

Appendix Document

S.19 Calculation Algorithm/Measure Logic Diagram

$$\frac{A \text{ (\# of patients meeting numerator criteria)}}{PD \text{ (\# patients in denominator)} - C \text{ (\# patients with valid denominator exclusions)}}$$

S.25 Data Source or Collection Instrument

DATA COLLECTION TOOL

To assist with the data collection at each physician practice site, an On-Site Adjudication Tool (OSAT) was developed by Telligen. The tool was customized to capture the data elements for Evaluation of Footwear and Neurological Evaluation performance measures. In addition to assisting the auditor with verification of age, diabetes mellitus, and history of bilateral foot/leg amputation, the tool provided the ability to capture location of documentation for each individual data element. Upon completion of abstraction at each on-site visit, the auditors performed back-up onto an encrypted flash drive. At the completion of the audit, the case results were exported from the tool and analyzed. No patient or physician identifiable information was captured. The tool provided the ability to enter data for a maximum of 100 cases per practice site.

OSAT was developed using the Product Designer Module. The module is used to compose abstraction resource files which define abstraction components. The module allows for unique project creation, while tailoring features to each customer's needs. Questions, answers, and measures are added as defined by the project. In addition, the tool is sophisticated enough to allow for the creation of skip, edit, and measure logic, based on the needs of the project. Skip logic defines rules for enabling questions based on defined patterns. Edit logic defines validations to be performed on answers provided by users of the tool. During the design phase, functionality tests were conducted with ongoing abstractor recommendations being incorporated into the application. Once the design functionality was complete, an OSAT build was created and tested to ensure readiness for field use.

1b.3 If no or limited performance data on the measure as specified is reported in 1b2

**Table 2. Measure #127 (NQF 0416):
Diabetes Mellitus: Diabetic Foot and
Ankle Care, Ulcer Prevention –
Evaluation of Footwear**

CPT	Description	2011	2012	N	%
		N	%		
Denom	All continuously enrolled patients aged 18 years and older with a diagnosis of diabetes mellitus	907,810		798,722	
Num	Patients who were evaluated for proper footwear and sizing at least once within 12 months	6,175	0.68%	7,792	0.86%
G8410	Footwear Evaluation Performed	5,494	0.61%	7,046	0.78%
G8416	Footwear Evaluation not Performed for Documented Reasons	94	0.01%	120	0.01%
G8415	Footwear Evaluation not Performed	890	0.10%	913	0.10%

APPENDIX

2011 Reporting Experience
Including Trends (2008-2012)
Physician Quality Reporting System

Table A22. Eligible Professional (EP) Eligibility and Participation Information by Individual Measure for the Physician Quality Reporting System (2008 to 2011)

Measure Number	Measure Description	EPs in 2008	EPs in 2009	EPs in 2010	EPs in 2011	Reporting Rate in 2008	Reporting Rate in 2009	Reporting Rate in 2010	Reporting Rate in 2011
116	Antibiotic Treatment for Adults with Acute Bronchitis: Avoidance of Inappropriate Use	98,563	99,564	98,605	100,215	0.2%	0.3%	0.4%	0.4%
117	Diabetes Mellitus: Dilated Eye Exam in Diabetic Patient	320,355	326,026	340,041	347,761	2.3%	4.0%	4.3%	5.2%
118	Coronary Artery Disease (CAD): Angiotensin-Converting Enzyme (ACE) Inhibitor or Angiotensin Receptor Blocker (ARB) Therapy for Patients with CAD and Diabetes and/or Left Ventricular Systolic Dysfunction (LVSD) ^{A, b}	215,770	222,374	1,751	2,266	0.7%	1.7%	100.0%	96.6%
119	Diabetes Mellitus: Urine Screening for Microalbumin or Medical Attention for Nephropathy in Diabetic Patients	321,407	311,093	325,839	332,508	1.5%	3.0%	3.1%	3.7%
121	Chronic Kidney Disease (CKD): Laboratory Testing (Calcium, Phosphorus, Intact Parathyroid Hormone (iPTH) and Lipid Profile)	37,451	46,392	53,494	61,611	0.7%	3.2%	4.4%	3.7%
122	Chronic Kidney Disease (CKD): Blood Pressure Management	37,452	46,295	53,335	61,449	1.2%	3.1%	4.3%	3.4%
123	Chronic Kidney Disease (CKD): Plan of Care – Elevated Hemoglobin for Patients Receiving Erythropoiesis-Stimulating Agents (ESA)	37,450	46,026	52,359	60,684	0.9%	1.6%	1.2%	0.9%
124	Health Information Technology (HIT): Adoption/Use of Electronic Health Records (EHR)	735,245	758,066	761,891	781,820	1.7%	5.0%	6.9%	9.1%
126	Diabetes Mellitus: Diabetic Foot and Ankle Care, Peripheral Neuropathy – Neurological Evaluation	317,190	357,891	338,908	345,501	0.4%	0.8%	1.0%	1.4%
127	Diabetes Mellitus: Diabetic Foot and Ankle Care, Ulcer Prevention – Evaluation of Footwear	317,155	357,851	338,907	345,497	0.2%	0.6%	0.7%	1.0%
128	Preventive Care and Screening: Body Mass Index (BMI) Screening and Follow-Up	732,278	782,405	704,404	722,617	0.3%	1.1%	1.3%	2.7%
130	Documentation and Verification of Current Medications in the Medical Record	265,808	768,837	691,221	710,120	0.7%	2.1%	3.4%	6.2%

