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# Do patients with diabetes wear shoes of the correct size?

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**Disclosure**
The authors have stated that they have no interests which might be perceived as causing a conflict or bias.

**SUMMARY**

**Background:** Fifteen per cent of patients with diabetes will develop a foot ulcer at some point in their life. Ill-fitting footwear frequently contributes to foot ulceration. A good fitting shoe is an essential component in the management of the diabetic foot. The objective of this study was to assess the feet and footwear of patients with diabetes to determine whether they are wearing the correct-sized shoes. **Methods:** One-hundred patients with diabetes who were attending the general diabetic clinic had their foot length measured using a 'Clarks' shoe shop device and foot width using a pair of callipers. Measurements were taken whilst seated and standing. Shoe dimensions were also assessed by recording the manufactured shoe length and using callipers to assess shoe width. A calibrated measuring stick standardised shoe lengths. Neurovascular status and the presence of deformities in the foot were also recorded. **Results:** One-third of diabetic patients were wearing the correct shoes on either foot whilst seated or whilst standing. However, only 24% of patients were wearing shoes that were of the correct length and width for both feet whilst seated and 20% upon standing. Seventeen per cent of patients appeared in both groups. No significance was found between any other variables, such as sensory neuropathy. **Conclusions:** Many patients with diabetes wear shoes that do not fit, particularly, shoes that are too narrow for their foot width. Assessing the appropriateness of footwear maybe an important part of foot examination.

**What's known**
Patients with diabetes are subjected to several associated complications, particularly foot ulcer development. Those patients with sensory neuropathy are at an increased risk of ulcer formation if they do wear the correct-sized footwear for their feet. A good fitting shoe is an essential component in the prophylactic care of the diabetic foot.

**What's new**
The necessity for good fitting footwear is frequently commented upon within published literature. However, the details concerning this are limited, reflecting how it may be difficult to achieve in a routine clinical setting. This study highlights the extent of the problem; the reasons why this may be difficult; and, the problems that surround the measurement of feet.

## Introduction

The incidence of diabetes is increasing as are its associated complications. One important complication is foot ulcer development. Fifteen per cent of patients with diabetes will develop an ulcer at some point in their life (1,2). Only about half of patients actually notice the lesion themselves, with the majority occurring on the digits (2). Ill-fitting footwear frequently contributes to foot ulceration (3,4).

Inadequate shoe fitting cannot be felt in those patients with sensory neuropathy (5). Ulcers can form because of tight-fitting shoes causing constant pressure. However, loose shoes also cause ulcers, as a result of friction (3).

When footwear is fitted properly, it can reduce high pressure areas and hence reduce callus formation and the threat of ulcer formation. It will also fulfil its function as a barrier to the environment (4). Ill-fitting footwear can disrupt the biomechanics of the foot and ankle, and can subsequently give rise to problems, including pain (6). Footwear should be designed to relieve pressure areas, reduce shock and shear forces and be able to accommodate deformities by supporting and stabilising them. It is necessary that shoes fit for both size and shape (7–9).

Patients with diabetes, especially those with sensory neuropathy need appropriate shoes. The shoe must be wide enough to accommodate the first metatarsophalangeal joint (8). Shoes should be fitted whilst weight bearing. The location of the widest part of the shoe should be checked allowing extra room at the toe box, adequate room should be left across the ball of the foot and a snug fit should be made around the heel (8,9). It is also important to realise that many people have mismatched foot sizes (10).

Although, the need for good fitting shoes is frequently commented upon in the literature, details are often scarce, reflecting how difficult this can be to achieve in routine clinical settings. Footwear should be defined according to findings found on

clinical examination (11). Good shoe fit is essential for prophylactic care of the diabetic foot (12).

The aim of this study was to examine the feet of patients with diabetes to assess if they are wearing the correct shoe for their feet by measuring two of the most relevant and straightforward variables in shoe construction.

## Methods

Patients attending the general diabetic clinic for their routine checkup at Ninewells Hospital and Medical School, Dundee, were enrolled into this study. Patients were approached by consecutive attendance at the general diabetes clinic. The Tayside Committee on Research and Medical Ethics approved the study, and data collection commenced in July 2004 and reached completion in December 2004.

Patients were included in the study if they were at least 18 years of age and were attending the diabetic clinic as a new patient or for follow-up. Exclusion criteria included patients attending a diabetic foot clinic, if they were unable to transfer from a seated to a standing position or had difficulty standing; and if they wore a lower limb prosthesis or if they wore shoes or boots supplied from the Orthotic Department. Patients were asked to fill in a questionnaire relating to aspects of their diabetes. Questions were asked about the management of their condition, the duration of their diabetes, their shoe size and the frequency with which they checked their feet for problems. Height and weight were measured in the clinic.

