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The slipping slipper sign: a marker of severe peripheral diabetic neuropathy and foot sepsis

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ABSTRACT

Background: Peripheral neuropathy is a major contributor to diabetic foot complications including ulceration, sepsis and limb loss. The aim of this study was to document the frequency of this previously undocumented clinical marker of peripheral neuropathy, the "slipping slipper sign" (SSS), characterised by unrecognised loss of slippers from one's feet while walking, and to compare it with traditional clinical tests for peripheral neuropathy.

Objective: To evaluate the relationship between a positive SSS and diabetic peripheral neuropathy.

Subjects and methods: The study included 105 diabetic outpatients without active foot problems, 40 diabetic inpatients with active foot sepsis, and 69 other patients with neither diabetes nor active foot sepsis as negative controls. Demographic data, clinical neuropathy scores and the presence or absence of the SSS were obtained.

Results: No control subjects had a positive SSS. In contrast, 64 of 145 diabetic patients had severe neuropathy of whom 53 had a positive SSS (83% sensitivity) and 74 of 81 without severe neuropathy had a negative SSS (91% specificity). Diabetic patients with concurrent foot sepsis had a higher frequency of severe neuropathy (70%) and positive SSS (65%) compared with those without (36% and 35%, respectively, $p<0.001$). Multivariate analysis showed that a positive SSS was strongly related to severity of neuropathy independent of duration of diabetes.

Conclusion: The SSS reflects severe peripheral neuropathy and is particularly prevalent among those with active foot disease. Patients who have experienced the SSS should be encouraged to seek attention and preventive action taken.

Foot ulceration in diabetes is a major public health problem worldwide[1] and is one of the leading causes of hospitalisation, morbidity and mortality for persons with diabetes in developing countries.[2 3] It is well known that loss of protective sensation due to peripheral neuropathy is a frequent complication of diabetes and a major contributor towards development of ulceration, foot sepsis and amputation.[4–8]

Despite its clinical significance, peripheral diabetic neuropathy is often overlooked and poorly evaluated in the clinical setting. Validated methods of testing for peripheral neuropathy include nerve conduction studies (NCS), neuropathy disability and symptom scores,[9] and cutaneous pressure perception using the 10 g monofilament. NCS are regarded as the gold standard to evaluate and validate other screening tests used in diagnosing diabetic neuropathy[10 11] as they are objective, reliable and sensitive. Their use regarding general screening in diabetic clinics, however, is limited either because of economic cost, consumption of limited clinical time or because various recommendations for interpreting these data have contributed to confusion.[12 13]

Improper footwear has been implicated in up to one in three cases of foot ulceration leading to amputation.[14 15] On the other hand, it is our clinical observation that slippers (a common and popular footwear choice in the Caribbean and many other developing countries) may reveal strong clues to a foot at risk. Slippers are defined here as varieties of casual footwear which all have one common feature of being unstrapped at the ankles (the front may be open or closed, but the back is always open) (fig 1). In many, a vertical shaft of material wedges between the great and second toe and connects to one or more straps across the forefoot. Such footwear is widely used around the world and referred to varyingly as slippers (current study), flip-flops (UK), jandals (New Zealand) and thongs (Australia). It is our experience[16] that many diabetic patients complain of, or admit to, having lost such slippers off their feet without recognising that they have done so, a positive slipping slipper sign (SSS).

Having encountered patients in whom slippers slipped unknowingly off their feet during normal day-to-day activities and having found evidence for severe neuropathy in many of them, we proceeded to investigate the association between slipping slippers and peripheral neuropathy in a cross sectional study.

SUBJECTS AND METHODS

Selection of subjects and data collection

This study was conducted at the Port of Spain and San Fernando General Hospitals in Trinidad, West Indies, during the period July to August 2004. Inclusion criteria were diabetic patients attending the outpatient diabetic clinics or admitted to the surgical wards for treatment (amputation, debridement or medical treatment) of first presentation of diabetic foot sepsis. We also included a group of non-diabetic control subjects. All subjects selected for the study wore slippers at least once a week.