Table A24. Eligible Professional (EP) Individual Measure Reporting Consistency Across Program Years for the Physician Quality Reporting System (2008 to 2011)

Measure Number	Measure Description	Participating EPs Reporting Individually 2008 to 2011 ^a	Participating EPs Reporting Individually 2009 to 2011 ^a	Participating EPs Reporting Individually 2010 to 2011 ^a	Participating EPs Reporting Individually 2011 Only ^a	Average Number of Years EPs Reported the Measure ^b	Standard Deviation for Average Number of Years EPs Reported the Measure ^b
119	Diabetes Mellitus: Urine Screening for Microalbumin or Medical Attention for Nephropathy in Diabetic Patients	1,476	2,416	2,484	5,414	2.00	1.08
121	Chronic Kidney Disease (CKD): Laboratory Testing (Calcium, Phosphorus, Intact Parathyroid Hormone (iPTH) and Lipid Profile)	94	540	783	827	1.96	0.88
122	Chronic Kidney Disease (CKD): Blood Pressure Management	128	518	628	795	1.99	0.94
123	Chronic Kidney Disease (CKD): Plan of Care – Elevated Hemoglobin for Patients Receiving Erythropoiesis-Stimulating Agents (ESA)	72	128	110	225	2.09	1.09
124	Health Information Technology (HIT): Adoption/Use of Electronic Health Records (EHR)	5,611	15,576	17,301	31,496	1.93	0.99
126	Diabetes Mellitus: Diabetic Foot and Ankle Care, Peripheral Neuropathy – Neurological Evaluation	147	629	1,158	2,675	1.62	0.84
127	Diabetes Mellitus: Diabetic Foot and Ankle Care, Ulcer Prevention – Evaluation of Footwear	83	488	669	2,230	1.55	0.82
128	Preventive Care and Screening: Body Mass Index (BMI) Screening and Follow-Up	754	2,160	3,024	13,380	1.50	0.84
130	Documentation and Verification of Current Medications in the Medical Record	730	6,334	9,564	26,706	1.56	0.80
131	Pain Assessment Prior to Initiation of Patient Therapy and Follow-Up	1,572	1,569	1,511	3,078	2.21	1.17
134	Screening for Clinical Depression and Follow-Up Plan	42	139	230	328	1.86	0.92
135	Chronic Kidney Disease (CKD): Influenza Immunization	n/a	55	30	176	1.54	0.82

Table A28. Percent of Eligible Professionals who Participated and had at Least a 90 Percent Performance Rate by Individual Measures for the Physician Quality Reporting System (2011)

Measure Number	Measure Description	Percent of Eligible Professionals Who Had a Performance Rate of At Least 90 Percent
100	Colorectal Cancer Resection Pathology Reporting: pT Category (Primary Tumor) and pN Category (Regional Lymph Nodes) with Histologic Grade	93.1%
102	Prostate Cancer: Avoidance of Overuse of Bone Scan for Staging Low-Risk Prostate Cancer Patients	55.6%
104	Prostate Cancer: Adjuvant Hormonal Therapy for High-Risk Prostate Cancer Patients	69.1%
105	Prostate Cancer: Three-Dimensional (3D) Radiotherapy	94.1%
106	Major Depressive Disorder (MDD): Diagnostic Evaluation	73.1%
107	Major Depressive Disorder (MDD): Suicide Risk Assessment	78.0%
108	Rheumatoid Arthritis (RA): Disease Modifying Anti-Rheumatic Drug (DMARD) Therapy	55.7%
109	Osteoarthritis (OA): Function and Pain Assessment	69.4%
110	Preventive Care and Screening: Influenza Immunization for Patients \geq 50 Years Old	19.5%
111	Preventive Care and Screening: Pneumonia Vaccination for Patients 65 Years and Older	24.0%
112	Preventive Care and Screening: Screening Mammography	23.0%
113	Preventive Care and Screening: Colorectal Cancer Screening	24.7%
116	Antibiotic Treatment for Adults with Acute Bronchitis: Avoidance of Inappropriate Use	26.0%
117	Diabetes Mellitus: Dilated Eye Exam in Diabetic Patient	72.3%
118	Coronary Artery Disease (CAD): Angiotensin-Converting Enzyme (ACE) Inhibitor or Angiotensin Receptor Blocker (ARB) Therapy for Patients with CAD and Diabetes and/or Left Ventricular Systolic Dysfunction (LVSD) ^{a,b}	28.1%
119	Diabetes Mellitus: Urine Screening for Microalbumin or Medical Attention for Nephropathy in Diabetic Patients	46.5%
121	Chronic Kidney Disease (CKD): Laboratory Testing (Calcium, Phosphorus, Intact Parathyroid Hormone (iPTH) and Lipid Profile)	31.0%
122	Chronic Kidney Disease (CKD): Blood Pressure Management	45.5%
123	Chronic Kidney Disease (CKD): Plan of Care - Elevated Hemoglobin for Patients Receiving Erythropoiesis-Stimulating Agents (ESA)	73.8%
124	Health Information Technology (HIT): Adoption/Use of Electronic Health Records (EHR)	98.5%
126	Diabetes Mellitus: Diabetic Foot and Ankle Care, Peripheral Neuropathy – Neurological Evaluation	74.0%
127	Diabetes Mellitus: Diabetic Foot and Ankle Care, Ulcer Prevention – Evaluation of Footwear	63.2%
128	Preventive Care and Screening: Body Mass Index (BMI) Screening and Follow-Up	33.7%