Patient's feet were examined by a single observer after removal of socks and shoes. The patients' feet were first inspected for deformity, bunions, callus and ulcers. The locations of any ulcers were noted. Foot length was measured using a length-measuring device designed for 'Clarks' shoes. Separate measuring devices were available for both men and women. The 'Clarks' metre is calibrated for measuring feet in a seated position. However, the measurements were taken whilst seated and standing to assess if a difference was present. This method assumed the fact that the scale for measuring feet whilst seated is identical to that whilst standing.

Foot width was measured using a pair of sliding callipers. Measurements were taken across the widest part of the foot, over the metatarsal heads, while the patient was standing. This was measured to the nearest millimetre.

The dorsalis pedis and the posterior tibial foot pulses were also assessed as being either present or absent. Sensation of the foot was assessed using a 10 g monofilament on five sites of the plantar aspect of each foot (the hallux and the 1st, 2nd, 3rd and 5th metatarsal heads). This was performed in line with local protocol at that time.

The length and width of the patient's current footwear were also recorded. The footwear being assessed was that which the patient was wearing on arrival at the clinic. It was assumed that patients wore this size of shoe regularly.

Shoe length was assessed by recording the measurement stated on the sole or the inside of the shoe according to its manufacturer. This was standardised by using a measuring stick calibrated in centimetres at the Institute of Motion Analysis and Research. This was a sliding device that measured the distance between the heel and the toe. Shoe width was recorded using the sliding callipers which were inserted into the shoe. The measurement was taken at the maximal width in centimetres.

## Statistical methods

Data were first checked for validity by examining descriptive parameters and plots. Extreme values were verified by referring to the original measurement sheets. The frequency distribution of the differences between appropriate pairs of foot and shoe measurements were determined.

The 'goodness of fit' of shoe to foot size was investigated using the magnitude (absolute value without sign) of the difference between foot and shoe length, and foot and shoe width. Foot length was measured to the nearest half size. The width of the shoe was judged to be satisfactory if it was within 0.7 cm (one-width size) of the foot width. The analysis was performed utilising the statistical software package SPSS version 12.0 (SPSS, Chicago, IL, USA). Data was presented as foot size minus shoe size.

## Results

One-hundred volunteers with diabetes participated in this study. They were aged between 24 and 89 years (mean age ± standard deviation; 62.0 ± 14.9 years) of whom 52% were male. Thirty-six per cent ($n = 36$) of patients were self-administering insulin. The median length of time that volunteers had diagnosed diabetes was 5.0 years (interquartile range: 2.0–10.0 years).

Table 1 shows how often patients checked their own feet for problems. Only 29% ($n = 29$) checked their feet daily, whilst 49% ($n = 49$) checked them less than weekly and 22% ($n = 22$) never checked their feet. Patients with neuropathy were more likely to check their feet for problems on a daily basis ($p < 0.01$). Overall, 45% ($n = 45$) of patients had previous problems with their feet, either ulcers,

**Table 1** How often patients check their feet for problems

| How often patients check their feet | All, $n = 100$ (%) | No neuropathy, $n = 80$ (%) | Neuropathy, $n = 20$ (%) |
|---|---|---|---|
| Daily | 29 (29) | 18 (22.5) | 11 (55) |
| 1–3 times per week | 27 (27) | 22 (27.5) | 5 (25) |
| Fortnightly | 8 (8) | 7 (8.75) | 1 (5) |
| Monthly | 5 (5) | 5 (6.25) | 0 (0) |
| Every 3 months | 9 (9) | 8 (10) | 1 (5) |
| Never | 22 (22) | 20 (25) | 2 (10) |
| Total | 100 (100) | 80 (100) | 20 (100) |

callus, bunions, corns or oedema, or a combination of these.

At examination 7% ($n = 7$) had current ulcers present, 15% ($n = 15$) had callus present and 10% ($n = 10$) had bunions. Twenty per cent ($n = 20$) of patients had sensory impairment, where sensory impairment is defined as an inability to feel eight of 10 areas on both feet using a 10 g monofilament. At least 32% ($n = 32$) of patients had one absent pulse, with 6% ($n = 6$) of patients having four pedal pulses impalpable. Fourteen per cent ($n = 14$) had both sensory impairment and absent or reduced pulses.

Foot size was measured in a seated position utilising the 'Clarks' metre. The differences between foot and shoe length were assessed by subtracting the shoe length from the foot length. The correct size is indicated when foot size minus shoe size is equal to zero. If this figure is > 0 it indicates that the shoe was too short and < 0, the shoe was too long for the patient's foot (Figure 1 and Table 2).

