Hand Syndromes Associated with Diabetes: Impairments and Obesity Predict Disability

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ABSTRACT. ***Objective.*** We determined patterns of disability in diabetic hand conditions and identified factors that contributed to functional limitations.

Methods. Hand assessments were performed on 60 adults with DM1 or DM2 and carpal tunnel syndrome, trigger finger, Dupuytren's disease, or the syndrome of limited joint mobility. The examination included measurement of grip strength, light touch perception, and dexterity, as well as self-reported function using the Disabilities of the Arm, Shoulder and Hand (DASH) instrument and the Medical Outcomes Study Short Form-36 questionnaire. Associations with hand disability were analyzed using correlation and regression.

Results. The most frequent presentation was carpal tunnel syndrome (45%) but it was common for patients to present with clinical features associated with more than one hand syndrome (47%). Overall, women had greater difficulties, with significantly higher DASH scores than men [mean 30.3 (95% CI 23.2, 37.5) vs 18.0 (95% CI 12.1, 23.9), respectively; $p = 0.01$]. Grip strength, dexterity, and obesity were associated with hand disability ($p < 0.05$).

Conclusion. In adults with hand syndromes associated with diabetes, disability was related to impaired muscle function and carpal tunnel syndrome. Obesity and overall physical functioning influenced hand disability, particularly in women. (J Rheumatol First Release Nov 1 2009; doi:10.3899/jrheum.090239)

Key Indexing Terms:
DIABETES MELLITUS · HAND · DISABILITY
GRIP STRENGTH · DEXTERITY · MONOFILAMENT

Adults with diabetes are at increased risk of functional limitations and physical disability that can reduce their quality of life. Research in this area has mainly focused on restricted mobility, but difficulties with activities of daily living, such as "cooking meals," that require a level of hand function have also been documented[1]. Factors associated with physical disability include the personal characteristics of older age and female sex; the diabetic complications of cardiovascular disease, peripheral vascular disease, neuropathy, and visual impairment; the comorbidities of stroke and depression; and obesity[1-10]. A loss of muscle strength, including grip strength, has also been associated with the development of physical disability in diabetes[11,12].

The contribution of the hand syndromes associated with diabetes to limitations of activities of daily living and disability is less clearly understood. Two reports have been published in this area. One showed a relationship between disability of the hand and grip strength, rather than the soft-tissue syndromes[13]. The other showed that reduced sensation of the hand, attributed to neuropathy in longstanding diabetes, was associated with difficulties with activities of daily living[14].

Although the treatments offered for these hand disorders are similar in diabetes as in the general population, there are differences in outcomes[15,16]. Recognizing features of a presentation that may have an influence on outcomes is an important part of clinical assessment. The purpose of our study was to determine patterns of disability in the hand syndromes related to diabetes. In addition, factors associated with reduced hand function in adults with diabetes were evaluated.

MATERIALS AND METHODS

Participants. Sixty adults with type 1 or 2 diabetes were recruited from diabetic and orthopedic outpatient clinics at a public hospital, as well as private rheumatology and orthopedic practices located in Adelaide, South Australia. Criteria for inclusion into the study included men or women aged over 18 years, diagnosed with diabetes and at least one of the related hand disorders: carpal tunnel syndrome, trigger finger, Dupuytren's disease, or the syndrome of limited joint mobility[17-24]. Other diagnoses that would interfere with hand function, including stroke, rheumatoid arthritis, and severe visual impairment, were excluded.

Participants were required to give oral and written informed consent. The institutional ethical committee approved the study.

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Clinical characteristics. An observational cohort study evaluating hand function was conducted. Demographic information and information on hand symptoms were collected by interview. Case records were reviewed to obtain HbA1c levels and a history of neuropathy and nephropathy. Retinopathy was accepted as self-report of laser eye surgery. Body mass index (BMI) was calculated from measured height and weight (kg/m^2).

Hand syndromes were diagnosed from characteristic clinical features[25-27] or prior surgery for the disorder and, for carpal tunnel syndrome, symptoms were confirmed by nerve conduction studies[28].