Table A13. Submission Information for Individual Measures Submitted through the Claims Mechanism for the Physician Quality Reporting System (2011)

Measure Number	Measure Description	Eligible Professionals	Eligible Professionals who Reported ≥ 1 Valid QDC	% of Eligible Professionals who Reported ≥ 1 Valid QDC	Eligible Professionals who Satisfactorily Reported	% of Eligible Professionals who Satisfactorily Reported	Average Reporting Rate per Eligible Professional
122	Chronic Kidney Disease (CKD): Blood Pressure Management	60,681	800	1.3%	376	47.0%	46.8%
123	Chronic Kidney Disease (CKD): Plan of Care - Elevated Hemoglobin for Patients Receiving Erythropoiesis - Stimulating Agents (ESA)	60,681	469	0.8%	201	42.9%	42.0%
124	Health Information Technology (HIT): Adoption/Use of Electronic Health Records (EHR)	779,813	45,845	5.9%	31,328	68.3%	59.9%
126	Diabetes Mellitus: Diabetic Foot and Ankle Care, Peripheral Neuropathy – Neurological Evaluation	345,383	3,923	1.1%	1,837	46.8%	41.9%
127	Diabetes Mellitus: Diabetic Foot and Ankle Care, Ulcer Prevention – Evaluation of Footwear	345,383	2,674	0.8%	1,027	38.4%	39.3%
128	Preventive Care and Screening: Body Mass Index (BMI) Screening and Follow-Up	721,678	11,529	1.6%	4,835	41.9%	35.7%
130	Documentation of Current Medications in the Medical Record	709,286	29,740	4.2%	17,761	59.7%	50.9%
131	Pain Assessment Prior to Initiation of Patient Therapy and Follow-Up	177,480	7,632	4.3%	5,979	78.3%	64.9%
134	Screening for Clinical Depression and Follow-Up Plan	120,626	744	0.6%	623	83.7%	74.3%
135	Chronic Kidney Disease (CKD): Influenza Immunization	45,120	155	0.3%	93	60.0%	52.1%
140	Age-Related Macular Degeneration (AMD): Counseling on Antioxidant Supplement	75,887	9,174	12.1%	6,186	67.4%	71.2%
141	Primary Open-Angle Glaucoma (POAG): Reduction of Intraocular Pressure (IOP) by 15% OR Documentation of a Plan of Care	45,599	5,226	11.5%	3,294	63.0%	63.5%
142	Osteoarthritis (OA): Assessment for Use of Anti-Inflammatory or Analgesic Over-the-Counter (OTC) Medications	218,838	1,899	0.9%	738	38.9%	38.4%

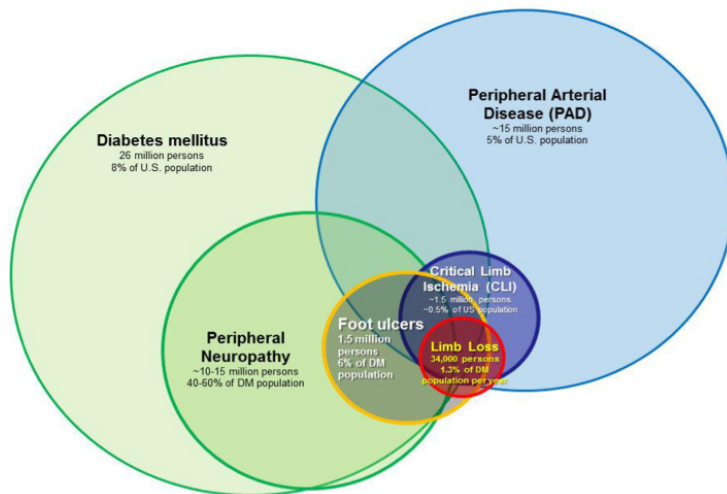
Table A23. Reporting and Performance Information by Individual Measure for the Physician Quality Reporting System (2008 to 2011)