Shoes were deemed incorrect length if they were more than half a size difference as compared with foot size (Figure 1). About 33% of patients were more than a half-size out in shoe length when seated. A shoe width of more than one width size (0.7 cm) difference with foot width was deemed an incorrect size. Differences between foot and shoe width are shown in Figure 2 and presented similarly. About 45% had more than 0.7 cm difference in width with the majority of these being too narrow. A participant was wearing an ill-fitting shoe if they were wearing shoes of incorrect length or width (Table 2).

**Table 2** The proportion of patients who were wearing shoes of incorrect length or width (whilst seated) – more than half a size difference in length or more than 0.7 cm difference in width

| Whilst seated | Shoe too wide | Shoe is the correct width | Shoe too narrow | Total |
|---|---|---|---|---|
| **Right foot** | | | | |
| Shoe too long | 0 | 15 | 8 | 23 |
| Shoe is the correct length | 1 | 37 | 29 | 67 |
| Shoe too short | 0 | 4 | 6 | 10 |
| Total | 1 | 56 | 43 | 100 |
| **Left foot** | | | | |
| Shoe too long | 0 | 14 | 10 | 24 |
| Shoe is the correct length | 1 | 35 | 30 | 66 |
| Shoe too short | 0 | 4 | 6 | 10 |
| Total | 1 | 53 | 46 | 100 |

The differences between foot sizes when measured whilst seated as compared with standing, measured utilising the 'Clarks' metre in both positions are shown in Figure 3. Negative values indicate that the foot size has increased from the seated to the standing position. When standing, patients' foot length increased, on average (±standard deviation) by 0.3 ± 0.3 shoe sizes for the right foot and 0.4 ± 0.4

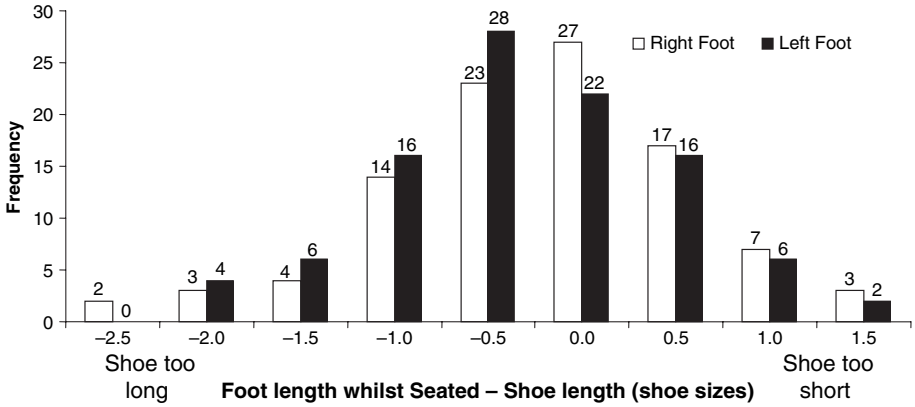


**Figure 1** Foot length whilst seated – shoe length (shoe sizes)

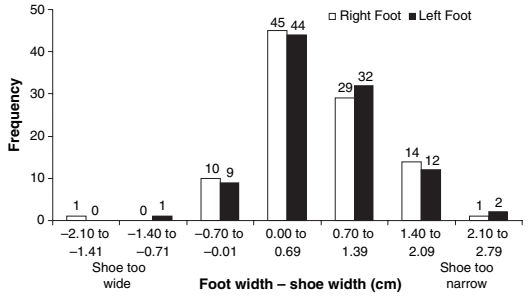


**Figure 2** Foot width whilst standing – shoe width (cm)

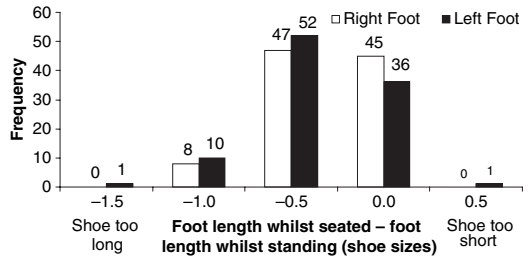


**Figure 3** Foot length whilst seated – foot length whilst standing (shoe sizes)

shoe sizes for the left foot. This is demonstrated in Figure 3. A negative number indicates that foot size had increased from a seated to a standing position.

The results were then analysed to demonstrate whether patients had the correct length (within half a shoe size) and the correct width (within 0.7 cm) of shoes for both their feet. Only 24% ($n = 24$) of patients had the correct shoes according to length and width whilst seated, and 20% ($n = 20$) whilst standing. Seventeen per cent ($n = 17$) of patients appeared in both groups indicating that patients do not necessarily have shoes that fit their feet in a seated and a standing position.

The significance of ill-fitting shoes with neuropathy and absent pulses was also assessed on each foot whilst seated and standing using chi-squared tests. No association with these two factors and ill-fitting shoes was demonstrated.

