = 2.26, 95% confidence interval [CI]: 1.96–2.6) and three times as likely to experience a fracture (odds ratio = 3.65, 95% CI: 2.59–5.15) compared to people with diabetes without a foot ulcer (mean ± SD age: 64.4 ± 11.5 years) (Allen et al, 2017). While this retrospective study was not designed to understand the reasons for this increased falls risk, people with an active ulcer will be wearing some type of offloading device and this may likely play a role. Offloading devices are designed to restrict range of movement at the foot and ankle, and encourage offloading of the ulcer area. In addition to their restriction of joint range, they are also relatively bulky devices and will increase gait asymmetry. Although offloading is the goal of treatment, patients will still be ambulatory to some degree, and will need to move around, but the use of offloading casts likely presents an increased falls risk for patients. This should likely be considered and communicated to patients when treating diabetic foot ulcers and fitting offloading devices, as the patient may need to allow time to adjust their gait to the new device.

A 2-year prospective study of people with diabetes with a previous foot ulcer (mean age: 62.8 years) has reported 54% of patients experiencing at least one fall within the first year of follow-up (Wallace et al, 2002). This is a very high incidence of one-year falls compared to the ~33% incidence in the general population for individuals aged over 65 years (therefore, even older than the patients in the previous study) and underlines the presence of increased risk factors within this specific cohort with a previous diabetic foot ulcer. In people with a previous diabetic foot ulcer, having one or more comorbidity was identified as a major underlying risk factor (odds ratio: 2.10) along with insensate feet (odds ratio: 1.39) (Wallace et al, 2002).

## The role of foot care in falls prevention

Even within the general population, there is an increasing realisation of the importance of podiatry and appropriate foot management in the prevention of falls, but diabetes in particular presents a special case for the importance of foot care interventions (Najafi et al, 2013). A number of randomised controlled trials have investigated the potential of podiatry-based interventions to reduce falls-risk in older adults (Cockayne et al, 2017a; 2017b; Wylie et al, 2017). Community-dwelling adults aged over 65 years were randomised to intervention (*n*=493) and usual care (*n*=517) and monitored for self-reported falls over the 12-month follow-up period (Cockayne et al, 2017a; 2017b). The podiatry intervention included falls prevention advice, footwear advice and provision (where appropriate), foot orthoses and an exercise programme (three times/week) for the foot and ankle muscles. The podiatry intervention group experienced a small non-significant reduction in the incidence rate of falls (adjusted incidence rate ratio 0.88, 95% CI 0.73 to 1.05, *P*=0.16) and falls were lower (49.7 versus 54.9%, adjusted odds ratio 0.78, 95% CI 0.60 to 1.00, *P*=0.05) over the 12 months follow-up compared to the usual care group.

A review of the literature on footwear interventions (including orthoses) and their effects on balance and gait in older adults found a consistent trend for footwear interventions to confer a substantial improvement in static postural balance, with greater control over lateral stability (Hatton et al, 2013). Appropriate surgical interventions for foot pathologies where there is a clinical need may also improve balance and reduce the risk of falls. Patients undergoing Hallux valgus surgery have been reported to show improved balance during a static one and two-legged postural balance test compared to patients with Hallux valgus that had not undergone surgery, but gait performance remained similar between the groups (Sadra et al, 2013).

While the above evidence for podiatry intervention in falls prevention provides confidence of a foot care-centred approach, these studies have been conducted in the general population and not specifically in people with diabetes. A recent study in people with diabetic peripheral neuropathy, however, used foot and ankle exercise training with visual feedback and observed an improvement in static postural balance control and improved postural coordination between the ankle and hip joints in executing stepping manoeuvres (Grewal et al, 2013).

Podiatry-based interventions for falls prevention show promise, despite a current lack of studies with adequate statistical power and a lack of

studies specifically in people with diabetes. People with diabetes present a particular opportunity for foot care interventions given the many risk factors presented, including foot insensitivity, foot deformities and diabetic foot ulcers. The patient with an active diabetic foot ulcer is at a particularly heightened risk likely because of the disturbances to gait provided through offloading devices. Nevertheless, further research is required to confirm the underlying mechanisms and test the effectiveness of targeted podiatry interventions in people with diabetic peripheral neuropathy and particularly those with an active diabetic foot ulcer.

## Conclusions

People with diabetic peripheral neuropathy are at a heightened risk of falls compared to the general population. Psychological distress, depressive symptoms, fear of falls and reduced physical activity are all additional to the direct injurious consequences of falls. Gait studies have shown how people with diabetic peripheral neuropathy display marked unsteadiness and a number of other neuromuscular adaptations that predispose falls. Gait laboratory measures of unsteadiness also match very closely with patient's perception of their unsteadiness.

