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Hand Functions in Type 1 and Type 2 Diabetes Mellitus

Функција шаке код болесника са шећерном болешћу

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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, preparing and eating meals. The aim of this work was to evaluate the hand functions and grip strength in patients with type 1 and 2 DM.

Methods Observational case-control study investigating the hand functions and grip strength in patients with type 1 and type 2 DM. 41 patient with type1 DM aged 25–50 years and sex and age matched 40 non-diabetic controls, 91 patient with type 2 DM aged 40–65 years and sex and age matched 60 non-diabetic controls were recruited from the outpatient clinic special for diabetes. Patients with documented history of diabetic neuropathy, and adhesive capsulitis were excluded. Duruoz Hand Index was used to assess the functional hand disability. Grip strength was tested with a calibrated Jamar dynamometer.

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

Conclusion Our findings revealed that patients with type 1 DM and type 2 DM have different degrees of hand disability as compared to healty control groups.

Keywords: Hand function; Diabetes Mellitus; grip strength.

САЖЕТАК

Увод/Циљ Функција руке 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 Оперваціона студија случајева са усклађеним групама по полу и старости: 41 болесник са типом 1 дијабетеса (старости 25–50 година) са контролном групом од 40 здравих и 91 болесник са типом 2 дијабетеса (старости 40–65 година) и контроном групом од 60 здравих особа. Болесници са дијабетичном неуропатијом и адхезивним синовитисом нису укључени у ово истраживање. *Duruoz* индекс руке је коришћен за оцену функционалних могућности шаке. Снага стиска је тестирана *Jamar* динамометром.

Резултати *Duruoz* индекс руке код оболелих од дијабетиса типа 2 у односу на контролну групу је био високо статистички значајан ($p<0.01$), а није било значајне разлике (n.s.) између оболелих од дијабетеса тип 1 и контролне групе. Снага стиска код болесника са типом 1 дијабетеса у односу на контролну групу је био статистичи значајан ($p<0.05$), а није било значајне разлике (n.s.) између оболелих од дијабетеса тип 2 и њихове контролне групе. Није пронађена битна негативна корелација између снаге стикса и скора *Duruoz* индекса руке код обољелих од дијабетеса типа 1 и типа 2 ($p<0.05$).

Закључак Болесници са типом 1 и типом 2 дијабетеса имају различит степен неспособности руке у односу на здраве у контролним групама.

Кључне речи: Функција руке, шећерни дијабетес, снага стиска шаке

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic condition characterised by persistent hyperglycaemia 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 causes disability and morbidity [1]. Diffuse idiopathic skeletal hyperostosis, osteoarthritis, osteoporosis, neuropathic artropathy, 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 diabeticpatients [3-7].

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

Raje et al. showed that patients with diabetes had higher symptom scores for hand and shoulder symptoms compared with control subjects [10]. Mustafa et al. conducted a cross-sectional study on 1000 patients with T2 DM. They found that 695 patients (69.5%) have had some sort of hand disorder [11].

Studies started to search the 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 nondiabetic controls [9,12]. The effect of the reduced hand strength on hand functional disability has also not been clearly demonstrated before. Hand function is very important in daily activities. 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.

METHODS

This is an observational case-control study in which 41 patient with type1 DM aged 25-50 years (18 female, 23 male) and sex and age matched 40 non-diabetic controls (19 female, 21 male), 91 patient 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 outpatient clinic special for diabetesof an education and research hospital. Non-diabetic controls were recruited from the relatives of the patients who came to hospital with, either husband, wife, mother or father. Criteria for the inclusion to the study were that patients had diabetes, have no documented history of diabetic sensorimotor neuropathy,and adhesive capsulitis. The control subjects had no diagnosis of diabetes, pre-diabetes, and glucose intolerance, no documented history of trauma, cervical radiculopathy, and hand related pain in the previous 12 months.

Body mass index (BMI) was calculated by using the formula of weight (kg)/height (m^2). 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 defined as waist circumference ≥94cm for Europid men and ≥80cm for Europid women [14].

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

The Duruoz Hand Index (DHI) or Hand Function Disability Scale (HFDS) or Cochin Scale developed by Duruoz et al. 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 of 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 worse hand function. [15].It is also a reliable instrument for the assessment of hand functional disability in type 2 diabetic patients [16].