Patients who were unable to give an adequate history, had experienced a stroke, had high alcohol consumption (>14 units/week for women and >21 units/week were for men), were illicit drug users or those with mono- or polyneuropathies due to causes other than diabetes mellitus were excluded from the study. Those who had previous lower limb amputations and so were unable to wear slippers were also excluded.

Figure 1 Slippers come in various designs. The front may be open or closed, but the back is always open.

Demographic data including name, gender, age, self reported ethnic origin, type, treatment and duration of diabetes, past medical history, smoking history, and evidence of regular alcohol consumption (>7 units/week) were obtained after informed consent and with ethical approval. In addition, data were obtained on the occurrence of non-healing ulcers, previous foot sepsis and injury to feet, as well as whether or not the patient walked barefooted or the frequency with which one's feet were examined either by a healthcare professional or self examined. Medical records were consulted to establish whether the patient was registered blind/partially sighted. Patients were assessed for foot sepsis, peripheral neuropathy and were also asked to respond to a questionnaire to determine whether or not they had experienced the SSS, which was defined as positive if the response to the question "Have you ever lost your slipper from your feet while walking and not realised that you had done so?" was in the affirmative. The frequency and the duration of the sign before assessment were also recorded.

Determination of neuropathy scores

The severity of neuropathy was assessed using a modified neuropathy disability score (NDS) and neuropathy symptom score (NSS).[9]

The NDS was derived as follows:

- Examination of the Achilles reflex using a tendon hammer
- Vibration and temperature at the dorsal surface of the hallux using a cold tuning fork (128 Hz)
- Pain sensation using a 10 g monofilament.

With eyes closed, the patients were required to elicit a "yes/no" response to the 10 g monofilament pressure and correctly identify the point of contact. To assess vibration sensation the patients were asked to close their eyes and state the presence and cessation of vibration. For temperature discrimination, patients were asked to correctly identify the temperature as cold or hot. The sensory modalities were scored as either present = 0, or reduced/absent = 1 for each side, and reflexes as normal = 0, present with reinforcement = 1, or absent = 2 per side. The maximum abnormal score was 10. The score was categorised to determine mild (3–5), moderate (6–8) or severe (9–10) neuropathy as previously described.[9]

The NSS score was derived as follows:

- Patients were asked about their experience of pain or discomfort in their legs within the previous 6 months. If the patient described burning, numbness or tingling, a score of 2 was assigned. Fatigue, cramping or aching scored 1. The presence of symptoms of the feet was assigned a score of 2, the calves 1, and elsewhere 0.
- Exacerbation of symptoms at night scored 2 versus 1 for day and night, and 0 for day alone. An additional score of 1 was given if the symptoms had ever woken the patient from sleep.
- The patients were asked if any manoeuvres could alleviate the symptoms. Scores assigned were 2 for walking, 1 for standing, and 0 for sitting or lying. The maximum symptom score was 9. This score was categorised to determine mild (3–4), moderate (5–6) and severe (7–9) symptoms of neuropathy.[9]
- For patients who had unilateral above knee, transfemoral or transtibial amputations performed on their present admission, the NDS was assessed with the remaining foot and the score doubled.

The minimum acceptable criteria for a diagnosis of peripheral neuropathy were moderate signs with or without symptoms, or mild signs with moderate symptoms. Mild signs alone or with mild symptoms were not considered adequate to make a diagnosis of peripheral neuropathy. In this study a patient was considered to have severe neuropathy if they had a moderate NDS score with a severe NSS score, a moderate NSS score with a severe NDS score, or both severe NDS and NSS score.

Data analysis

Data were analysed using SPSS version 12.0 Microsoft Windows for the frequency of severe neuropathy among diabetic and non-diabetic subjects and to determine the correlation between neuropathy score and the presence of the SSS. Further analysis was undertaken to determine whether severity of neuropathy and frequency of SSS was associated with foot infection. In addition, multivariate analysis was undertaken to establish the clinical correlates which might predict the SSS.

