Clinical and Experimental Health Sciences

Upper Extremity Functioning in Individuals with Type 2 Diabetes Mellitus: A Comparative Study

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ABSTRACT

Objective: The aim of this study was to evaluate the upper extremity functions of individuals with type 2 diabetes mellitus and to compare them with those of healthy subjects.

Methods: The study included 36 diabetic patients (mean age: 55.05±5.85 years; 21 female, 15 male) and 36 healthy control subjects (mean age: 53.52±7.74 years; 20 female, 16 male). Grip strength was evaluated using a hand dynamometer. Upper extremity endurance was evaluated using the Unsupported Upper Limb Exercise Test (UULEX), and upper extremity disability level with the Disabilities of the Arm Shoulder and Hand Test (DASH-T).

Results: The diabetic patients obtained lower scores of upper extremity endurance ($p<0.05$) and the disability level of the diabetics was found to be higher than that of the healthy control group ($p<0.05$). No significant difference was determined between the groups in terms of grip strength ($p>0.05$).

Conclusion: In individuals with type 2 diabetes mellitus, there is a significant decrease in upper extremity endurance and an increase in the level of upper extremity disability.

Keywords: Diabetes mellitus, disability, muscle strength, upper extremity, physical endurance

1. INTRODUCTION

Diabetes mellitus (DM) is a chronic, metabolic disease and much of its morbidity and mortality is associated with micro and macro vascular complications. DM is also associated with musculoskeletal disorders that can cause loss of function in the hands and shoulders, significantly diminishing the quality of life of patients (1).

Diabetic neuropathy has been shown to play a role in muscular problems and physical functions. Peripheral neuropathy also changes muscle mass, quality and fiber density by affecting not only sensory and motor functions, but also the strength and endurance of muscles in diabetic individuals. Poor muscle quality, decreased muscle strength, exercise intolerance due to lack of physical activity, and obesity are common in people with diabetes, resulting in poor physical function (2,3). There may also be the addition of occupational and psychosocial factors related to upper extremity musculoskeletal disorders in the presence of DM and thus hand and shoulder problems are seen more frequently in the diabetic population (4). For all the above-mentioned reasons, type 2 diabetes increases the disability level of diabetics. This pathological process affects both upper and lower extremity physical functions.

Muscular endurance plays an important role in the accomplishment of daily activities of individuals both with and without disabilities. One of the factors leading to shoulder problems and disability in diabetics is insufficient endurance. This condition decreases the working capacity of these patients (5). Previous studies have elaborated on the neuropathic effect on distal extremities generally and research has mainly been conducted on this issue (6,7). There are numerous studies in literature that have measured the upper extremity disability level and hand grip strength of individuals with type 2 diabetes (8-11). In several studies, upper limb muscle strength has been evaluated but not an evaluation of the extent of the difference from healthy individuals (12-14). However, to the best of our knowledge there are no studies that have investigated the impact of

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muscle endurance of the shoulder girdle on upper extremity functions in diabetics.

The aim of this study was to assess grip strength, endurance, and disability levels of the upper extremities in type 2 diabetics and to compare these values with those of healthy individuals. It was hypothesized that upper extremity function (low limb endurance, higher disability level, low hand grip strength) would be lower in individuals with type 2 diabetes.

2. METHODS

This comparative study was conducted at Near East University Hospital, Department of Internal Medicine during February 2017 and May 2017. The study was approved by the Ethics Committee of Scientific Researches of Near East University (NEU/2017/44-369 on 24/02/2017).

2.1. Participants

This study was conducted on a total of 72 participants, comprising 36 type 2 DM patients (age: 55.05±5.85 years; 21 females,15 males) and 36 healthy control subjects (age: 53.52±7.74 years; 20 females, 16 males). A confirmed diagnosis of type 2 DM was made by an internal medicine specialist. The healthy control group subjects were recruited from volunteers with no diabetes symptoms and normal blood glucose levels. Participants in the age range of 30-65 years who met the inclusion criteria were recruited for both groups. The inclusion and exclusion criteria were defined and applied by a medical doctor and a physiotherapist. The medical diagnosis was made by a relevant medical doctor. All measurements and tests used in this study were performed by an experienced physical therapist.