Grip strength was tested with a calibrated Jamar dynamometer (Smith and Nephewi Irwington, NY 10533, USA). For each tests 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 floor, the shoulder adducted and neutrally rotated, elbow flexed at 90°, 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 (S.D.) and range. Chi-square 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 & PASS 2008 Statistical Software (Utah, USA).

RESULTS

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

Twenty (48.8%) patients with type 1 DM have less than 10 year, 21 (51.2%) have more than 10 year duration of diabetes. Seventy-one (78.0%) patients with type 2 DM have less than 10 year, 20

Table 1. The characteristics of the study population.

		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±4.10	26.26±4.71	0.491	30.30±4.54	29.24±4.66	0.167
	<25	21 (51.2 %)	19 (47.5%)		8 (8.8%)	9 (15.0%)	
	25–30	16 (39.0%)	14 (35.0%)	0.595	37 (40.7%)	26 (43.3%)	0.385
	>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 (15.0%)		11 (12.1%)	4 (6.7%)	

Table 2. HgA1c levels and duration of DM in patients with type 1 DM and type 2 DM.

		Type 1 DM (n=41) n (%)	Type 2 DM (n=91) n (%)
HgA1c levels	<6.5	6 (15.0 %)	21 (32.1 %)
	>6.5	34 (85.0 %)	70 (76.9 %)
Duration of DM	< 10 y	20 (48.8 %)	71 (78.0 %)
	> 10 y	21 (51.2 %)	20 (22.0 %)

(22%) have more than 10 year duration of diabetes. Six (15%) patients with type 1 DM have <6.5 HbA1c, 34 (85%) have >6.5 HbA1c levels. Twenty-one (23.1%) patients with type 2 DM have <6.5 HbA1c, 70 (76.9%) have >6.5 HbA1c levels (Table 2).

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

Grip strength values were shown in table 3. There is no statistically significant difference between grip strength values of dominant and non-dominant hand in all groups. Dominant grip strenght was used for statistical correlations.Based on the grip strength values there was a significant difference between the patients with type 1DM and its control group ($p<0.05$), whereas there was no significant difference between the patients with type 2 DM and its control group. Patients with type 1

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±3.20	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 have significantly higher grip strength values than patients with type 2 DM ($p<0.01$). There was negatively significant correlation between the hand grip strength values of dominant and non-dominant hands and HgA1c levels in patients with type 1 DM ($p<0.01$), whereas there was no significant relation in patients with type 2 DM.There was no statistically significant correlation between the hand grip strength values and duration of diabetes in patients with both type 1 and 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 worse hand functions was significantly associated only with female gender in patients with type 1 DM ($p<0.05$).

Table 4: Linear regression analyses.

	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

B – Regression coefficient $p<0.05$

DISCUSSION

The hand has a critical function on 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 1DM and type 2 DM.

In our study, DHI scores in patients with type 2 DM were significantly higher than the control group but there was no significant difference between the patients with type 1DM and its 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 its control group but, there was a significant difference between the patients with type 1DM and its control group.

Pfützner et al. 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 DM and type 2 DM patients but, type 1 DM patients and non-diabetic controls performed similar in the dexterity tests [19]. In this respect, it is not an interesting result of our study is that type 1DM and its controls had similar hand functions.

Casanova et al. 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 5 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 patient's perception of their hand function appear to be much better than their real performance because of incidious onset of the problem and gradual adaptation [20].

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

It has been previously 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 significant relation in patients with type 2 DM. When we take into account that musculoskeletal abnormalities may result from a prolonged disturbances of glucose metabolism, 78.0% patients with type 2 DM have less than 10 year duration of diabetes in our study.

Lewko et al. 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 patient's quality of life [23]. So, assessment of hand function is important.

