

Functional Hand Performance Evaluation in Diabetic and Non-Diabetic Patients

Abstract

Introduction: Diabetes, as a chronic internal disease, also manifests musculoskeletal complications. In addition to causing comorbidities in the muscular-skeletal system, it can significantly impact the functional capacity of the muscular system. In this study, we assessed the strength and functional capacity of diabetic individuals compared to age-matched healthy individuals.

Materials & Methods: In a descriptive-analytical study, two groups were compared: diabetic patients—subdivided into two groups based on oral medication treatment and insulin injection—and healthy individuals. Grip strength and pinch strength (key and pulp pinch) were measured in all participants using a dynamometer. Disease-related variables were also recorded in the diabetic group to evaluate their potential impact on functional hand performance.

Results & Discussion: This study included 90 participants—45 diabetic patients and 45 healthy individuals—comprising 21 men (23.3%) and 69 women (76.7%). According to the dynamometer results, there was a statistically significant difference in grip strength and pinch strength (key and pulp) between diabetic patients and healthy individuals, with higher strength recorded in the healthy group. However, no statistically significant difference was observed in grip strength and pinch strength between diabetic patients treated with oral medications and those treated with insulin injections.

Conclusion: The study results indicated that healthy individuals had greater grip strength and pinch strength (key and pulp) compared to diabetic patients. Additionally, there was no statistically significant difference in hand functional capacity between diabetic patients treated with oral medications and those treated with insulin injections, suggesting that hyperglycemia's impact on functional performance may be independent of treatment type.

Keywords: Diabetes mellitus, Grip strength, Hand, Muscle weakness.

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Introduction

Diabetes, over time, can negatively impact patients' daily quality of life. Its complications and related disorders, including cardiovascular diseases, vision problems, hypertension, obesity, and depression, lead to various structural and functional changes in the body, such as neuropathy, retinopathy, nephropathy, cardiovascular diseases, and musculoskeletal issues⁽¹⁾. Neuropathy is a particularly troubling complication and is highly prevalent among diabetic patients⁽²⁾. While many studies have focused on pathologies and functional impairments related to diabetic foot, relatively few have examined the effects on diabetic hands⁽³⁻⁵⁾.

Diabetic hand syndrome encompasses a range of symptoms, including numbness, chronic pain, stiffness, tingling, reduced strength, abnormal sensory functioning, or fatigue⁽⁶⁻⁸⁾. These symptoms can result in deficits in sensory-motor control and functional efficiency of the hands. Hands are vital limbs with complex anatomical structures and precise motor functions, enabling various daily and occupational tasks. Diabetes may lead to progressive physical and functional impairments in neuropathic hands⁽⁹⁾.

Hand performance, a crucial indicator of fine motor function, is often used clinically as a predictor of hand precision. Poor motor skills result in diminished functional efficiency, which can reduce quality of life⁽¹⁰⁾. However, limited information exists regarding the role of hands in the health-related quality of life of diabetic patients. Therefore, this study aimed to compare the functional capacity of hands between healthy individuals and diabetic patients, evaluating the factors influencing hand functionality.

Materials & Methods

This descriptive-analytical study involved two groups: diabetic patients and healthy individuals (control group). Diabetic patients were further categorized into insulin-treated and non-insulin-treated subgroups. Plasma glucose levels in the control group were measured during hand function evaluation at the Imam Khomeini Hospital clinic, affiliated with Urmia University of Medical Sciences.

Exclusion Criteria

- Gestational diabetes
- Pediatric diabetic patients
- ICU inpatients
- Patients on regular hemodialysis
- Individuals with severe psychiatric disorders
- Patients with a history of upper limb amputation, injury, or deformity affecting motor function
- Patients with neurological disorders

Collected Data

Demographic data such as age, gender, smoking status, duration of diabetes, treatment type (insulin or oral medication), hemoglobin A1c levels, and concurrent hand diseases were recorded. Anthropometric measurements, including weight, height, and BMI, were performed. Weight was measured using a SECA 803 digital scale, and height was measured using a portable SECA 206 stadiometer with 0.1 cm precision. BMI was calculated as weight (kg) divided by height squared (m²).

Hand Grip Strength (HGS) Measurement

HGS was measured using a hydraulic hand dynamometer at the hospital. Participants were seated with their elbows bent at 90 degrees, forearms in a neutral position, and wrists dorsiflexed between 0° to 30°.

The dynamometer handle was set to the second position for standardization. Participants, regardless of hand dominance, were instructed to squeeze the dynamometer handle as firmly as possible, first with the dominant hand and then with the non-dominant hand. Two HGS measurements were taken for each hand with a 20-second rest interval to reduce fatigue.

Data Analysis

Data were analyzed using SPSS software. An independent t-test was employed to assess differences in means, and Spearman's correlation was used to analyze relationships between variables. The study was conducted at Urmia University of Medical Sciences following ethical committee approval.