The inclusion criteria for diabetic group and the control group were;

- Participants diagnosed with type 2 DM who used medication stably for minimum 3 months or longer for the diabetic group
- Participants whose blood glucose values were within normal limits for the control group

The exclusion criteria for diabetic group and the control group were;

- Having an orthopedic and neurologic disorder of the upper extremities for in both group
- Had an operation in the upper extremities for both groups
- Having a communication problem for both groups

The criteria for drop out from the study were;

- Failing to complete all of the tests
- Having an illness during the assessment process
- Having incomplete or missing data
- Having a BMI (Body Mass Index) level of higher than 30 kg/m^2

2.2. Study Design

This was a cross-sectional and comparative study. All participants were informed about the study and provided verbal and written consent for participation. The demographic data of the participants and some characteristics were recorded (Table 1). All measurements were taken on the same day by the same therapist. Initially 82 participants were enrolled and after the exclusion of 10 with BMI >30 kg/m^2, statistical analysis was made of the remaining 72. The participants were separated into two groups: (1) diabetic group (n=36); (2) healthy control group (n=36) (Figure 1).

Table 1. *Demographic and clinical characteristics of the diabetic and control group*

Variable	Diabetic Group (n=36)	Control Group (n=36)
Gender (n,%)		
Female	21 (%58.3)	20 (%55.6)
Male	15 (%41.7)	16 (%44.4)
Age(years)(mean±SD)	55.05±5.85	53.52±7.74
BMI(kg/m^2)	28.58±3.53	27.30±3.74
Exercise Habit (n,%) Yes/No	14 (38,9%) / 22 (61.11%)	15 (%41,7) / 21 (58,3%)
Dominant Hand (n,%) Right/Left	32 (%88.9) / 4 (11.1%)	29(%80.55) / 7(19.44%)
Diabetes Duration	7,78±6,58	–

BMI:Body mass index, SD: Standart deviation

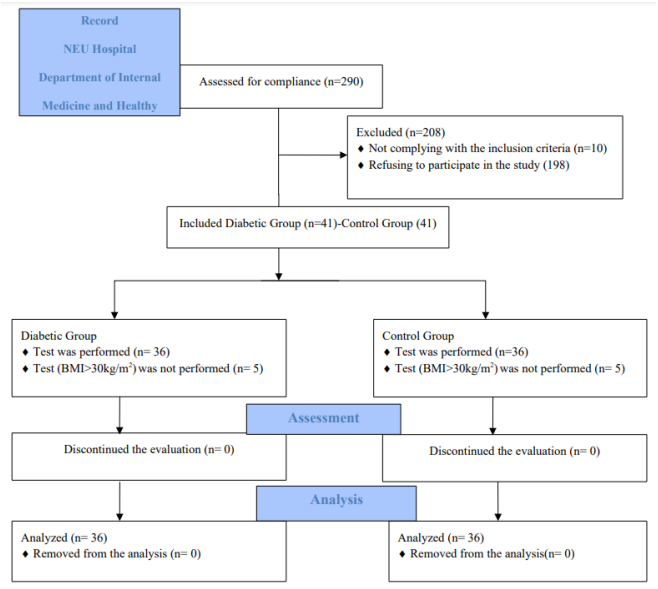

Figure 1. *Selection of the individuals recruited for the study and group formation*

2.3. Assessment

2.3.1. Hand grip strength: grip hand dynamometer (GRIP-D TKK5401)

Hand grip strength was measured with a Grip Hand (TKK 5401 Grip-D; Takei, Niigata, Japan) hand dynamometer. Grip tests were performed in the standard position recommended by

the American Society of Hand Therapists because of the lower possibility of making a difference in hand grip strength values (15). In this standard position, the patients are seated with hips and knees at 90° flexion, shoulders in adduction, forearms in a neutral position, elbows at 90° flexion, wrists at 0 – 30° extension with 0 – 15° ulnar deviation. The measurement was repeated three times with 15 seconds rest between each measurement. The average of the 3 measurements was used in the evaluation (16). The assessments for the right and left hands were made separately, the average was calculated, and a single value was recorded.

2.3.2. The Upper Extremity Endurance: Unsupported Upper Limb Exercise Test

The Unsupported Upper Limb Exercise Test (UULEX) was used for the assessment of upper extremity endurance. The participants were seated on a chair with their knees touching a wall that contained the lines of the UULEX. The lowest line corresponded to the knee level of the subject. The subject held a plastic bar weighing 0.2 kg keeping the arms shoulder width apart, and moved from the hips towards the different levels of the UULEX lines. Each movement started at the hip joint and ended at the hip joint of the participants. The first level was performed for 2 min, and then the upper levels were performed for 1 min. Each level started and ended at the hip joint. The bar was lifted approximately 30 times (rising to the level) per minute as accompanied by a metronome. When the subjects achieved their maximum height, the 0.2 kg bar was exchanged for a bar weighing 0.5 kg. The same procedure was followed until the maximum height was reached for this weight. Subsequently, the weight was increased by 0.5 kg every minute until 2 kg was reached (Figure 2). The subjects were instructed to continue the test until tolerance limitation. The time from the beginning to the end of the test was recorded as the test duration (17,18).