Self-report instruments. Two questionnaires were used to measure hand disability and health status. The Disabilities of the Arm, Shoulder and Hand (DASH) is a validated questionnaire that measures upper limb symptoms and functional status[29-31]. It includes 30 questions with the option of 5 responses for each question. A score is calculated from 0 to a maximum of 100; higher scores indicated greater disability. Version 2 of the Medical Outcomes Study Short Form-36 (SF-36v2) is a generic health measure that yields 8 scales as well as physical and mental health summary measures[32]. The scales are norm-based around the same average (50) and same standard deviation (10 points).

Tests of hand function. Assessments were performed by 1 investigator. Hand grip strength, light touch perception and the ability to use the fingers with dexterity were measured. Hand grip strength was measured with a calibrated EVAL electrodynamometer (Greenleaf Medical Systems, Palo Alto, CA, USA) using a standardized protocol[33]. Light touch perception was measured with the WEST hand set of monofilaments (Connecticut Bioinstruments, Riverdale, NY, USA). The hand screening protocol measured the lightest of the 5 monofilaments that was felt when applied across 7 sites covering the peripheral nerve supply of the hand[34]. Of the 7 sites, 3 areas were supplied by median and ulnar nerves and 1 area was supplied by the radial nerve (maximum score = 35). The time to complete the Rolyan 9-hole peg test (Homecraft Rolyan, Notts, UK) using a standardized protocol[35] measured finger dexterity. Scores from the dominant hand were used in the analyses.

Data analysis. All scores were tested for normality and the decision to use parametric or nonparametric statistics was based on the distribution of data. Normative data, available for some variables, were used to compare the sample data. As the results of the DASH were skewed, the differences between groups were evaluated with Mann-Whitney U tests and the strength of association was evaluated with Spearman correlation coefficients. Variables hypothesized to be potential mediators of disability were included in stepwise multiple regression models to obtain an optimum set of predictor variables. Significance level was set at $p < 0.05$ for all tests. Statistical analyses were performed with Intercooled Stata 10.0 for Windows (2008, StataCorp, College Station, TX, USA).

RESULTS

Clinical characteristics. Of the 60 participants (34 women, 57%), complete data were available for 59 (98%), as the questionnaires were not completed by 1 participant. The clinical characteristics of the study population are shown in Table 1. Four diagnoses related to the hands in diabetes were represented in both sexes. Twenty-seven participants (45%) had carpal tunnel syndrome, 24 (40%) had trigger finger, 16 (27%) had Dupuytren's disease, and 15 (25%) had limited joint mobility. However, the diagnostic categories were not independent, as it was common for participants to present with more than 1 hand syndrome, as current symptoms or in their history (n = 28, 47%).

Self-report instruments. Levels of hand disability for each hand disorder, as measured by the DASH, are presented in Figure 1. There were no significant differences in disability related to the hand disorder but the influence of gender was apparent. In the study population, women reported more disability, with significantly greater DASH scores than men [mean 30.3 (95% CI 23.2, 37.5) vs 18.0 (95% CI 12.1, 23.9), respectively; p = 0.01].

Poor physical health was characteristic in this diabetic sample. The physical component summary score of the Medical Outcomes Study Short Form-36 (SF-36) was less than expected for age and gender matched norms[32] ($p < 0.05$). The mental component summary score was similar to population normative data. The scales of the SF-36 were not significantly influenced by gender, although there was a borderline difference (p = 0.07) in physical functioning (Table 2). We postulate that this may be a Type 2 error, and that a larger sample size would have demonstrated that

Table 1. Clinical characteristics of men, women, and the total sample. Values are number (%) unless otherwise indicated.