Results

This study included 90 participants: 45 diabetic patients and 45 healthy individuals. The sample consisted of 21 men (23.3%) and 69 women (76.7%), with a mean age of 57.2 ± 5.6 years. According to dynamometer results, a statistically significant difference in grip strength and pinch strength (key and pulp) was observed between the diabetic and healthy groups, with healthy individuals demonstrating higher strength levels (Table 1, Figure 1).

Out of the 45 diabetic patients, 36 (80%) were treated with oral medication and 9 (20%) with insulin injections. Based on clinical examination and history, carpal tunnel neuropathy symptoms were present in 19 patients (42%).

In 26 diabetic patients (58%), no signs of peripheral neuropathy or carpal tunnel syndrome were observed.

There was no statistically significant difference in hand functional ability, grip strength, or pinch strength between the two groups of patients receiving oral medication and insulin injections (Table 2, Figure 2).

Table 1. Comparison of Functional Ability of Right and Left Hands Between Diabetic and Healthy Individuals

variable	Diabetic patients N=45	Healthy N=45	P value
Age	58.4±6	57.6±5.2	0.06
Grip left (kg)	20.1±4.4	29.4±3.5	<0.001
Grip right (kg)	27.4±5.4	37.1±4.8	<0.001
Key pinch right(kg)	6±0.8	6.7±0.5	<0.001
Key pinch left(kg)	4.1±0.6	4.8±0.5	<0.001
Pulp pinch Right(kg)	5.3±0.5	6.3±0.4	<0.001
Pulp pinch left(kg)	4.1±	5.5±0.6	<0.001

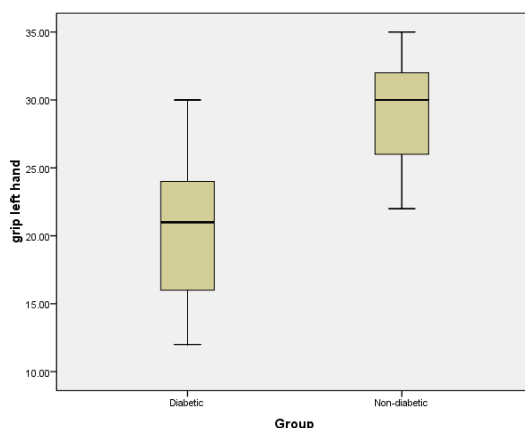


Figure 1: Left-Hand Grip Strength in Diabetic and Healthy Individuals

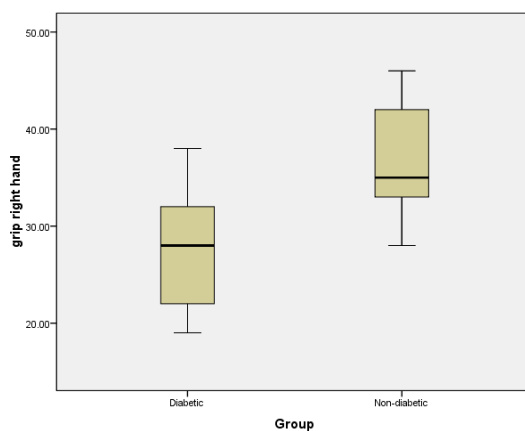


Figure 2: Comparison of Right-Hand Grip Strength Between Diabetic and Healthy Individuals.

Table 2: Comparison Between Two Groups of Diabetic Patients Under Oral and Insulin Treatment

variable	Oral drug patients N=36	Insulin injection N=9	P value
Age	57.7±6.2	61.5±3.8	0.08
Grip left (kg)	22.3±2.7	19.4±4.6	0.1
Grip right (kg)	27.1±5.2	28.5±5.1	0.4
Key pinch right(kg)	6.02±0.8	5.9±0.9	0.7
Key pinch left(kg)	4.07±0.6	4.3±0.5	0.05
Pulp pinch Right(kg)	5.7±0.5	5.2±0.5	0.5
Pulp pinch left(kg)	4.09±0.7	4.03±0.6	0.3
HbA1C(%)	7.6±0.4	7.8±0.5	0.1
FBS(mg/dL)	153.3±24	149.7±37	0.7