Figure 2. *The unsupported upper limb exercise test*

The Upper Extremity Disability Level: The Disabilities of the Arm, Shoulder and Hand Test (DASH-T)

The DASH test, which is a valid and reliable test, consists of 30 items; 21 items assessing the difficulty experienced during daily life activities, 5 items assessing symptoms (pain, activity-based pain, tingling, stiffness, weakness), and each of the 4 remaining items assessed social function, job, sleep, and self-confidence levels (19). The subject selects the best response to each item on a 5-point Likert system (1: no difficulty, 2: slightly difficult, 3: somewhat difficult, 4: extremely difficult, 5: unable to do it). According to the outcome of the DASH test, a score was obtained in each section in the range of 0-100 (0: no disability, 100: maximum disability) (20).

2.4. Statistical Analysis

The data were analyzed using SPSS vn. 18.0 software. As a result of the power analysis, it was calculated that with 72 patients included in the study (at least 36 patients in each group), 80% power with 95% confidence level for d=0.80 effect size would be obtained (17). Continuous variables were presented as mean ± standard deviation (SD) values, and categorical variables as number (n) and percentage (%). In independent group comparisons, for data conforming to normal distribution, the Significance Test for the Difference between the Two Means was used, and for data not conforming to normal distribution, the Mann-Whitney U Test was used. A value of $p<0.05$ was accepted as statistically significant (21).

3. RESULTS

Figure 1 presents the flow diagram of participants selection. A total of 72 participants, 36 in the diabetes group [male (n=15), female (n=21)], 36 in the healthy group [male (n=16), female (n=20)] completed the study. Exercise habits were present in 14 people in the diabetes group and 15 people in the healthy group. While the right hand was dominant in 88.9% of the diabetes group, it was 80.55% in the healthy group. No significant differences were determined between the groups in respect of age (p=0,41) and BMI (p=0,06) (Table 2). No significant difference in grip strength between the two groups was found (p=0.05). The mean UULEX level (1-8) of the diabetics and healthy control group was 5.97±0.44, and 6.33±0.53 respectively. The mean UULEX weight of the diabetic group and the control group was 1472.20±546.99 gr, and 1944.40±199.20 gr respectively. The mean UULEX duration was 8.98±1.80 min for the diabetic group and 11.45±1.56 min for the healthy control group. When the two groups were compared in terms of sub scores of the UULEX level (p=0.00), weight (p=0.00) and duration (p=0.00), the scores of the diabetic patients were significantly lower than those of the healthy control group. In the comparison of the DASH-T total scores, the scores of the healthy control group (37.25±3.87) were statistically significantly better than those of the diabetic patient group (56.61±18.76) (p=0.00). The findings are summarized in Table 3.

Table 2. *Comparison of physical characteristics of diabetic and control group*

Variable	Diabetic Group (n=36) (Mean±SD)	Control Group (n=36) (Mean±SD)	p*
Age (year)	55.05±5.85	53.52±7.74	0.410
BMI(kg/m^2)	28.58±3.53	27.30±3.74	0.061

**Student t test/ SD: Standart deviation, BMI:Body mass index*

Table 3. *Comparison of the measurement results of the diabetic and control group*

Variable	Diabetic Group (N=36) (Mean±SD)	Control Group (N=36) (Mean±SD)	p
Hand Grip Strength(Kg)	30.21±10.37	34.44±11.00	0.057*
UULEX			
Level(1-8)	5.97±0.44	6.33±0.53	**0.004***
Weight(gr)	1472.20±546.99	1944.40±199.20	**0.000***
Duration(min)	8.98±1.80	11.45±1.56	**0.000****
DASH-T Score	56.61±18.76/150	37.25±3.87/150	**0.000***

**Mann Whitney U test, **Student t test/ SD: Standart deviation, UULEX: Unsupported upper limb exercise test, DASH-T: The Disabilities of the Arm, Shoulder and Hand Test*

4. DISCUSSION

The most important finding of this study was that upper extremity endurance parameters values in diabetic individuals show a significant decrease compared to those of healthy individuals. Although the upper extremity disability level was higher in the diabetic individuals, there was no significant difference in hand grip strength between the two groups.

