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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Hand functions in type 1 and type 2 diabetes mellitus

Pinar Akpinar[1], Afitap Icagasioglu[2], Esra Selimoglu[3], Banu Mesci[4]

[1]Fatih Sultan Mehmet Education and Research Hospital, Department of Physical Medicine and Rehabilitation, Istanbul, Turkey;
[2]Istanbul Medeniyet University, Goztepe Education and Research Hospital, Department of Physical Medicine and Rehabilitation, Istanbul, Turkey;
[3]Erenkoy Physical Therapy and Rehabilitation Hospital, Department of Physical Medicine and Rehabilitation, Istanbul, Turkey;
[4]Medeniyet University, Goztepe Education and Research Hospital, Department of Internal Medicine, Istanbul, Turkey

SUMMARY

Introduction/Objective Hand functions have an enormous impact on activities of daily living in patients with diabetes mellitus (DM), such as self-care, administering insulin injections, and preparing and eating meals.

The aim of the study was to evaluate hand functions and grip strength in patients with type 1 and type 2 DM.

Methods This was an observational case-control study investigating the hand functions and grip strength in patients with type 1 and type 2 DM. The study comprised 41 patients with type 1 DM aged 25–50 years sex- and age-matched, 40 non-diabetic controls, and 91 patients with type 2 DM aged 40–65 years sex- and age-matched 60 non-diabetic controls. Patients with documented history of diabetic sensorimotor neuropathy and adhesive capsulitis were excluded. The Duruoz Hand Index was used to assess the functional hand disability. Grip strength was tested with a calibrated Jamar dynamometer.

Results The Duruoz Hand Index scores in patients with type 2 DM were significantly higher than in persons in the control group ($p < 0.01$), but there was no significant difference between the type 1 DM and the control group ($p > 0.05$). Grip strength values of patients with type 1 DM were significantly lower compared to those in the control group ($p < 0.05$), whereas there was no significant difference between patients with type 2 DM and their control group. There was a negatively significant correlation between grip strength and the Duruoz Hand Index scores in patients with both type 1 and type 2 DM ($p < 0.05$).

Conclusion Patients with type 1 DM and type 2 DM have different degrees of hand disability as compared to healthy control groups.

Keywords: hand function; diabetes mellitus; grip strength

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic condition characterized by persistent hyperglycemia with resultant morbidity and mortality related primarily to its associated microvascular and macrovascular complications. DM is the leading cause of end-stage renal disease, adult vision loss, and non-traumatic limb amputations due to its classic micro- and macrovascular complications [1, 2]. In addition to these "classic" complications, patients with diabetes have a variety of musculoskeletal manifestations which cause disability and morbidity [1]. Diffuse idiopathic skeletal hyperostosis, osteoarthritis, osteoporosis, neuropathic arthropathy, calcium pyrophosphate dihydrate deposition disease, adhesive capsulitis, Dupuytren's disease, and carpal tunnel syndrome are frequently seen disorders. Musculoskeletal complications have been reported in about 36–75% of diabetic patients [3–7].

Moreover, patients with diabetes have reported to be more disabled in self-care tasks and housework than the non-diabetic ones, but there is less attention to upper extremity problems [8, 9]. These problems may be left unrecognized and untreated due to increased attention to other systems affected by diabetes.

Raje et al. [10] showed that patients with diabetes had higher symptom scores for hand and shoulder symptoms compared with control subjects. Mustafa et al. [11] conducted a cross-sectional study on 1,000 patients with type 2 DM. They found that 695 patients (69.5%) have had some sort of hand disorder.

Studies started to investigate grip strength as a further complication of diabetes affecting the hands. Grip and key pinch strength have been found to be lower in the hands of type 2 diabetics compared to the non-diabetic controls [9, 12]. The effect of the reduced hand strength on hand functional disability had also not been clearly demonstrated before. Occupational performance such as frequent daily measurements of blood glucose in patients with DM is very crucial.

We aimed to evaluate the hand strength and functional disability in patients with type 1 and type 2 DM.

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Correspondence to:
Pinar AKPINAR
Department of Physical Medicine and Rehabilitation
Fatih Sultan Mehmet Education and Reaseach Hospital
Istanbul, Turkey
pinar.pinarakpinar@gmail.com

METHODS

This is an observational case-control study in which 41 patients with type 1 DM aged 25–50 years (18 female, 23 male) and sex- and age-matched 40 non-diabetic controls (19 female, 21 male), as well as 91 patients with type 2 DM aged 40–65 years (65 female, 26 male) and sex- and age-matched 60 non-diabetic controls (43 female, 17 male) were recruited from a clinic for diabetes of an education and research hospital. Non-diabetic controls were recruited from the relatives of the included patients, be it their spouses, parents, etc. The criteria for the inclusion into the study were as follows: the patients had diabetes, had no documented history of diabetic sensorimotor neuropathy nor adhesive capsulitis. The control subjects had no diagnosis of diabetes, pre-diabetes, or glucose intolerance, no documented history of trauma, cervical radiculopathy, nor any hand-related pain in the previous 12 months.