An active diabetic foot ulcer increases the risk of falls, potentially linked to the use of offloading devices causing gait alterations and unsteadiness. Patients with a previous diabetic foot ulcer are also at increased falls risk, likely due to the presence of multiple comorbidities, including insensate feet. Podiatry has a major role to play in screening for risk factors that predispose falls and in developing appropriate footwear interventions to reduce falls-risk. The treatment of active diabetic foot ulcers also presents an important role for the podiatrist not only in treating the foot pathology, but also in ensuring appropriate falls prevention advice during a period of heightened risk. WME

## References


Allen L, Powell-Cope G, Mbah, A et al (2017) A retrospective review of adverse events related to diabetic foot ulcers. *Ostomy Wound Manage* 63(6): 30–3

Andersen H (2012) Motor dysfunction in diabetes. *Diabetes Metab Res Rev* 28(Suppl 1): 89–92

Boulton AJ, Hardisty CA, Hardisty CA et al (1983) Dynamic foot pressure and other studies as diagnostic and management aids in diabetic neuropathy. *Diabetes Care* 6(1): 26–33

Brown SJ, Handsaker JC, Bowling FL et al (2015) Diabetic peripheral neuropathy compromises balance during daily activities. *Diabetes Care* 38(6): 1116–22

Brown SJ, Handsaker JC, Bowling FL et al (2014) Do patients with diabetic neuropathy use a higher proportion of their maximum strength when walking? *J Biomech* 47(15): 3639–44

Cavanagh PR, Derr JA, Ulbrecht JS et al (1992) Problems with gait and posture in neuropathic patients with insulin-dependent diabetes mellitus. *Diabetic Med* 9(5): 469–74

Cockayne S, Adamson J, Clarke A et al (2017a) Cohort randomised controlled trial of a multifaceted podiatry intervention for the prevention of falls in older people (The REFORM Trial). *PLoS One* 12(1): e0168712

Cockayne S, Rodgers S, Green L et al (2017b) Clinical effectiveness and cost-effectiveness of a multifaceted podiatry intervention for falls prevention in older people: a multicentre cohort randomised controlled trial (the REducing Falls with ORthoses and a Multifaceted podiatry intervention trial). *Health Technol Assess* 21(24): 1–198

Grewal GS, Sayeed R, Schwenk M et al (2013) Balance rehabilitation: promoting the role of virtual reality in patients with diabetic peripheral neuropathy. *J Am Podiatr Med Assoc* 103(6): 498–507

Handsaker JC, Brown SJ, Bowling FL et al (2014) Contributory factors to unsteadiness during walking up and down stairs in patients with diabetic peripheral neuropathy. *Diabetes Care* 37(11): 3047–53

Hatton AL, Rome K, Dixon J et al (2013) Footwear interventions: a review of their sensorimotor and mechanical effects on balance performance and gait in older adults. *J Am Podiatr Med Assoc* 103(6): 516–33

Hewston P, Garcia A, Alvarado B, Deshpande N (2018) Fear of falling in older adults with diabetes mellitus: the IMIAS study. *Can J Aging* 37(3): 261–9

Najafi B, de Bruin ED, Reeves ND et al (2013) The role of podiatry in the prevention of falls in older people: a JAPMA special issue. *J Am Podiatr Med Assoc* 103(6): 452–6

Reeves ND, Brown SJ, Petrovic M et al (2017) How does self-perceived unsteadiness influence balance and gait in people with diabetes? Preliminary observations. *Diabetes Care* 40(5): e51–e52

Richardson JK, Hurvitz EA (1995) Peripheral neuropathy: a true risk factor for falls. *J Gerontol A Biol Sci Med Sci* 50(4): M211–5

Richardson JK, Ching C, Hurvitz EA (1992) The relationship between electromyographically documented peripheral neuropathy and falls. *J Am Geriatr Soc* 40(10): 1008–12

Sadra S, Fleischer A, Klein E et al (2013) Hallux valgus surgery may produce early improvements in balance control: results of a cross-sectional pilot study. *J Am Podiatr Med Assoc* 103(6): 489–97

Savelberg HH, Savelberg HH, Schaper NC et al (2009) Redistribution of joint moments is associated with changed plantar pressure in diabetic polyneuropathy. *BMC Musculoskelet Disord* 10: 16

Sawacha Z, Gabriella G, Gabriella G et al (2009) Diabetic gait and posture abnormalities: a biomechanical investigation through three dimensional gait analysis. *Clin Biomech* 24(9): 722–8

Simoneau GG, Ulbrecht JS, Derr JA et al (1994) Postural instability in patients with diabetic sensory neuropathy. *Diabetes Care* 17(12): 1411–21

Vileikyte L, Peyrot M, Gonzalez JS et al (2009) Predictors of depressive symptoms in persons with diabetic peripheral neuropathy: a longitudinal study. *Diabetologia* 52(7): 1265–73

Wallace C, Wallace C, Reiber GE et al (2002) Incidence of falls, risk factors for falls, and fall-related fractures in individuals with diabetes and a prior foot ulcer. *Diabetes Care* 25(11): 1983–6

Wylie G, Menz HB, McFarlane S et al (2017) Podiatry intervention versus usual care to prevent falls in care homes: pilot randomised controlled trial (the PIRFECT study). *BMC Geriatr* 17(1): 143