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Hand grip strength in patients with type 2 diabetes mellitus

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Abstract

Aim: The aim of the present study was to compare hand grip strength and pinch power, which are important parameters of hand function, in 76 patients with type 2 diabetes mellitus (T2DM) (mean age: 50.11 ± 7.6) with 47 non-diabetic control subjects (mean age: 46.93 ± 10.2).
Methods: Grip strength was assessed with a Jamar dynamometer and pinch power was measured with a pinch gauge. Body composition was measured using a Tanita body composition analyzer. Mann–Whitney, Fisher's exact and chi-square tests were used to determine the differences within groups and a p-value <0.05 was taken as statistically significant.
Results: Hand grip strength test values were significantly lower in the diabetic group compared with the control group. Key pinch power value for the right hand was significantly lower in the diabetic group than in the control group whereas the left hand value was similar.
Conclusion: Hand grip strength and key pinch power values were found to be lower in patients with T2DM than in age-matched control subjects. Hands, as well as feet, are also affected by diabetes and physicians should be aware of this.

Keywords: Type 2 diabetes; Hand grip strength; Key pinch power; Jamar dynamometer; Pinch gauge

1. Introduction

Type 2 diabetes mellitus (T2DM), is the most common endocrine disorder worldwide, and it is characterized by metabolic abnormalities and by chronic complications involving the eyes, kidneys, nerves, and blood vessels [1]. These complications can cause morbidity and premature mortality, and lead to serious social and cause economic problems due to loss of employment.

Foot ulcers and joint problems in T2DM are the most significant causes of morbidity and admittance to orthopedic outpatient clinics. The major predisposing

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cause is diabetic polyneuropathy because the sensory denervation impairs the perception of trauma after wearing ill-fitting shoes. Alterations in proprioception may give rise to an abnormal pattern of weight bearing and sometimes to the development of Charcot's joints. In addition to sensory neuropathy, motor neuropathy is often emphasized, considering that diabetic foot pathology, which is characterized by intrinsic muscle atrophy, can result in a motor imbalance and diffuse claw–toe. This pathology affects both the foot function and postural stability [2].

In diabetic patients, the strength of flexor and extensor muscles at the elbow, wrist, knee, and ankle have been evaluated clinically using manual muscle testing (MMT) and isokinetic dynamometry [3,4]. The volume of ankle dorsal and plantar flexors, and intrinsic muscle atrophy of the foot have been investigated radiologically using magnetic resonance imaging (MRI) [2,5]. In contrast to the measurement of the strength of the lower extremity muscles; hand grip strength has seldom been studied in patients with diabetes mellitus (DM) [6]. In the present study, our aims were to establish, using a Jamar dynamometer and a pinch gauge, whether the grip and pinch power of the hand in patients with DM were different than those of healthy non-diabetic control subjects.

2. Patients and methods

Seventy-six patients with T2DM (mean age: 50.11 ± 7.6 years) were recruited from outpatient clinics of the Department of Internal Medicine, at Kahramanmaras Sutcu Imam University. Forty-seven healthy volunteers (mean age: 46.93 ± 10.2) without diabetes, established by an oral glucose tolerance test (OGTT), served as the control group.

DM was diagnosed according to American Diabetes Association (ADA) diagnostic criteria as follows: a fasting plasma glucose $\geq$7.0 mmol/L or 2-h plasma glucose $\geq$11.1 mmol/L after a 75 g oral glucose load [7]. Criteria for inclusion in the study were that the patients had T2DM (known or newly diagnosed after glucose challenge test or those receiving oral hypoglycemic pills) and that the control subjects had no glucose abnormality, no history of pain in the shoulder, arm or hand, no documented history of trauma or cervical radiculopathy in the previous 12 months.

A calibrated, Jamar dynamometer (Smith and Nephew, Irwington, NY 10533, USA) was used to assess grip strength at the first three settings. A pinch gauge (PG-30, B&L Engineering Santa Fe, CA, USA) was used to assess the key pinch. Both the dynamometer and pinch gauge were reset to zero prior to each reading and were read to the nearest increment of the two scale divisions. The American Society of Hand Therapists' recommendations for testing both grip and pinch strengths were followed [8]. Subjects were seated comfortably on a chair without armrests. The shoulder was adducted and neutrally rotated, with the elbow at 90° flexion, and the forearm and wrist in a neutral position. Standard verbal encouragement in the same tone of voice ("squeeze the handle/button as hard as possible") was used during the measurements. Three measurements of each grip and pinch were obtained at 15 s intervals and mean values were analyzed. Measurements started with the dominant hand. The right hand was dominant in 67 (88.2%) of T2DM patients, whereas in 2 (2.6%) the left hand was dominant, and the remaining 7 (9.2%) were ambidextrous. In the control group the dominant hand was the right in 38 (80.9%) subjects, the left in 6 (12.8%), and 3 subjects (6.4%) were ambidextrous.