Body mass index (BMI) was calculated by using the formula of weight (kg) / height (m^2). The following three BMI categories were created: less than 25 kg/m^2, 25 to 29.9 kg/m^2, and 30 kg/m^2 or more [13]. Waist circumference was measured according to the International Diabetes Federation. Central obesity was defined as waist circumference ≥ 94 cm for Europid men and ≥ 80 cm for Europid women [14].

HbA1c, smoking habits, diabetes duration, and subjects who exercise regularly were noted parameters.

The Duruoz Hand Index (DHI) or Hand Function Disability Scale (HFDS) or Cochin Scale developed by Duruoz et al. [15] was used to assess the functional hand disability. It is a self-reported questionnaire developed to assess the hand ability in the kitchen, while performing personal hygiene, office tasks, during dressing and other general items. DHI consists of 18 questions that assess functional disability and handicap of the hand. Each answer is scored on a scale from 0 (no difficulty) to 5 (impossible to do). Scores from each of the five categories are summed to yield a total score range from 0 to 90. A higher score indicated poorer hand function [15]. It is also a reliable instrument for the assessment of hand functional disability in type 2 diabetes patients [16].

Grip strength was tested with a calibrated Jamar dynamometer (Smith & Nephew plc., London, UK). For each test of grip strength, the standard test position approved by the American Society of Hand Therapists was used [17, 18]. This testing position is described as sitting in a straight-backed chair with feet flat on the ground, the shoulder adducted and neutrally rotated, the elbow flexed at 90°, the forearm in a neutral position, and the wrist between 0° and 30° extension, and between 0° and 15° ulnar deviation. In all cases, the arm should not be supported by the examiner or by an armrest. The dynamometer is presented vertically and in line with the forearm to maintain the standard forearm and wrist positions. For each strength test the scores of three successive trials were recorded and the mean of three scores was used. Both dominant and non-dominant hands were tested.

Informed consent was obtained, and all procedures were conducted in accordance with the Helsinki Declaration of 1975 and approved by the local institutional clinical research ethical committee.

Statistics

Results were given as mean ± standard deviation (SD) and range. The χ^2 test was done to compare the categorical demographic variables, while Student's t-test was used for the intergroup comparisons of parameters with normal distribution, and Mann–Whitney U-test was used for the intergroup comparisons of parameters without normal distribution. Spearman correlation analysis in non-parametric variables was used to express the strength of the association between two variables. Linear regression analyses was used for multivariate analyses. A p-value of < 0.05 was taken as statistically significant. Statistical analysis was performed using NCSS 2007 and PASS 2008 Statistical Software (NCSS, LLC, Kaysville, UT, USA).

RESULTS

The characteristics of the study population are given in Table 1. Patients with type 2 DM were older, had higher BMI and waist circumference, and did less exercise than patients with type 1 DM, as expected.

Twenty (48.8%) patients with type 1 DM had diabetes for a period of time shorter than 10 years, and 21 (51.2%) patients had it for more than 10 years. Seventy-one (78.0%) patients with type 2 DM had it for less than 10 years, and 20 (22%) patients for more than 10 years. Six (15%) patients with type 1 DM had HbA1c < 6.5, and 34 (85%) had HbA1c > 6.5. Twenty-one (23.1%) patients with type 2 DM had HbA1c < 6.5, and 70 (76.9%) had HbA1c > 6.5 (Table 2).

The mean DHI scores of all groups and correlations between the groups are given in Table 3. DHI scores were significantly lower in patients with type1 DM than in type 2 DM patients ($p < 0.01$). Based on the DHI scores, there was no significant difference between the type 1 DM and the control group ($p > 0.05$). DHI scores in patients with type 2 DM were significantly higher than their control group ($p < 0.01$). There was no statistically significant correlation between the DHI scores and the duration of diabetes in patients with either type 1 or type 2 DM ($p > 0.05$). Also, there was no statistically significant correlation between the DHI scores and HgA1c levels in patients with either type or type 2 DM ($p > 0.05$).