Measure Number	Measure Description	Average Percent of Instances Reported in 2008	Average Percent of Instances Reported in 2009	Average Percent of Instances Reported in 2010	Average Percent of Instances Reported in 2011	Average Performance Rate in 2008	Average Performance Rate in 2009	Average Performance Rate in 2010	Average Performance Rate in 2011
121	Chronic Kidney Disease (CKD): Laboratory Testing (Calcium, Phosphorus, Intact Parathyroid Hormone (iPTH) and Lipid Profile)	56.2%	84.7%	89.3%	87.1%	75.4%	35.2%	40.0%	45.3%
122	Chronic Kidney Disease (CKD): Blood Pressure Management	61.4%	78.9%	84.3%	80.1%	83.0%	68.9%	58.2%	65.6%
123	Chronic Kidney Disease (CKD): Plan of Care – Elevated Hemoglobin for Patients Receiving Erythropoiesis-Stimulating Agents (ESA)	56.0%	61.0%	54.1%	53.6%	82.0%	96.0%	94.8%	95.0%
124	Health Information Technology (HIT): Adoption/Use of Electronic Health Records (EHR)	65.3%	74.9%	78.5%	78.0%	100.0%	99.1%	99.2%	98.9%
126	Diabetes Mellitus: Diabetic Foot and Ankle Care, Peripheral Neuropathy – Neurological Evaluation	58.3%	66.2%	59.5%	55.0%	63.0%	52.8%	74.2%	86.6%
127	Diabetes Mellitus: Diabetic Foot and Ankle Care, Ulcer Prevention – Evaluation of Footwear	60.9%	67.3%	54.7%	53.3%	48.0%	43.9%	66.9%	69.2%
128	Preventive Care and Screening: Body Mass Index (BMI) Screening and Follow-Up	49.8%	54.5%	55.0%	65.5%	55.9%	49.6%	60.2%	58.3%
130	Documentation and Verification of Current Medications in the Medical Record	56.3%	69.9%	69.2%	70.5%	79.7%	68.4%	74.7%	85.7%
131	Pain Assessment Prior to Initiation of Patient Therapy and Follow-Up	63.1%	65.6%	73.5%	73.6%	98.1%	97.4%	97.3%	94.8%
134	Screening for Clinical Depression and Follow-Up Plan	54.4%	64.3%	73.0%	79.5%	83.4%	67.2%	84.2%	82.6%

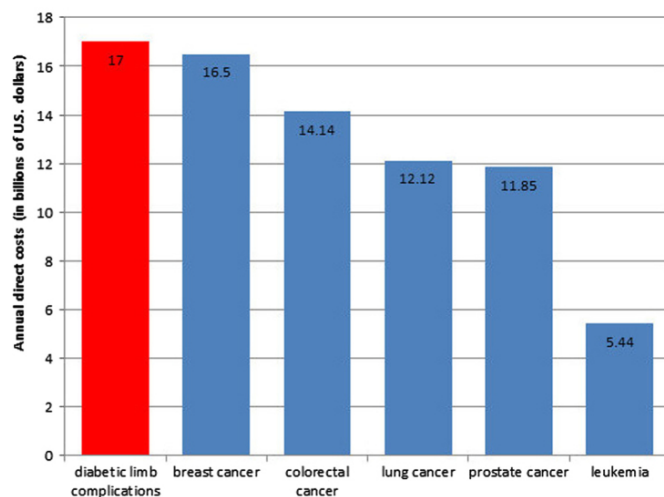
Table A25. Individual Measure Performance Information Among Eligible Professionals who Participated Continuously in the Measure for Four Years for the Physician Quality Reporting System (2008 to 2011)

Measure Number	Measure Description	Eligible Professionals (EPs) who Reported the Measure Four Years Continuously*	Average Performance Rate per EP in 2008	Average Performance Rate per EP in 2009	Average Performance Rate per EP in 2010	Average Performance Rate per EP in 2011	Growth Rate
118	Coronary Artery Disease (CAD): Angiotensin-Converting Enzyme (ACE) Inhibitor or Angiotensin Receptor Blocker (ARB) Therapy for Patients with CAD and Diabetes and/or Left Ventricular Systolic Dysfunction (LVSD) ^{a,b}	71	87.5%	96.1%	83.2%	80.3%	-2.8%
119	Diabetes Mellitus: Urine Screening for Microalbumin or Medical Attention for Nephropathy in Diabetic Patients	1,476	69.0%	76.2%	79.8%	82.4%	6.1%
121	Chronic Kidney Disease (CKD): Laboratory Testing (Calcium, Phosphorus, Intact Parathyroid Hormone (iPTH) and Lipid Profile)	94	89.9%	74.6%	72.0%	69.6%	-8.2%
122	Chronic Kidney Disease (CKD): Blood Pressure Management	128	88.4%	94.5%	94.3%	93.8%	2.0%
123	Chronic Kidney Disease (CKD): Plan of Care - Elevated Hemoglobin for Patients Receiving Erythropoiesis - Stimulating Agents (ESA)	72	81.9%	97.3%	98.0%	96.3%	5.5%
124	Health Information Technology (HIT): Adoption/Use of Electronic Health Records (EHR)	5,611	100.0%	99.9%	99.9%	99.4%	-0.2%
126	Diabetes Mellitus: Diabetic Foot and Ankle Care, Peripheral Neuropathy – Neurological Evaluation	147	83.2%	89.0%	87.5%	88.9%	2.2%
127	Diabetes Mellitus: Diabetic Foot and Ankle Care, Ulcer Prevention – Evaluation of Footwear	83	81.6%	79.1%	74.0%	82.9%	0.6%
128	Preventive Care and Screening: Body Mass Index (BMI) Screening and Follow-Up	754	55.8%	58.5%	62.7%	64.8%	5.1%
130	Documentation of Current Medications in the Medical Record	730	85.1%	83.2%	85.7%	88.5%	1.3%
131	Pain Assessment Prior to Initiation of Patient Therapy and Follow-Up	1,572	99.1%	98.8%	98.4%	97.7%	-0.5%