Characteristic	Males, n = 26	Females, n = 34	Total, n = 60
Age, mean (SD), yrs	59.4 (10.7)	62.1 (10.2)	60.9 (10.5)
Body mass index, median (IQR), kg/m^2	29.2 (28.4, 31.5)	29.3 (26.3, 39.1)	29.2 (26.7, 32.9)
Duration of diabetes, median (IQR), yrs	11.5 (7, 22)	16.5 (8, 28)	14.5 (7, 28)
HbA1c, mean (SD)	7.4 (1.3)	7.7 (1.7)	7.6 (1.5)
Type 1 diabetes	6 (23)	9 (26)	15 (25)
Retinopathy	5 (19)	9 (26)	14 (23)
Nephropathy	5 (19)	9 (26)	14 (23)
Neuropathy	1 (4)	4 (12)	5 (8)
Insulin	13 (50)	20 (59)	33 (55)
Carpal tunnel syndrome	9 (35)	18 (53)	27 (45)
Trigger finger	12 (46)	12 (35)	24 (40)
Dupuytren's disease	5 (19)	11 (32)	16 (27)
Limited joint mobility	10 (38)	5 (15)	15 (25)

IQR: interquartile range; HbA1c: glycosylated hemoglobin (%).

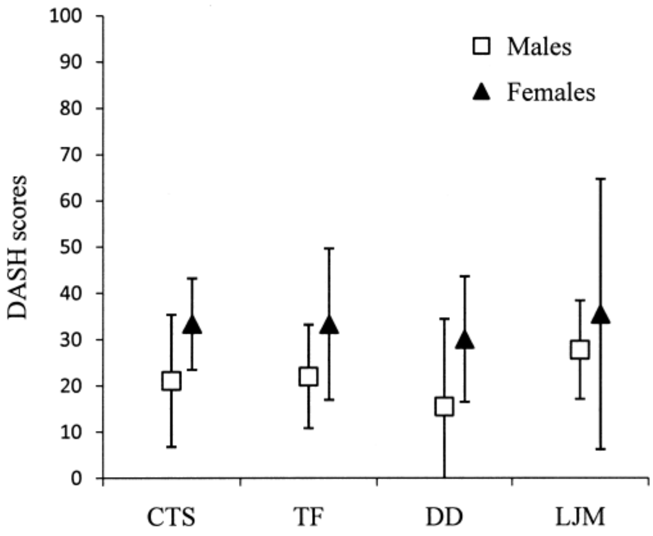

Figure 1. Disability means with 95% CI of males and females for each hand disorder. CTS: carpal tunnel syndrome; TF: trigger finger; DD: Dupuytren's disease; LJM: limited joint mobility.

females have poorer physical function.

Tests of hand function. Reduced grip strength was a characteristic of this sample. Mean grip strength was significantly less than expected for age and gender matched norms[33] (p < 0.05). Gender influenced grip strength. Males had a mean grip strength of 39.1 kg (SD 1.9) and women had a mean of 23.2 kg (SD 1.2), which was significantly less (p < 0.0001).

The sample was also characterized by reduced sensation affecting the hands that was not influenced by gender. Generally, this was a symmetrical finding, with light touch perception of the dominant hand being similar to the nondominant hand (r = 0.83, p < 0.0001). In addition to those with carpal tunnel syndrome, sensation was reduced in participants with a history of carpal tunnel release, peripheral neuropathy affecting the feet, or the syndrome of limited joint mobility. When testing thresholds in impaired sensation, the light touch of the 0.07 g WEST monofilament that denotes normal cannot be felt and the threshold changes to a stiffer filament applying a heavier force. In the median nerve distribution, at the tip of the index finger of the dominant hand, 87% of participants had diminished light touch, below the normal threshold of the 0.07 g monofilament. In addition, 62% of participants had diminished protective sensation, with a threshold below the heavier touch of the 0.02 g monofilament. Similarly, in the ulnar nerve distribution at the tip of the little finger of the dominant hand, 72% of participants had a threshold below the normal 0.07 g, 38% of participants had diminished protective sensation with a threshold below 0.02 g, and 1 participant (2%) had a threshold below the 2.0 g filament.

Table 2. Mean (SD) values of Short Form 36 scales for men and women.