In a systematic review by Gundmi et al. it was shown that the sample size of all studies was found to be low in general, and as a common result of the studies, it was found that people with type 2 diabetes mellitus had a decrease in hand function. (22). However, based on the grip strength values obtained in this study, no statistically significant difference was determined between the diabetic group and the control group. This unexpected result may have been due to different ratios of dominant extremity between groups, given that the dominant hand is significantly stronger in right-handed people (23). Another factor is that the shorter DM duration in the current study sample may affect the results, although the same results were also found by Akpinar et al (24).

Muscle strength and endurance are the two different components of extremity muscle function: while extremity muscle strength depends on muscle strength generation capacity, extremity muscle endurance indicates the muscle's capability to maintain or repeat a certain task over time. While one repetition maximum (1 RM) method has been mostly used for muscle strength evaluation in various studies, it has also been used for endurance in some studies (25). The 1 RM method is not suitable for diabetic individuals due to the maximum load on the joint, and it is difficult to attain for individuals without training. Furthermore, it is not possible to perform all the movements comfortably in a sitting position. Therefore, there is a clear need for more moderate and safer methods for the evaluation of force and endurance, considering the factors of age and diabetes.

In this study, the UULEX was used to assess upper extremity proximal zone endurance. The first report of UULEX in literature was to assess upper extremity functional level in individuals with chronic obstructive pulmonary disease (17,18). Although UULEX has been shown to be a valid and reliable test for healthy and rheumatoid individuals (26-28), there are no studies in literature illustrating that this test is valid and reliable for diabetic individuals. This can be considered a limitation of this study. However, the method was preferred since it can be performed while seated, it progresses from easy to difficult levels, assesses performance, and can be used for people at any age. In addition, it is easy to use and inexpensive. The UULEX test allows simultaneous evaluation of the upper extremity endurance according to duration, weight, and level.

Shah et al. assessed the distal upper extremity in individuals with type 2 diabetes and measured hand grip endurance (29). In that study, only upper extremity distal region endurance was evaluated, and there was observed to be a significant decrease in the diabetic group compared to the control group. In the current study, the upper extremity proximal region endurance value was lower in diabetics. Park et al. evaluated endurance of the muscles in the forearm and upper arm before and after exercise in diabetic individuals, but provided no information about how the endurance values changed in diabetic individuals compared to healthy individuals, or the endurance of shoulder circumference (25).

Although there are no studies which have assessed proximal upper extremity endurance of shoulder zone muscles, lower extremity proximal endurance has been assessed more often and endurance has been reported to decrease in diabetic individuals. Allen et al. stated that diabetic peripheral neuropathy reduced lower extremity endurance. Lizerman et al. reported that there was a significant reduction in knee flexor muscles endurance in diabetes cases (30,31).

The current study results showed that upper extremity proximal zone endurance was lower in the participants with type 2 DM compared to the healthy participants. According to best of our knowledge this study is the first study assessing upper extremity proximal endurance. Reduction of performance in patients with type 2 diabetes not only in the distal zone but also in the proximal zone is significant for the follow up of these patients and should definitely be assessed.

In a prospective study by Wani and Mullerpatan conducted using the DASH-T questionnaire, functional weakness of the upper extremity was found at the rate of 52.9% in diabetics (32). Laslett et al. investigated shoulder pain, disability and quality of life in diabetic patients and reported that those with higher HbA1c levels or who were receiving retinopathy treatment experienced more severe shoulder pain and disability (33). Another limitation of this study, other than the lack of validity and reliability study of the UULEX test in

patients with type 2 diabetes, is the need of examination level of endurance exposure according to severity and duration of diabetes together with the early effects of diabetes. Further studies are needed depending on the duration and severity of diabetes by using valid and reliable tests in addition to the UULEX test.

The practical implications of the results of this study can be said to be:

1. Future studies are warranted to demonstrate the validity and reliability of UULEX in individuals with type 2 DM.
2. The investigation of the upper extremity functions of diabetic patients and determination of the level of impact is critical.

5. CONCLUSION

Overall, the present study indicated that the endurance and disability levels of patients with type 2 diabetes were affected more substantially than those of healthy individuals. In the light of these outcomes, it is important that not only grip strength but also the upper extremity proximal region should be assessed. Low upper extremity endurance and a high level of disability will cause limitations in daily life activities and injuries due to loading.

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