Table 1 The slipping slipper sign (SSS) and severe neuropathy in patients with diabetes mellitus

Neuropathy	SSS absent	SSS present	Total
Absent/not severe	74 (51%)	7 (4.8%)	81 (55.8%)
Severe	11 (7.6%)	53 (36.6%)	64 (44.2%)
Total	85 (58.6%)	60 (41.4%)	145 (100%)

n = 145, p<0.001 (Pearson χ^2 test).

Table 2 One hundred and forty-five adults with diabetes mellitus categorised into groups by foot sepsis

Characteristics	Diabetics, no (%) Without foot sepsis n = 105	With foot sepsis n = 40	p Value
Males	31 (29.5)	15 (37.5)	0.425*
Ethnicity Afro-Caribbean	35 (33.3)	15 (37.5)	0.846*
Ethnicity Indo-Caribbean	66 (62.9)	24 (60.0)	
Type II diabetes present	90 (85.7)	38 (95.0)	0.155*
Insulin treatment	60 (57.1)	26 (65.0)	0.452*
Severe neuropathy present	36 (34.3)	28 (70.0)	<0.001*
Slipping slipper sign present	34 (32.4)	26 (65.0)	0.001*
Mean (SD)			
Age (years)	56.4 (12.5)	53.9 (9.0)	0.254†
Duration diabetes (years)	15.5 (10.9)	14.8 (7.7)	0.809‡
Duration slipping slipper sign (months)	8.05 (34.7)	15.5 (34.0)	0.001‡

Results are shown as no (%) or mean (SD) as appropriate.
For details of the asymptomatic control group please see text.
*χ^2; †t test; ‡Mann–Whitney U test.

Table 3 Factors correlated with the presence of the slipping slipper sign in 145 patients with diabetes mellitus

Factor	Rho	p Value
Duration of diabetes	0.281	0.001
Foot sepsis present	0.296	<0.001
Severe neuropathy present	0.784	<0.001
Age	0.007	0.935
Diabetes type	0.089	0.290
Ethnicity	−0.101	0.229
Insulin treatment	0.154	0.064
Gender	−0.031	0.710

Data were expressed as number (%) or mean (SD) as appropriate. Bivariate analyses were performed by Spearman's correlation for continuous data or χ^2 test for categorical data. Multivariate analysis with positive SSS as outcome variable was performed using backward stepwise logistic regression. Statistical significance was set at $p<0.05$.

RESULTS

A total of 105 diabetic outpatients (no foot sepsis), 40 diabetic inpatients (with foot sepsis), and 69 controls (without diabetes or foot sepsis) met the study inclusion criteria after consecutive sampling on the wards and outpatients' departments of both hospitals.

For the control group mean (SD) age was 51 (12) years. There were 30 (44%) males and this group had the following ethnic composition: Indo-Caribbean 39 (57%), Afro-Caribbean, 26 (38%), and the rest were of mixed ancestry. Among the group of diabetic subjects mean age was 55.7 (11.7) years and ethnic composition was Indo-Caribbean 90 (62%), Afro-Caribbean 50 (34%), and the rest were of mixed or other ancestry. The demographics (age, gender and ethnicity) of the control group were not significantly different from that of the diabetic group. By definition, none of the controls had neuropathy or foot sepsis.

All patients wore slippers whether indoors or out. About one in three (37%) frequently walked barefooted outside and 50% walked barefooted indoors. More than three in four (81%) never had their feet checked by professional health care workers and 42% never checked their feet themselves.

Table 1 shows that among the 145 diabetic subjects in the study, 64 had severe neuropathy of whom 53 had a positive SSS (sensitivity 83%). Of the 81 with non-severe neuropathy 74 had a negative SSS (specificity 91%). The relatively high sensitivity and specificity of this easily administered test gives it tremendous potential in the clinical environment, especially at the primary care level.

Table 2 shows that despite no significant differences in the characteristics of age, gender, ethnicity or duration of diabetes between those with or without foot disease, the frequency of severe neuropathy (70% vs 34%, $p<0.001$) as well as the frequency of the SSS (65% vs 35%, $p = 0.001$) was significantly higher among those with foot sepsis compared with those without. The SSS was also present for twice as long among those with foot sepsis (mean (SD) 15.5 (34.7) months) compared with those without (8.05 (34.0) months) and this was significant ($p = 0.001$). Thus, in many patients neuropathy may reside as a silent phenomenon revealing itself only through the complication of infection. These data show that by predating infection, the SSS is actually revealing the otherwise unrecognised neuropathy.