## Discussion

This study demonstrates that two-thirds of patients with diabetes were wearing shoes that were of an incorrect size for their feet (interestingly, almost a third of patients when asked their shoe size were wearing shoes that did not match this value). The reasons may be plentiful. It is likely that adults do not get their feet measured on a regular basis, but remember their shoe size from when it was measured a long-time ago and subsequently purchase a shoe size that had previously fitted them without realising that their feet may have changed in size and shape (13). Foot size should always be checked properly prior to shoe purchase (3). Fashion issues may also be a factor. Some patients did state that they purchase differing shoe sizes on different occasions. This is particularly problematic for patients with diabetes, especially those with neuropathy. Standardisation of shoe sizes among shoe manufacturers would be helpful.

Many manufacturers do not make half sizes, nor do they make shoes of varying widths. One study identified that patients have to buy longer shoes to get the width fitting they require to accommodate their feet (13). Broader footwear is required if foot injuries from ill-fitting footwear is to be avoided, especially in patients with diabetes (3).

Our results also demonstrate that shoe size and shape change whilst going from a seated to a standing position. The reason behind this is that when someone is seated, not all of their body weight is acting at the feet. When they transfer to a standing position all body mass and gravity act downwards on the foot. This flattens the arches of the foot and the foot adopts a wider and a longer base (14). On average, we show that foot length increased by up to half a size. This may also contribute to ill-fitting shoes but we cannot be certain as the measuring devices used in this study were calibrated for measurement in the seated position only. This may be more pronounced in patients with diabetic neuropathy and is certainly more important in such patients.

When the width of the foot was measured and compared with the internal dimensions of the shoe, large differences were noted. This was often evident by observing metatarsal heads bulging at the surface of the shoe. Patients may not see this if their visual acuity is reduced, or they may not feel this if there is evidence of neuropathy. Approximately half of individuals assessed owned shoes that were of incorrect width. This agrees with earlier reports, that patients have difficulties in finding shoes of differing widths (13).

Interestingly, in this study, patients with neuropathy or absent foot pulses were just as likely to wear ill-fitting shoes than those with no neuropathy and palpable pedal pulses. However, this group of patients had no experience of previous foot problems. If patients had been selected from specialist diabetic foot clinics, it is anticipated that these patients would receive more attention about their footwear, and be wearing better fitting shoes.

It has been noted that patients with neuropathy purchase shoes that are too small for their feet. The

tight fit may make them perceive that the shoe is a correct and comfortable fit, but putting them at risk of ulceration (4,15). If neuropathy coexists with peripheral vascular disease, tight shoes may be even more problematic because of impaired healing potential.

Education and daily inspection of feet is essential to patients with diabetes. Difficulties with visual acuity, immobility (2) obesity and cognitive impairment may present difficulties in doing this (4). Further education is required for our patients as 44% ($n = 44$) of all patients and 20% ($n = 5$) of neuropathic patients still do not check their feet even weekly. However, patients with neuropathy were more likely to be checking their feet for problems, reflecting some benefit of foot education in such patients.

There were, however, a number of limitations within this study. First, the shoes that patients were wearing as they arrived at the clinic were assumed to be the normal shoes that the patients wore which may or may not be the case. However, it is important to mention, that patients were approached for the study as they arrived at the diabetic clinic. Patients were not previously aware of the study and therefore did not have the opportunity to change their footwear.

The study was hampered by the lack of standardisation given to shoe sizes. Shoes made by different manufacturers have different properties and hence, different characteristics. It should be noted that some patients may have to vary their shoe size according to the make of shoe that they buy. This has obvious implications for patients with diabetes. For this study we managed to circumvent this by using the measuring stick calibrated for measuring shoe sizes.

Standard foot measurements may not be sensitive enough for the requirements of many patients with diabetes especially if 'half' sizes are not used. If so, then referral to orthotic specialists should be considered. However, for the majority of patients, basic foot measurements are likely to help patients identify better fitting shoes than at present.

The assessment of foot dimensions took < 5 min, but slightly longer if a neurovascular assessment was also included. This highlights the issue that footwear could be assessed routinely in a diabetic review appointment to reduce the risk of patients wearing ill-fitting shoes. Particularly those patients with neurovascular risk factors.

To conclude, the majority of patients with diabetes wear inappropriately fitting shoes, most commonly shoes which are too narrow. Further research could show if this was improved by visits to specialist foot clinics. Patients with diabetes should have both their feet and footwear checked on a regular basis. The importance of good-fitting shoes needs to be highlighted with patients and wholesalers, to avoid the risk of foot ulceration and avoid the inappropriate purchase of potentially expensive footwear.

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