Discussion

With the increasing prevalence of chronic and debilitating diabetes, we will undoubtedly encounter more complications related to this disease. Musculoskeletal disorders in diabetic patients are often overlooked, but these complications can lead to significant pain, morbidity, and disability. Upper limb complications, commonly referred to as "diabetic hand," include not only diabetes-specific conditions like limited joint mobility (LJM), but also non-diabetic conditions like trigger finger, Dupuytren's disease, and carpal tunnel syndrome (CTS) (39,40). The impact of diabetic hand complications on hand functional disability, defined as difficulty in performing activities of daily living, in Type 2 diabetes remains unclear⁽¹⁻⁵⁾. The effects of soft tissue problems in the hand associated with diabetes, such as joint mobility limitation, Dupuytren's disease, and trigger finger, on hand functional disability are largely unknown. Grip strength and pinch strength in diabetic Type 2 patients are lower compared to non-diabetic individuals, and the effect of reduced hand strength on functional disability has not been clearly demonstrated before⁽¹¹⁻¹³⁾. According to results obtained from a dynamometer device, there was a significant statistical difference between the two groups of diabetic patients and healthy individuals in terms of grip strength and key and pulp pinch strength, with healthy individuals recording higher strength levels. Previous studies have established a link between diabetes and decreased muscle strength and quality. Grip strength serves as an indicator of nutritional status, with positive correlations to bone mineral density in postmenopausal women and negative correlations to physical weakness, as well as predicting cardiovascular and cancer-related mortality in men (55,56). Diabetic individuals in the present study demonstrated significantly lower grip strength ($p < 0.001$) compared to non-diabetic individuals, which aligns with numerous studies showing consistently lower grip strength in diabetic groups compared to non-diabetic individuals⁽¹⁴⁾. Cetinus et al. conducted a study on 76 diabetic patients and 47 healthy controls and found that diabetic individuals had an average grip strength of 31.53 ± 11.82 kg compared to 36.34 ± 11.01 kg in non-diabetic individuals (58-63). These findings align with our study, as the average grip strength in diabetic patients was 20.14 ± 4.4 kg in the left hand and 27.44

± 5.4 kg in the right hand, while healthy individuals had an average of 29.4 ± 3.5 kg and 37.18 ± 4.8 kg respectively, showing a significant difference between the two groups⁽¹⁵⁾.

Savas et al. evaluated 44 Type 2 diabetic patients and 60 age- and sex-matched controls and found that grip and pinch strength in diabetic patients (27.48 ± 9.26 kg) were significantly lower than in the non-diabetic control group (31.72 ± 9.86 kg) (61). Similarly, Sayer et al. reported lower grip strength in diabetic men (41.8 kg) compared to those with impaired glucose tolerance (IGT) (44.1 kg) and normal glucose tolerance (44.7 kg) (60). In an Indian population study, diabetic men and women had lower grip strength compared to non-diabetic individuals (men: diabetic 20.76 ± 3.55 kg vs. control 32.90 ± 7.60 kg; women: diabetic 18.36 ± 3.50 kg vs. control 25.16 ± 4.45 kg)⁽¹⁶⁾.

Cetinus and colleagues attributed lower grip strength to the muscular weakness of the upper limb flexors, potentially due to the severity of neuropathy⁽¹⁵⁾. In the present study, the average grip strength in insulin-treated diabetic patients was 19.4 ± 4.6 kg in the left hand and 28.5 ± 5.1 kg in the right hand, while patients treated with oral medication had an average grip strength of 22.3 ± 3.7 kg in the left hand and 27.1 ± 5.2 kg in the right hand, with no significant differences observed between the two treatment groups. Furthermore, HbA1C and FBS levels did not show significant statistical differences between the two treatment groups.

Therefore, weaker muscles resulting from immobility may decrease the potential for glucose absorption, leading to hyperglycemia. Chronic diseases along with comorbidities can negatively affect cardiovascular function. The heart may compensate for the underlying pathological burdens, resulting in less efficient blood distribution to body tissues⁽¹⁷⁾.

Wander et al. reported that hand grip strength, considered an overall body strength indicator, is significantly related to physical performance⁽¹⁸⁾. Although multiple factors such as age, mood, time of day, and anthropometric characteristics have been reported as potential influences on hand grip strength (HGS)⁽¹⁹⁾, progressive muscle weakness, joint immobility, and other pathological manifestations may contribute to poor HGS. However, resistance exercises have been shown to improve muscle strength in T2D patients^(20,21).

Studies have shown that activation of specific inflammatory signaling pathways can lead to

apoptosis (programmed cell death), which negatively affects muscle mass and function in various clinical conditions^(22,23). It is worth noting that regular exercise has been consistently shown to reduce blood pressure and improve blood sugar control^(24,25), potentially enhancing metabolic performance and preventing sarcopenia by improving mitochondrial function and reducing inflammation, oxidative damage, and muscle myocyte apoptosis. Furthermore, reduced grip strength among diabetics may be attributed to peripheral neuropathy or diabetic hand syndrome⁽²⁶⁾.

Our study found that 36 out of 45 diabetic patients (80%) received oral medication and 9 (20%) were treated with insulin injections. Carpal tunnel neuropathy symptoms were present in 19 patients (42%) according to clinical examination and history, while no signs of peripheral neuropathy or carpal tunnel syndrome were observed in 26 diabetic patients (58%). Diabetic hand syndrome, characterized by limited joint mobility or diabetic arthropathy, flexor tenosynovitis, and Dupuytren's disease, can cause significant complications and negatively affect grip strength⁽²⁷⁾. Grip strength has been shown to be an indicator of autonomic damage in individuals with diabetes⁽²⁸⁾.

Conclusion

The results of the study indicate that healthy individuals demonstrated higher grip strength and pinch strength compared to the diabetic group. Additionally, there was no statistically significant difference in hand functional ability (grip strength and pinch strength) between the two treatment groups, suggesting that hyperglycemia has an impact independent of the type of treatment.

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Ethics

This study was conducted at Urmia University of Medical Sciences following approval by the ethics committee and as part of a residency thesis.

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