1c.3 Provide epidemiologic or resource use data that demonstrates the measure addresses a high priority aspect of healthcare).



Diabetes and subsequent foot complications affect incredibly high numbers of people. Ulcerations secondary to neuropathy and poor fitting footwear is a leading cause to infections, hospitalizations and amputations. The cost in both money and quality of life for the person with diabetes who develops an ulceration that leads to an amputation is staggering. The five year survival rate for a person with diabetes that undergoes an amputation is less than many forms of cancer.



The system of care for the diabetic foot: objectives, outcomes, and opportunities Neal R. Barshes, MD, MPH^{1*}, Meena Sigireddi, MPH², James S. Wrobel, DPM, MS³, Archana Mahankali, MD⁴, Jeffrey M. Robbins, DPM⁵, Panos Kougiyas, MD¹ and David G. Armstrong, DPM, MD, PhD⁶

4a.1 . For each CURRENT use, checked above, provide:

- Name of program and sponsor
- Purpose
- Geographic area and number and percentage of accountable entities and patients included

Quality Measures in Wound Care

US Wound Registry Measures for Reporting

<http://www.uswoundregistry.com/Specifications.aspx>

PQRS Measure #127, NQF #0416	Diabetes Mellitus: Diabetic Foot and Ankle Care, Ulcer Prevention – Evaluation of Footwear			
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Do US Veterans Wear Appropriately Sized Shoes?

The Veterans Affairs Shoe Size Selection Study

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Poorly fitting footwear has frequently been cited as an etiologic factor in the pathway to diabetic foot ulceration. However, we are unaware of any reports in the medical literature specifically measuring shoe size *versus* foot size in this high-risk population. We assessed the prevalence of poorly fitting footwear in individuals with and without diabetic foot ulceration. We evaluated the shoe size of 440 consecutive patients (94.1% male; mean \pm SD age, 67.2 \pm 12.5 years) presenting to an interdisciplinary teaching clinic. Of this population, 58.4% were diagnosed as having diabetes, and 6.8% had active diabetic foot ulceration. Only 25.5% of the patients were wearing appropriately sized shoes. Individuals with diabetic foot ulceration were 5.1 times more likely to have poorly fitting shoes than those without a wound (93.3% *versus* 73.2%; odds ratio [OR], 5.1; 95% confidence interval [CI], 1.2–21.9; $P = .02$). This association was also evident when assessing only the 32.3% of the total population with diabetes and loss of protective sensation (93.3% *versus* 75.0%; OR, 4.8; 95% CI, 1.1–20.9; $P = .04$). Poorly fitting shoes seem to be more prevalent in people with diabetic foot wounds than in those without wounds with or without peripheral neuropathy. This implies that appropriate meticulous screening for shoe-foot mismatches may be useful in reducing the risk of lower-extremity ulceration. (J Am Podiatr Med Assoc 96(4): 290-292, 2006)

Diabetic foot ulcerations are among the most common severe complications of diabetes mellitus. Approximately one-quarter of all hospital days for patients with diabetes are related to foot complications.¹⁻³ In

the United States, 45% to 83% of all lower-extremity amputations involve diabetes.⁴⁻⁷ Overall, patients with diabetes are 15 to 46 times more likely to undergo amputation than patients without diabetes.^{5, 8-10}

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The cost of healing an ulcer is conservatively estimated to be \$7,000 to \$45,000.¹¹ Lower-extremity complications in patients with diabetes are common, costly, and associated with high rates of recurrence, morbidity, and mortality, and the prevention of foot ulcers should be considered a major public health goal.