SF-36 Scale	Males, n = 26	Females, n = 33	p
Physical functioning	43.4 (9.4)	38.3 (11.6)	0.07
Role physical	43.4 (9.9)	42.4 (11.2)	0.71
Bodily pain	43.0 (8.9)	42.1 (8.6)	0.70
General health	42.7 (10.2)	39.7 (11.7)	0.31
Vitality	48.2 (11.6)	47.5 (9.4)	0.80
Social functioning	47.2 (11.2)	47.9 (10.8)	0.80
Role emotional	44.8 (14.2)	44.1 (14.1)	0.85
Mental health	48.9 (11.3)	48.5 (11.7)	0.88

The median [interquartile range (IQR)] time to complete the 9-hole peg test of dexterity was 20.3 s (IQR 18.3, 23.7) and was not influenced by gender. This measure of dextrous performance had a stronger correlation with sensation scores (r = –0.71, p < 0.0001) than with grip strength (r = –0.33, p = 0.009).

Factors associated with hand disability. Significant relationships between hand disability and the 8 scales of the SF-36 were observed. These ranged from a strong relationship (–0.71, p < 0.001) for the physical functioning scale to a moderate relationship (–0.39, p = 0.002) for the mental health scale. Hand disability was also related to the hand function tests. Hand disability correlated moderately with grip strength (–0.54, p < 0.001) and with the performance of the 9-hole peg test of dexterity (0.55, p < 0.001), and weakly with sensation (–0.29, p = 0.02). There were intercorrelations between variables. Grip strength, sensation, and dexterity were also related to physical functioning (0.51 to 0.31, p < 0.05); BMI had a weak relationship to both physical functioning (–0.34, p = 0.009) and hand disability (0.26, p = 0.05).

Variables that had a linear relationship with hand disability of p < 0.20 were included in 2 multiple linear regression models. The first model examined health status and included the scales of the SF-36, BMI, gender, and duration of diabetes (Table 3). The second model examined hand function and included grip strength, sensation and dexterity, BMI, gender, and duration of diabetes (Table 4).

For the health status model that explained 66% of the variance, the predicted hand disability was 100.1 – (0.8 × Physical Functioning) – (7.8 × gender) – (0.5 × Bodily Pain) – (0.4 × Vitality) where males = 1 and females = 0. For the hand function model that explained 36% of the variance, the predicted hand disability was –2.7 – (0.6 × grip strength) + (1.1 × dexterity) + (0.7 × BMI).

DISCUSSION

We investigated the relationships between self-reported instruments and assessments of hand function. The SF-36 and the tests of hand function showed significant correlations with the DASH that ranged from –0.71 for the physical functioning scale to –0.29 for the light touch perception scores of the WEST hand monofilaments. The International Classification of Functioning, Disability and Health (ICF)

Table 3. Regression analysis using health status variables to predict hand disability.

	Coefficient ß	Standard Error ß	p	95% CI	
Physical functioning	–0.75	0.18	< 0.001	–1.11	–0.40
Gender	–7.78	3.0	0.012	–13.77	–1.77
Bodily pain	–0.52	0.22	0.022	–0.97	–0.07
Vitality	0.40	0.19	0.038	–0.77	–0.02
Constant	100.1	7.9	< 0.001	84.24	115.94
Adjusted $R^2 = 0.66$					

Table 4. Regression analysis using hand function variables to predict disability.

	Coefficient ß	Standard Error ß	p	95% CI	
Grip strength	–0.64	0.19	0.001	–1.01	–0.27
Dexterity	1.12	0.40	0.007	0.33	1.93
BMI	0.72	0.32	0.030	0.07	1.38
Adjusted $R^2 = 0.38$					

proposes a classification of functioning, at levels of impairment, activity limitation, and participation restriction that is influenced by personal and contextual factors[36]. The relationships observed between impairments of hand function and limitations of activity influenced by gender and aspects of physical or mental health support this theoretical model. Disability was not related to age or to the control of blood sugar levels, but did reflect the complex interplay of a number of different factors.

We identified that women had greater limitations of daily activities from these hand syndromes. While it has previously been established that women with diabetes have greater physical limitations, the contribution of these musculoskeletal conditions to limitations of hand function in women is a new finding. Despite the heterogeneity of clinical presentations, higher levels of disability reported in women could be reflecting the dominance of carpal tunnel syndrome affecting hand function. However, it could also be reflecting that a loss of upper body strength has a greater effect on women; because women have significantly less grip strength, declines in strength will result in an increasing proportion of maximal capacity being required for daily activities.