Table 4 Multivariate analysis with presence of a positive slipping slipper sign and outcome variables using backward stepwise logistic regression

Factor	B	p Value
Severe neuropathy	3.999	<0.001
Diabetes ⩾15 years	1.141	0.034
Foot sepsis	0.932	0.334
Insulin treatment	0.000	0.997

B, regression coefficient.

Table 3 shows the strongly significant correlates for a positive SSS were duration of diabetes ($p = 0.001$), the presence of foot sepsis ($p<0.001$), and severe neuropathy ($p<0.001$). To explore these interlocking relationships, multivariate analysis with the presence of the SSS as outcome variable was undertaken (table 4) and this showed that there was a strong relationship with presence of severe neuropathy (odds ratio 54.5, 95% confidence interval 18.7 to 159).

DISCUSSION

Our study shows that a simple enquiry about footwear can elicit, with a high and satisfactory degree of sensitivity (83%) and specificity (91%), the presence of severe neuropathy in diabetic feet. A fallen slipper is quickly recognised by normal feet. By their very design, these slippers require neuromuscular and neurosensory integrity, both of which are often compromised in diabetic neuropathy.[5 6 9 17] Any significant degree of muscle weakness could lead to failure of the feet to hold on to these slippers, while any significant degree of loss of sensation will account for the lack of recognition of the lost footwear, together comprising the SSS. This study shows that the SSS is an effective surrogate marker for a neuropathic foot that is at heightened risk. Not only does the slipped slipper reveal the underlying severe neuropathy, but the act of slippage might in itself predispose the neuropathic foot to further unrecognised trauma and infection.

Our study has established that severe peripheral neuropathy is quite common among diabetes subjects in the hospital setting and is twice as common among those with foot sepsis. Interestingly, the SSS was present for a mean period of 2 years before presentation with clinical disease. This gap may represent a window of opportunity for timely prophylactic action against diabetic foot disease.

Data from primary care also highlight the scale of the public health problem posed by the diabetic foot. For example, up to 50% of clinic attendees have been shown to have symptoms of neuropathy, one in eight report foot ulceration, one in 17 a previous hospitalisation for ulceration, and one in 25 a previous amputation.[3] In Trinidad and Tobago, foot problems account for 14% of hospital admissions, 29% of bed occupancy by people with diabetes, and as many as 50% of non-traumatic

Main messages

- Diabetic peripheral neuropathy is associated with a positive slipping slipper sign.
- A novel clinical sign (the slipping slipper sign) is described whereby footwear, unstrapped at the ankle, may slip off and goes unrecognised by the wearer when there is severe diabetic peripheral neuropathy.

Current research question

To explore the association of a positive slipping slipper sign, neuropathy and foot sepsis.

amputations are performed on diabetics.[3 18] Indeed, across the entire Caribbean region diabetic foot sepsis is the leading cause of amputation.[19] The consistently high presence of neuropathy explains the alarming consequence of foot complications encountered in practice, which might be minimised by earlier recognition through a quick, reliable and valid test.

The high degree of correlation between a positive SSS and severe neuropathy in the current study is noteworthy. The addition of this easily administered question during the clinical encounter comes without added cost yet could add tremendous value. It would be useful for similar studies to be undertaken in other settings to establish generalisability.

In conclusion, our data show that a positive SSS is an indication of severe peripheral neuropathy in diabetics with or without foot sepsis. The SSS may well serve as a novel methodology for mass screening for feet at risk because it is sensitive, simple and has no cost implications. Simple messages via the media, customised towards local cultures and aimed at elicitation of a positive SSS, may be used to alert patients to the need for enhanced footcare and to encourage contact with appropriate healthcare professionals. Furthermore, prospective studies comparing diabetics with or without the SSS for subsequent risk of foot complications are also warranted.

Competing interests: None declared.

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