Ulcers form in people with diabetes because of a lack of sensation (neuropathy), coupled with repetitive pressure forces (walking). One of the central tenets of reducing the incidence of ulcers is pressure reduction through the use of appropriate shoes and insoles. Only a few studies in the existing scientific literature address improper shoe fit. Poorly fitting shoes may account for the development of a sizable proportion of foot ulcers^{5, 8, 9} in the diabetic population and may be the source of a host of maladies in individuals at lower risk (without diabetes). Some authors have provided evidence of such a problem in the elderly population. It has also been suggested that inappropriate footwear accounts for 50% of overuse injuries among military recruits.^{12, 13} We are unaware of the prevalence of foot-shoe mismatches in US veterans. In this study, we assessed how likely it is that a US veteran with or without diabetes, with or without foot wounds, and with or without neuropathy wears a correctly sized pair of shoes.

Materials and Methods

This prospective study was performed at a large, urban, referral-based foot clinic at Southern Arizona Veterans Affairs Medical Center. We enrolled 440 consecutive patients, all US veterans, in the study. Information obtained from the subjects included shoe size and width, sex, presence or absence of diabetes, presence or absence of neuropathy, presence or absence of foot wound, and type and condition of the shoes usually worn. Actual foot size and width were measured using a standardized method and the Apex 1141 "Ritz stick" (Aetrex, Teaneck, New Jersey) foot-measuring device.^{12, 13} Each investigator in this study received identical training in use of the Apex 1141 foot-measuring device by one of us (B.P.N.), a certified pedorthist. Inappropriately sized footwear was defined as a shoe size at least one full size too large or too small using the aforementioned measuring device and clinical examination. Neuropathy was defined as the inability to sense the 10-g Semmes-Weinstein monofilament or a vibration perception threshold greater than 25 V.¹⁴⁻¹⁶ Individuals who could not walk without the aid of a walker or wheelchair were excluded. The foot was also inspected for the presence of any ulcerations defined as at least grade 1A using the University of Texas system.^{12, 13} All of the results

are expressed as mean \pm SD. Dichotomous variables were evaluated using a χ^2 test, with odds ratio (OR) and 95% confidence interval (CI). For all of the measures, α was set at 5%.¹⁷

Results

Of the 440 consecutive subjects enrolled in this study, 94.1% were men (mean \pm SD age, 67.2 \pm 12.5 years). Of this population, 58.4% were diagnosed as having diabetes, and 6.8% had active diabetic foot ulceration. For the entire population, only 25.5% of the patients were wearing appropriately sized shoes. Patients with diabetic foot ulceration were 5.1 times more likely to have poorly fitting shoes than were those without a wound (93.3% *versus* 73.2%; OR, 5.1; 95% CI, 1.2-21.9; $P = .02$). This association was also evident when assessing only the 32.3% of the total population with diabetes and loss of protective sensation (93.3% *versus* 75.0%; OR, 4.8; 95% CI, 1.1-20.9; $P = .04$).

Discussion

Diabetic foot ulcerations are among the most common severe complications of diabetes. Ulcers form in patients with diabetes because of a lack of sensation (neuropathy), coupled with repetitive pressure forces (walking). One of the central tenets in reducing the incidence of ulcers is pressure reduction through the use of appropriate shoes and insoles. Poorly fitting shoes may account for a large proportion of diabetic foot ulcers^{5, 8, 9} and may also play a role in creating or exacerbating other complications in people without diabetes.

The importance of wearing correctly sized shoes is obvious, especially for those who are at risk for foot infection and possible loss of limb. However, judging by the results of the few studies performed on this topic, choosing appropriately sized shoes is still problematic. This clearly highlights the importance of a coordinated effort to help patients and their providers become more knowledgeable about fitting shoes. The results of the present study confirm this, particularly for individuals at highest risk for pathologic abnormalities.

A 1995 study by Uccioli and coworkers¹⁸ suggested that custom-made shoes were very effective in preventing ulcerations in the diabetic population, but many people do not have access to or the financial means to acquire such shoes. Other authors^{19, 20} have noted that over-the-counter or minimally modified shoes have pressure-relieving ability equivalent to that of custom-made shoes and (if able to be fitted

adequately to the foot) should theoretically provide similar protection and accommodation.

According to Rossi,²¹ it is important to fit the longer foot, because 70% of men and women have one foot that is longer than the other. This is evident in the study by Kusumoto and Ashizawa,²² which noted that only 33% of the subjects had equal right-left foot length. In addition, only 8% or fewer students in the study wore correctly sized shoes, which is even lower than in the study by Burns et al,¹² in which 28% of the elderly population used the correct shoe size. However, in the same study, none of the patients with diabetes were wearing shoes of the correct size. The present study confirms these previously reported trends. In the present study, patients with diabetic foot ulceration were 5.1 times more likely to have poorly fitting shoes than those without a wound. It is understandable that no two feet are alike and that it is almost impossible for a patient with loss of sensation to make a correct decision as to whether a shoe is too tight or too loose. Therefore, we suggest that when choosing shoes, this population be meticulously fitted by an experienced professional.

A host of factors are involved in selecting an appropriately (or inappropriately) sized shoe. The present study measured only the most obvious. Heel-to-toe, heel-to-ball, width, and volumetric dimensions are at least as important. However, we intended to identify the prevalence of poor fit with the most basic assessment of shoe-foot size in a large patient population. We hope that further work in this area will evaluate the prevalence of poor fit when using these and additional measurements.