Percentages of body fat (BF), the basal metabolism rate (BMR), and fat mass of the subjects were obtained using a Tanita body composition analyzer TBF-300 (Tanita Corp., Tokyo, Japan). Tanita TBF-300 is a commercially available foot-to-foot bioelectrical impedance analysis (BIA) system. The manufacturer-supplied equations incorporate gender, mass, height, activity category and a measured impedance value to determine the percentages of BF, BMR, and fat mass. In order to assess these measurements, girth–hip ratio (G/H), height, body weight, and body mass index (BMI) were all measured.

All T2DM patients were examined for hypertension, smoking and diabetes duration, and were investigated for diabetic complications using clinical examination and laboratory findings (Urine protein, HbA1c).

The study was reviewed and approved by the local research and ethics committee and all subjects gave written consent.

Parametric or nonparametric tests were chosen to test for statistical significance depending on the data distribution. Mann–Whitney, chi-square, Fisher's exact, *T*-test, Kruskal–Wallis analysis of variance, Wilcoxon's signed rank test and Pearson's correlation coefficient were used to determine the differences and relations between groups. A *p*-value of <0.05 was taken as statistically significant. Statistical analysis was performed using SPSS 9.0 for Windows (SPSS Inc., Chicago, IL, USA).

3. Results

The characteristics and body composition values of the subjects were given in Tables 1 and 2. There were no significant difference between the groups with respect to age, sex, hypertension, proteinuria, and smoking ($p > 0.05$). However HbA1c values in diabetic patients were significantly higher than those of the control group ($7.14 \pm 1.64\%$ versus $5.16 \pm 0.62\%$, $p < 0.001$) (Table 1). BMI, G/H, BF, BMR, and fat mass were similar in both groups (Table 2).

Working status of subjects is given in Fig. 1. All subjects in both groups were classified as non-manual workers (housewives, civil servants, tradesmen, retired etc.) (Fig. 1).

The results of the hand grip strength test with the Jamar dynamometer were significantly lower in the diabetic group compared with the control group ($p < 0.05$). The key pinch strength value for the right hand was significantly lower in the diabetic group than in the control group ($p < 0.05$), whereas the left hand value was lower than in the control group but this was not statistically significant ($p > 0.05$) (Table 3). However, when the subjects of both the diabetic and control group were classified according to age intervals, hand grip and pinch strength values were found to be lower in diabetic patients in both the 30–49 and the >50 age groups ($p < 0.05$) (Table 4).

54.5% of the diabetic patients reported that daily activities and hand grasping power were not affected and 10.6% said that decreased hand power did not affect their daily activities. However, patients who reported that their hand power affected daily activities comprised 34.9% of the diabetic study group.

The relationship between HbA1c level and values of hand grip and key pinch strength of diabetic and control groups were analyzed using Pearson's correlation coefficient. There was no relationship found among HbA1c levels, proteinuria, hypertension and values of hand grip and key pinch strength in neither the diabetic patients nor the controls ($p > 0.05$).

The relationship between age, BMI and values of hand grip and key pinch strength of both the diabetic and control group were analyzed using Pearson's correlation coefficient but no significant relationship was ($p > 0.05$).

Both the hand grip and key pinch strength values were found to be higher in males than in females in both the diabetic and the control group ($p < 0.05$) (Table 5). Furthermore, there was a relationship between the grip strength and key pinch power in both the diabetic and control groups ($p < 0.001$). In the diabetic group, the relationship between grip strength and key pinch power was relatively higher than those of the control group (Table 6).

There were significant differences in the hand grip and key pinch strength values of the subjects between

Table 1
Characteristics of subjects

	Diabetic patients ($n = 76$)	Control ($n = 47$)	*p*-Value
Age (years) (mean ± S.D.)	50.11 ± 7.6	46.93 ± 10.2	>0.05
Sex F/M (*n* and %)	51 (67.1%)/25 (32.9%)	28 (59.6%)/19 (40.4%)	>0.05
Hypertension	($n = 49$) 65.3%	($n = 20$) 42.5%	>0.05
Proteinuria	($n = 13$) 17.1%	($n = 6$) 12.8%	>0.05
Smoking	($n = 1$) 1.3%	($n = 3$) 6.4%	>0.05
HbA1c (%) (mean ± S.D.)	7.14 ± 1.64 (4.6 − 10.9)	5.16 ± 0.62 (4.1 − 7.9)	<0.001
Diabetes duration (years)	5.94 ± 6.18	–	–

No significant difference between groups ($p > 0.05$) in age, sex, hypertension, proteinuria, smoking, but significant difference between groups ($p < 0.001$) in HbA1c.