Grip strength values are shown in Table 3. There was no statistically significant difference between grip strength values of the dominant and the non-dominant hand in either group. Dominant grip strength was used for statistical correlations. Based on the grip strength values, there was a significant difference between patients with type 1 DM and their control group ($p < 0.05$), whereas there was no significant difference between patients with type 2 DM and their control group. Patients with type 1 DM have significantly higher grip strength values than patients with type 2 DM ($p < 0.01$). There was a negatively significant correlation between the hand grip strength values of

Table 1. The characteristics of the study population

Variable		Type 1 DM (n = 41)	Control 1 (n = 40)	p	Type 2 DM (n = 91)	Control 2 (n = 60)	p
Age (years) (Mean ± SD)		37.80 ± 9.19	36.20 ± 6.58	0.371	53.27 ± 7.57	53.23 ± 5.45	0.972
Sex n (%)	Male	23 (56.1%)	21 (52.5%)	0.919	26 (28.6%)	17 (28.3%)	0.975
	Female	18 (43.9%)	19 (47.5%)		65 (71.4%)	43 (71.7%)	
BMI	Mean ± SD	25.58 ± 4.1	26.26 ± 4.71	0.491	30.30 ± 4.54	29.24 ± 4.66	0.167
	< 25	21 (51.2%)	19 (47.5%)	0.595	8 (8.8%)	9 (15.0%)	0.385
	25–30	16 (39%)	14 (35%)		37 (40.7%)	26 (43.3%)	
	> 30	4 (9.8%)	7 (17.5%)		46 (50.5%)	25 (41.7%)	
Waist circumference	Female: > 80 Male: > 94	8 (19.5%)	21 (52.5%)	0.002	78 (85.7%)	50 (83.3%)	0.867
	Female: < 80 Male: < 94	33 (80.5%)	19 (47.5%)		13 (14.3%)	10 (16.7%)	
Exercise	Never	24 (58.5%)	25 (62.5%)	0.933	67 (73.6%)	44 (73.3%)	0.410
	Non-regular	10 (24.4%)	9 (22.5%)		13 (14.3%)	12 (20.2%)	
	Regular	7 (17.1%)	6 (15%)		11 (12.1%)	4 (6.7%)	

BMI – body mass index

Table 2. HgA1c levels and the duration of diabetes mellitus (DM) in patients with type 1 and type 2 DM

Variable		Type 1 DM (n = 41) n (%)	Type 2 DM (n = 91) n (%)
HgA1c levels	< 6.5	6 (15%)	21 (32.1%)
	> 6.5	34 (85%)	70 (76.9%)
Duration of DM (years)	< 10	20 (48.8%)	71 (78%)
	> 10	21 (51.2%)	20 (22%)

dominant and non-dominant hands and the HgA1c levels in patients with type 1 DM ($p < 0.01$), whereas there was no significant correlation in patients with type 2 DM. There was no statistically significant correlation between the hand grip strength values and the duration of diabetes in patients with either type 1 or type 2 DM ($p > 0.05$).

Based on the exercise status, there was no significant correlation between the grip strength values and the DHI scores.

Results of the linear regression analysis are summarized in Table 4. Increased risk for poorer hand function was significantly associated only with female sex in patients with type 1 DM ($p < 0.05$).

DISCUSSION

The hand has a critical function in daily activities and may have an enormous impact on activities of daily living in patients with DM, such as frequent daily measurements of blood glucose. Studies investigating hand functions and grip strength in patients with DM yielded conflicting results. We assessed the hand function and grip strength in patients with type 1 and type 2 DM.

In our study, DHI scores in patients with type 2 DM were significantly higher than in persons in their control group, but there was no significant difference between the patients with type 1 DM and their control group. On the other hand, based on the grip strength values, there was no significant difference between the patients with type 2 DM and their control group, but there was a significant difference between the patients with type 1 DM and their control group.

Pfützner et al. [19] evaluated the dexterity in insulin-treated patients with type 1 and type 2 DM. The results showed that reduced dexterity skills were common in type 1 and type 2 DM patients, but type 1 DM patients and non-diabetic controls performed similarly in the dexterity tests. In this respect, the fact that type 1 DM patients and their controls had similar hand functions is not an interesting result of our study.

Casanova et al. [20] measured hand functions of patients with diabetes. Fifteen diabetes patients with a median age of 48 years, all having used insulin for a minimum of five years, were randomly selected from diabetes clinics. The Purdue Pegboard, O'Connor Tweezer Dexterity, and Smith Hand-Function tests were used. Hand functions were significantly decreased in the group with diabetes, and the decrease was out of proportion to patients' own subjective pretest assessments. These authors noted that diabetes patients' perception of their hand function appears to be much better than their real performance because of the insidious onset of the problem and gradual adaptation [20].