Conclusion

Many people presenting for foot care in this study were wearing incorrectly sized shoes. This was especially true for individuals who already had diabetic foot wounds. Greater accuracy in the shoe-foot match can be useful in reducing the risk of foot ulceration. Educating consumers, shoe store sales personnel, and health-care professionals in proper shoe-fitting techniques can be beneficial to all of the parties involved in this therapeutic relationship.

References

- SMITH D, WEINBERGER M, KATZ B: A controlled trial to increase office visits and reduce hospitalization in diabetic patients. *J Gen Intern Med* **2**: 232, 1987.
- GIBBONS G, ELIOPOULOS GM: "Infection of the Diabetic Foot," in *Management of Diabetic Foot Problems*, ed by GP Kozak, CS Hoar, JL Rowbotham, p 97, WB Saunders, Philadelphia, 1984.
- BLOCK P: The diabetic foot ulcer: a complex problem with a simple treatment approach. *Mil Med* **146**: 644, 1981.
- NATIONAL DIABETES ADVISORY BOARD: *The National Long-Range Plan to Combat Diabetes*, p 88, National Institutes of Health, Bethesda, MD, 1987.
- MOST RS, SINNOCK P: The epidemiology of lower extremity amputations in diabetic individuals. *Diabetes Care* **6**: 87, 1983.
- VAN HOUTUM WH, RAUWERDA JA, RUWAARD D, ET AL: Reduction in diabetes-related lower-extremity amputations in the Netherlands: 1991-2000. *Diabetes Care* **27**: 1042, 2004.
- VAN HOUTUM WH, LAVERY LA: Regional variation in the incidence of diabetes-related amputations in The Netherlands. *Diabetes Res Clin Pract* **31**: 125, 1996.
- LAVERY LA, VAN HOUTUM WH, ASHRY HR, ET AL: Diabetes-related lower-extremity amputations disproportionately affect Blacks and Mexican Americans. *South Med J* **92**: 593, 1999.
- ARMSTRONG DG, LAVERY LA, VAN HOUTUM WH, ET AL: Seasonal variations in lower extremity amputation. *J Foot Ankle Surg* **36**: 146, 1997.
- REIBER GE: The epidemiology of diabetic foot problems. *Diabet Med* **13** (suppl 1): S6, 1996.
- ARMSTRONG DG: Is diabetic foot care efficacious or cost-effective? *Ostomy Wound Manage* **47**: 28, 2001.
- BURNS SL, LEESE GP, MCMURDO ME: Older people and ill-fitting shoes. *Postgrad Med* **78**: 344, 2002.
- CHANTELAU E, GEDE A: Foot dimensions of elderly people with and without diabetes mellitus: a data basis for shoe design. *Gerontology* **48**: 241, 2002.
- ARMSTRONG DG, LAVERY LA, VELA SA, ET AL: Choosing a practical screening instrument to identify patients at risk for diabetic foot ulceration. *Arch Intern Med* **158**: 289, 1998.
- YOUNG MJ, BREDDY JL, VEVES A, ET AL: The prediction of diabetic neuropathic foot ulceration using vibration perception thresholds: a prospective study. *Diabetes Care* **17**: 557, 1994.
- YOUNG MJ, BOULTON AJ, MACLEOD AF, ET AL: A multicentre study of the prevalence of diabetic peripheral neuropathy in the United Kingdom hospital clinic population. *Diabetologia* **36**: 150, 1993.
- KIRKWOOD BR: *Essentials of Medical Statistics*, Blackwell, Oxford, 1988.
- UCCIOLI L, FAGLIA E, MONTICONE G, ET AL: Manufactured shoes in the prevention of diabetic foot ulcers. *Diabetes Care* **18**: 1376, 1995.
- LAVERY LA, VELA SA, FLEISCHLI JG, ET AL: Reducing plantar pressure in the neuropathic foot: a comparison of footwear. *Diabetes Care* **20**: 1706, 1997.
- PERRY JE, ULBRECHT JS, DERR JA, ET AL: The use of running shoes to reduce plantar pressures in patients who have diabetes. *J Bone Joint Surg Am* **77**: 1819, 1995.
- ROSSI W: The high incidence of mismated feet in the population. *Foot Ankle* **4**: 105, 1983.
- KUSUMOTO A, ASHIZAWA K: Foot and shoe size of Japanese female university students. *J Hum Ergol (Tokyo)* **17**: 91, 1988.

ORIGINAL PAPER

Do patients with diabetes wear shoes of the correct size?

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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 \pm 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, <i>n</i> = 100 (%)	No neuropathy, <i>n</i> = 80 (%)	Neuropathy, <i>n</i> = 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).