Table 2
Comparison of the body composition values (values are mean ± S.D.)

	Diabetic patients ($n = 76$)	Control ($n = 47$)	p-Value
BMI	30.59 ± 6.03	31.22 ± 5.0	>0.05
Girth–hip ratio (G/H)	0.88 ± 0.07	0.86 ± 0,06	>0.05
Percentages of body fat (BF)	34.86 ± 9.19	34.89 ± 7.85	>0.05
Basal metabolism rate (BMR)	6341.77 ± 795.49	6565.51 ± 1283.85	>0.05
Fat mass	28.39 ± 12.19	29.08 ± 10.82	>0.05

No significant difference between groups ($p > 0.05$) in BMI, G/H, BF, BMR, and fat mass.

the dominant and non-dominant hand ($p < 0.05$) (Table 7).

Implications on life and activities, as a consequence of the patients' lower hand grip and pinch strength values were investigated. All the diabetic patients were studied. 54.5% of the diabetic patients reported that daily activities and hand grasping power were not affected and 10.6% stated that decreased hand power did not affect their daily activities. However, subjects with affected hand power and daily activities comprised 34.9% of the diabetic population.

4. Discussion

It is well known that mild distal muscle weakness can accompany predominant distal symmetrical sensory neuropathy in DM patients [9]. While there are numerous quantitative studies on sensory neuropathy and autonomic disturbances, there is little data about motor function in diabetic patients [10,11]. Dyck et al. [3] indicated that clinically apparent muscle weakness was a severe disturbance in type 1 diabetes (T1DM) patients with more advanced neuropathy. However, neither the severity nor the distribution of the muscle weakness due to manual muscle testing (MMT) was reported in their clinical studies. Andersen and Jakobsen stated that the sensitivity of MMT was low and dynamometry should be considered in clinical trials of motor function in neuropathic patients [12]. Some investigators reported that there was a significant reduction in the muscle strength of the ankle dorsal and plantar flexors, and the knee extensors and flexors in 56 T1DM patients using

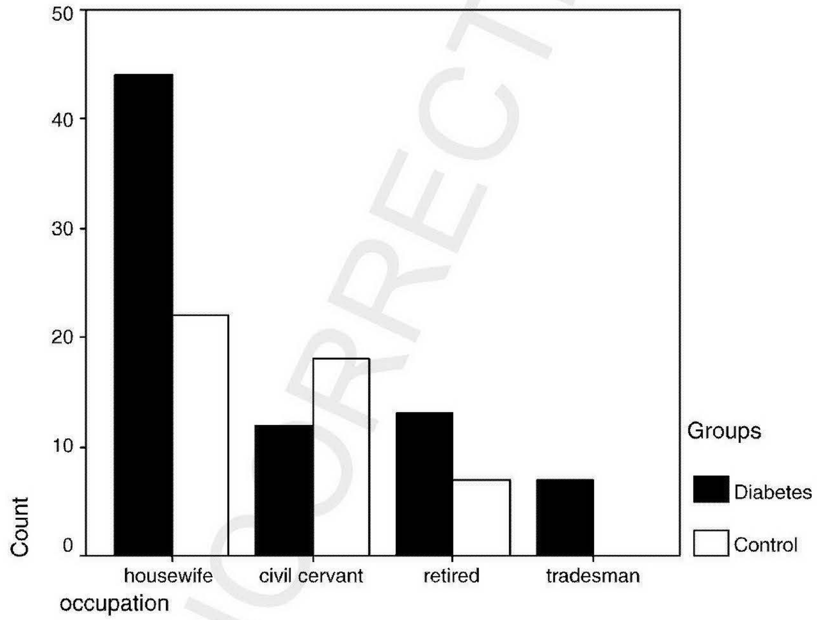

Fig. 1. Working status of subjects.