Table 3. DHI and grip strength values of all groups

	Type 1 DM (n = 41) Mean ± SD	Control 1 (n = 40) Mean ± SD	p	Type 2 DM (n = 91) Mean ± SD	Control 2 (n = 60) Mean ± SD	p
Duruoz Hand Index	0.97 ± 3.51	1.09 ± 3.26	0.874	3.74 ± 6.88	1.06 ± 3.2	0.005
Dominant hand grip strength (kg)	30.92 ± 12.03	36.79 ± 12.06	0.031	24.93 ± 10.72	25.73 ± 10.89	0.658
Non-dominant hand grip strength (kg)	30.30 ± 12.44	36.33 ± 12.38	0.032	24.58 ± 10.98	26.67 ± 10.71	0.250

DM – diabetes mellitus

Table 4. Linear regression analyses

Variable	Type 1 DM		Type 2 DM	
	B	p	B	p
Sex	3.9	0.002	1.260	0.623
Age	0.093	0.079	0.083	0.419
Exercise	-0.136	0.849	0.041	0.969
BMI	-0.027	0.882	-0.057	0.816
Duration of DM	0.089	0.289	0.127	0.327
HbA1c levels	0.046	0.846	-0.072	0.815
Waist circumference	0.084	0.281	0.124	0.242
Dominant hand grip strength	-0.032	0.587	-0.182	0.089

DM – diabetes mellitus; B – regression coefficient $p < 0.05$

De Carvalho e Silva et al. [21] studied the hand strength and functions in type 2 DM patients. They found that patients with type 2 DM have an impairment of hand functions and grip strength. Also, Savas et al. [9] and Cetinus et al. [12] found that grip strength values were lower in patients with type 2 DM than in the age-matched control subjects. However, based on the grip strength values, we found no statistically significant difference between the patients with type 2 DM and their control group. This conflicting result may be due to the shorter DM duration in patients with type 2 DM in our study.

It had been reported that hyperglycemia can affect contractile function and force generation in animal models [22]. In our study, there was a negatively significant correlation between the hand grip strength and HgA1c levels in patients with type 1 DM ($p < 0.01$), whereas there was no such significant correlation in patients with type 2 DM. When we take into account that musculoskeletal abnormalities may result from a prolonged disturbance of the glucose metabolism, 78% of type 2 DM patients in our study had diabetes for a period of time shorter than 10 years.

Lewko et al. [23] investigated the effects of poor hand functions in diabetes. They found that impaired hand function affects lower acceptance of the disease, the occurrence of depression, and reduces the patients' quality of life. Hence, the assessment of hand function is important.

CONCLUSION

Our findings reveal that hand functions are impaired in patients with type 2 DM, and grip strength values are decreased in patients with type 1 DM. Thus, type 1 and type 2 DM have different degrees of hand disability. It is important to assess hand functions to help patients with DM in daily activities.

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Функција шаке код болесника са шећерном болешћу типа 1 и типа 2

Пинар Акпинар[1], Афитап Иџагасиоглу[2], Есра Селимоглу[3], Бану Месџи[4]

[1]Образовно-истражна болница „Фатих Султан Мехмет", Одељење за физикалну медицину и рехабилитацију, Истанбул, Турска;
[2]Универзитет у Истанбулу „Меденијет", Образовно-истражна болница „Гозтепе", Одељење за физикалну медицину и рехабилитацију, Истанбул, Турска;
[3]Образовно-истражна болница „Еренкој", Одељење за физикалну медицину и рехабилитацију, Истанбул, Турска;
[4]Универзитет у Истанбулу „Меденијет", Образовно-истражна болница „Гозтепе", Одељење за интерну медицину, Истанбул, Турска

САЖЕТАК

Увод/Циљ Функција шаке има велики значај у свакодневном животу дијабетичара у стањима као што су брига о себи, давање инсулина, припрема оброка и исхрана.
Циљ рада је био да оцени функције шаке и снаге стиска код оболелих од дијабетеса типа 1 и 2.

Методе Рад представља опсервациону студију случајева са групама усклађеним по полу и старости: 41 болесник са типом 1 дијабетеса (старости 25–50 година) са контролном групом од 40 здравих, и 91 болесник са дијабетесом типа 2 (старости 40–65 година) и контролном групом од 60 здравих особа. Болесници са дијабетичном неуропатијом и адхезивним синовитисом нису укључени у ово истраживање. За оцену функционалних могућности шаке коришћен је Дуруозов индекс шаке. Снага стиска тестирана је динамометром *Jamar*.

Резултати Дуруозов индекс шаке код оболелих од дијабетеса типа 2 у односу на контролну групу био је високо статистички значајан ($p < 0,01$), а није било значајне разлике између оболелих од дијабетеса типа 1 и контролне групе. Снага стиска код болесника са дијабетесом типа 1 у односу на контролну групу био је статистички значајан ($p < 0,05$), а није било значајне разлике између оболелих од дијабетеса типа 2 и њихове контролне групе. Пронађена је битна негативна корелација између снаге стиска и скора Дуруозовог индекса шаке код оболелих од дијабетеса типа 1 и типа 2 ($p < 0,05$).

Закључак Болесници са дијабетесом типа 1 и типа 2 имају различит степен неспособности шаке у односу на здраве особе у контролним групама.

Кључне речи: функција шаке, шећерни дијабетес, снага стиска шаке