CONCLUSION

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

REFERENCES

1. Cagliero E. Rheumatic Manifestations of Diabetes Mellitus. Curr Rheumatol Rep 2003; 5(3): 189–94.
2. Nathan DM: Long-term complications of diabetes mellitus. N Engl J Med 1993; 328: 1676–85.
3. Mathew AJ, Nair JB, Pillai SS Rheumatic-musculo- skeletal manifestations in type 2 diabetes mellitus patients in South India. Int J Rheum Dis 2011; 14(1): 55–60.
4. Cagliero E, Apruzzese W, Perlmutter GS, Nathan DM Musculoskeletal disorders of the hand and shoulder in patients with diabetes mellitus. Am J Med 2002; 112(6): 487–90.
5. Mota M, Panus C, Mota E et al. Hand abnormalities of the patients with diabetes mellitus. Rom J Intern Med 2000; 38–39: 89–95.
6. Gamstedt A, Holm-Glad J, Ohlson CG, Sundstrom M Hand abnormalities are strongly associated with the duration of diabetes mellitus. J Intern Med 1993; 234: 189–93.
7. Sarkar P, Pain S, Sarkar RN, Ghosal R, Mandal SK, Baner- jee R Rheumatological manifestations in diabetes mellitus. J Indian Med Assoc 2008; 106 (9): 593–4.
8. Maty SC, Fried LP, Volpato S, Williamson J, Brancati FL, Blaum CS. Patterns of disability related to diabetes mellitus in older women. J Gerontol A Biol Sci Med Sci 2004; 59(2): 148–53.
9. Savaş S, Köroğlu B, Koyuncuoğlu H, Uzar E, Çelik H, Tamer N. The effects of the diabetes related soft tissue hand lesions and the reduced hand strength on functional disability of hand in type 2 diabetic patients. Diabetes Res Clin Pract 2007; 77(1): 77–83.
10. Raje YR, Cracknell G, Davoren PM. Frequency of hand and shoulder symptoms in patients with type 1 diabetes. Diabet Med. 2015; 32(7): 968–71.
11. Mustafa KN, Khader YS, Bsoul AK, Ajlouni K. Musculoskeletal disorders of the hand in type 2 diabetes mellitus: prevalence and its associated factors. Int J Rheum Dis. 2016; 19(7): 730–5.
12. Cetinus E, Buyukbese MA, Uzel M, Ekerbicer H, Karaoguz A. Hand grip strength in patients with Type 2 diabetes mellitus. Diabetes Res Clin Pract 2005; 70: 278–86.
13. World Health Organization. Obesity: preventing and managing the global epidemic. (WHO Technical Report Series, 894). Geneva: World Health Organization; 2000.
14. International Diabetes Federation (IDF) Consensus Worldwide Definition of the Metabolic Syndrome (24-pagebooklet). Available from: http://www.idf.org/webdata/docs/IDF_Meta_def_final.pdf
15. Duruoz MT, Poiraudeau S, Fermanian J, Menkes CS, Amor B, Dougados M, et al. Development and validation of a rheumatoid hand functional disability scale that assesses functional handicap. J Rheumatol. 1996; 23: 1167–72.
16. Turan Y, Duruoz MT, Aksakalli E, Gurgan A. Validation of Duruöz Hand Index for diabetic hand dysfunction. J Investig Med. 2009; 57(8): 887–91.
17. Fess EE, Moran CA. Clinical Assessment Recommendations. In: Casanova JS, editor. American Society of Hand Therapist; 2nd Edition. Chicago, USA: American Society of Hand Therapists; 1992. p. 41–5
18. Mathiowtz V, Rennells C, Donahoe L. Effect of the elbow position on grip and key pinch strength, Hand Surg 1985; 10; 5: 694–97.
19. Pfützner J,Hellhammer J, Musholt P, Pfützner AH, Böhnke J, Hero T, et al. Evaluation of Dexterity in Insulin-Treated Patients with Type 1 and Type 2 Diabetes Mellitus. J Diabetes Sci Technol. 2011; 5: 158–65.
20. Casanova JE, Casanova JS, Young MJ. Hand function in patients with diabetes mellitus. South Med J. 1991; 84: 1111–13.
21. de Carvalho e Silva F, Jakimiu FO, Skare TL. Diabetic hands: a study on strength and function. Diabetes Metab Syndr. 2014; 8(3): 162–5.
22. Helander I, Westerblad H, Katz A. Effects of glucose on contractile function, [Ca2+]i, and glycogen in isolated mouse skeletal muscle. Am J Physiol Cell Physiol. 2002; 282: 1306–12.
23. Lewko J, Kochanowicz J, Zarzycki W, Mariak Z, Górska M, Krajewska-Kulak E. Poor hand function in diabetics. Its causes and effects on thequality of life. Saudi Med J. 2012; 33(4): 429–35.