Table 3
Hand grip strength and key pinch values (kg) of both groups

Strength	Diabetic patients	Control
R Jamar first setting	27.61 ± 9.76	31.89 ± 8.88[a]
R Jamar second setting	31.53 ± 11.82	36.34 ± 11.01[a]
R Jamar third setting	28.92 ± 10.86	33.22 ± 10.53[a]
L Jamar first setting	25.91 ± 9.53	31.10 ± 9.08[a]
L Jamar second setting	29.77 ± 11.15	35.48 ± 10.35[a]
L Jamar third setting	27.54 ± 10.51	32.05 ± 9.30[a]
R key pinch	8.47 ± 2.56	9.37 ± 1.89[b]
L key pinch	8.15 ± 2.50	8.92 ± 1.83[c]

R: right; L: left.
[a] $p < 0.05$. Hand grip strength was significantly lower in the diabetic group than those of control group.
[b] $p < 0.05$. Key pinch strength value for right hand was significantly lower in the diabetic group than value of control group.
[c] $p > 0.05$. Key pinch strength value for left hand was lower in diabetic patients than value of control group. But there was no statistically significant difference.

isokinetic dynamometer, but a reduction in muscle strength of the wrist flexors and extensors was not significant [4]. Lord et al. [13] found impaired muscle strength of the knee extension in a group of aged women with T2DM. Andersen et al. [14] pointed out that T2DM patients may have weakness of the extensors and flexors at the ankle and of the knee flexors and extensors, with a preservation of muscle strength at the wrist and elbow. It was thought that the distribution of muscular weakness indicated a distal neuropathic process underlying the impaired motor performance, and this assumption was supported by the observation that muscular strength at the ankle and knee was related to the degree of severity of neuropathy.

In addition to clinically determined lower extremity muscular weakness in DM patients, it was reported that there was a 32% reduction in the volume of dorsal and plantar flexors [5], and also using MRI, remarkable atrophy in the intrinsic muscles of the foot in neuropathic patients was reported [2]. Both biochemical and structural changes in the plantar foot muscles of DM patients with neuropathic ulcers and a reduction in high-energy metabolites with an increase in fat content were also demonstrated via magnetic resonance spectroscopy [15]. Significant relationships between motor nerve conduction velocity, and these physiological variables were suggested as atrophy in the intrinsic muscles of the foot was seen as secondary to motor nerve dysfunction. Remarkable atrophy of the foot and ankle muscles was thought to be secondary to diabetic neuropathy [2,15].

A number of investigations related to the evaluation of the muscle strength in DM patients were carried out on the lower extremity muscles, and mild distal muscle weakness in the lower extremity, due to diabetic neuropathy, was identified. However, hand grip strength and pinch power values in diabetic patients are unclear in the literature.

In the present study, we evaluated the grip and pinch power of the hand in T2DM. Grip strength and pinch power are important parameters of hand function. The grip strength test was commonly used to evaluate the integrated performances of hand muscles by determining maximal grip force that could be produced in one muscular contraction [16]. Hand strength can be used to determine a treatment [17], to assess nutrition [18], to assess risk of mortality in

Table 4
Comparisons of hand grip and pinch strength (kg) values (mean ± S.D.) of subjects according to age intervals

Strength (kg)	Diabetic patients		Control	
	30–49	>50	30–49	>50
R Jamar first setting	28.32 ± 10.78	27.06 ± 9.01	32.35 ± 9.31[a]	30.62 ± 7.81[b]
R Jamar second setting	32.49 ± 12.65	30.79 ± 11.24	35.87 ± 10.78[a]	37.65 ± 12.03[b]
R Jamar third setting	29.44 ± 11.26	28.52 ± 10.66	32.55 ± 9.90[a]	35.04 ± 12.39[b]
L Jamar first setting	26.91 ± 10.03	25.13 ± 9.18	31.69 ± 9.49[a]	29.48 ± 8.00[b]
L Jamar second setting	30.46 ± 11.96	29.25 ± 10.61	35.18 ± 10.48[a]	36.32 ± 10.38[b]
L Jamar third setting	27.54 ± 10.88	27.55 ± 10.36	31.78 ± 9.38[a]	32.82 ± 9.46[b]
R key pinch	8.78 ± 2.66	8.21 ± 2.49	9.42 ± 1.95[a]	9.24 ± 1.80[b]
L key pinch	8.11 ± 2.36	8.18 ± 2.65	8.94 ± 1.72[a]	8.85 ± 2.22[b]

R: right; L: left.
[a] $p < 0.05$. Hand grip and pinch strength values of diabetic patients were lower than those of controls in 30–49 age interval.
[b] $p < 0.05$. Hand grip and pinch strength values of diabetic patients were lower than those of controls in >50 age.

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