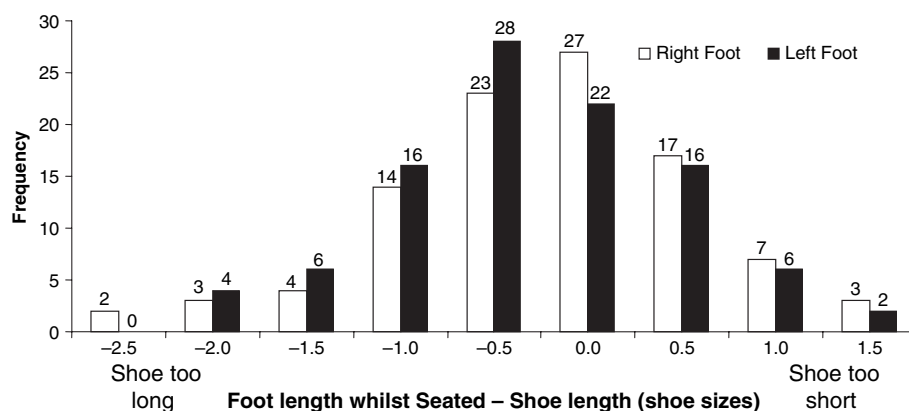
Shoes were deemed incorrect length if they were more than half a size difference as compared with foot size (Figure 1). About 33% of patients were

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

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).

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 (\pm 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)

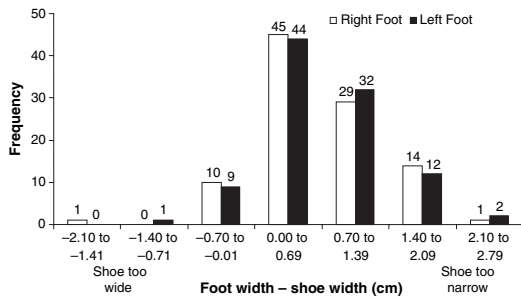


Figure 2 Foot width whilst standing – shoe width (cm)

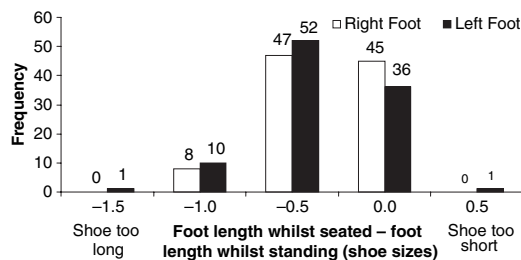


Figure 3 Foot length whilst seated – foot length whilst standing (shoe sizes)

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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References

- 1 Reiber GE. The epidemiology of diabetic foot ulcers. *Diabet Med* 1996; **13** (Suppl. 1): S6–11.
- 2 MacFarlane RM, Jeffcoate WJ. Factors contributing to the presentation of diabetic foot ulcers. *Diabet Med* 1997; **14**: 867–70.
- 3 Reddy PV, Vaid MA, Child DF. Diabetes and incorrectly fitting shoes. *Pract Diabetes* 1989; **6**: 16.
- 4 Mayfield JA, Reiber GE, Sanders LJ, Janisse D, Pogach LM. Preventive foot care in people with diabetes. *Diabetes Care* 1998; **21**: 2161–77.
- 5 Leslie RD, Pozzilli P. *Diabetic Complications*, 1st edn. London: Martin Dunitz, Taylor and Francis Group, copyright 2004, ISBN 1-84184-269-9.
- 6 Manna I, Pradham D, Ghosh S, Kar SK, Dhara P. A comparative study of foot dimensions between adult male and female and evaluation of foot hazards due to using of footwear. *J Physiol Anthropol Appl Human Sci* 2001; **20**: 241–6.
- 7 Tovey FI. The manufacture of diabetic footwear. *Diabet Med* 1984; **1**: 69–71.
- 8 Janisse DJ. The art and science of fitting shoes. *Foot Ankle* 1992; **13**: 257–62.
- 9 Goonetilleke RS. Designing footwear: back to basics in an effort to design for people. *Proceedings of SEAMEC* 2003; 25–31.
- 10 Rossi WA. The high incidence of mismatched feet in the population. *Foot Ankle* 1983; **4**: 105–12 [Abstract].
- 11 Dahmen R, Haspels R, Koomen B, Hoeksma AF. Therapeutic footwear for the neuropathic foot: an algorithm. *Diabetes Care* 2001; **24**: 705–9.
- 12 Hodges D, Kumar VN, Redford JB. Management of the diabetic foot. *Am Fam Physician* 1986; **33**: 189–95.
- 13 Burns SL, Leese GP, McMurdo ME. Older people and ill fitting shoes. *Postgrad Med J* 2002; **78**: 344–6.
- 14 Tsung BY, Zhang M, Fan YB, Boone DA. Quantitative comparison of plantar foot shapes under different weight-bearing conditions. *J Rehabil Res Dev* 2003; **40**: 517–26.
- 15 Knowles EA, Boulton AJM. Do people with diabetes wear their prescribed Footwear. *Diabet Med* 1996; **13**: 1064–9.

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