Obesity, a known risk factor for carpal tunnel syndrome[37], independently predicted hand disability. It is also a known risk factor for mobility difficulties in women[6]. This suggests that hand disability is related to an interaction of obesity and carpal tunnel syndrome, but may also be part of an overall decline in physical functioning. In women, difficulties using the hands for activities of daily living may have coexisted with restricted mobility, as the DASH was strongly associated with the physical functioning scale of the SF-36. This is similar to the report of generalized physical disability found in elderly patients with Type 2 diabetes[4].

We found that reduced grip strength was related to disability of the hands. This is consistent with previous findings[13]. Pain, finger joint stiffness, flexor muscle or tendon shortening, carpal tunnel syndrome, lower levels of physical activity, and the negative influence of diabetes and obesity on muscle quality could all contribute to poor muscle function and hand weakness. Grip strength was also related to physical functioning, which is consistent with reports that grip strength can be used as a measure of whole-body strength and physical disability[38,39].

Our study provides clues that exercise may be a suitable strategy to address reduced grip strength. However, because it is likely that hand disability results from multiple factors, the influences of pain, restricted movement, psychological factors, and the functional requirements of the individual should be considered before effective strengthening can occur. Randomized controlled trials of the effects of exercise in preventing limitations of hand function and disability in diabetes are needed.

We showed that loss of light touch affected the performance of tasks requiring dexterity and was related to disability of the hands. Most participants had sensory impairment affecting the fingertips, in areas supplied by the median and also the ulnar nerves. Similar patterns of sensory changes in the hands have been reported in diabetes[14,40] and in carpal tunnel syndrome[41]. Therefore, it is interesting to speculate that generalized peripheral neuropathy or thickening of the skin, due to increased glycosylation of connective tissue proteins, may have contributed to the loss of light touch from median nerve entrapment. An area for future research is the relationships between light touch perception, the glycosylation of tissues, and findings from nerve conduction studies.

Our results should be viewed in light of some limitations. The sample may not be representative of all adults with the hand syndromes related to diabetes, because participants were recruited from patients referred to orthopedic surgeons, rheumatologists, or hospital diabetes clinics, and those seeking treatment may have more disabling symptoms. In contrast to the 2 other publications in this area, carpal tunnel syndrome or a history of carpal tunnel release were common and are likely to have influenced levels of hand impairment and disability in this study. The diagnoses relating to the hands were often mixed and while this made interpretation by diagnostic category difficult, presenting with alteration in a variety of soft-tissue structures of the hand can occur in longstanding diabetes.

A number of confounders were not analyzed. Comorbidities are known to influence physical disability and may have negatively influenced the physical functioning of the women in the study. There were insufficient participants with Type 1 diabetes enrolled in the study to present separate analyses. The characterization of hand disability in Type 1 diabetes remains an area requiring further investigation.

Although the instruments were selected as being valid and reliable, all instruments have strengths and limitations. A limitation of measuring grip strength is that no distinction is made between the contribution of pain, finger stiffness, or muscle weakness to the values recorded. The determination of normal light touch perception using the WEST hand monofilaments is an area of controversy[42], particularly in older adults[43]. The 9-hole peg test is a simple test of dexterity that may not detect subtle limitations of performance.

Despite these limitations, our results support supplementing self-reported hand disability with impairment, performance, and health status measures. The measures were related but highlighted different aspects of hand functioning and suggested that multiple factors contributed to hand disability, including physiological and psychological factors.

Assessment of the hands in diabetes, and monitoring of carpal tunnel syndrome, trigger finger, Dupuytren's disease, and limited joint mobility is relevant, as these syndromes can cause difficulties with daily tasks requiring strength or dexterity. Using tests that are suitable for use in the clinic, we also observed that reduced sensation, influenced by carpal tunnel syndrome, contributed to disability. This study emphasized the interrelationships between the hands, obesity, and overall physical functioning in women. Maintaining dexterity and upper body strength, managing pain, and encouraging a healthy weight are important strategies to minimize disability in the hand syndromes associated with diabetes.

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