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Correlation between Hand Grip Strength and Nerve Conduction Velocity in Diabetic Patients

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Abstract

Introduction and research problem: Diabetic patients have an increased risk of developing functional disabilities. Hand function in diabetes is influenced by a variety of pathologies. Much less attention has been given to the hand. So, the objective of this study was to evaluate hand grip strength (HGS), nerve conduction velocity (NCV) and the correlation between both variables and the duration of diabetes in type 2 diabetic patients.

Research methodology: Thirty type 2 diabetic patients with their age range from 45 to 55 years and BMI between 25-29.9 kg/m^2 in addition to thirty age-matched normal subjects participated in this study. Both groups were evaluated for HGS and NCV of the median nerve of the dominant hand. After collecting data, statistical analysis was done.

Main results: There was a statistically significant difference regarding the mean HGS for the dominant hand of the study group versus the control group, and the mean motor NCV of the median nerve in the study group versus the control group ($p<0.0001$). There was a high positive correlation between HGS and NCV of the median nerve in the study group ($r= 0.88$).there was a negative correlation between the duration of diabetes and both HGS and NCV ($r= -0.84$) and ($r= -0.76$) respectively.

Conclusion and recommendations: There is a concomitant reduction in HGS and NCV in type 2 diabetic patients and this reduction was negatively correlated to the duration of diabetes. Therefore, incorporating HGS evaluation and training at the earlier stages may help in preventing complications and functional disability in those patients.

Keywords: Hand grip strength, Nerve conduction velocity, and Diabetes mellitus.

Introduction

Diabetes is a metabolic syndrome characterized by hyperglycemia due to deficient insulin secretion and/or insulin action. The chronic hyperglycemia leads to damage, dysfunction, and failure of different organs, mainly the kidneys, nerves, eyes, heart, and blood vessels **(American Diabetes Association, 2013)**.The prevalence of diabetes worldwide is expected to increase about 42% between the years 2003 and 2025**(International Diabetes Federation, 2003)**. Among countries with the highest prevalence of diabetes (adults aged 20 to 79 years), six out of 10 are in the Arab region **(International Diabetes Federation, 2011)**.

Diabetes affects various body systems including musculoskeletal leading to dysfunction and morbidity **(Joslin, 2004)**. The prevalence of connective tissue disorder in diabetic patients has increased in the recent years affecting significantly their quality of life. Approximately 82.6% of individual with diabetes have been found to exhibit musculoskeletal abnormalities, mainly of the degenerative, non-inflammatory type especially among patient with type 2 diabetes (T2DM) **(Duncan et al., 2001)**.

Musculoskeletal disorders, especially in muscles, may be attributed to insulin resistance and hyperglycemia, which cause an increase in the amount of circulating systemic inflammatory cytokines, a reduction in the number of mitochondria in the muscle cells, and a decrease in glycogen synthesis. All of which have a detrimental effect on the function of skeletal muscles **(Helmersson et al., 2004)**. It was proposed that muscle contractile function and force generation are strongly related to hyperglycemia **(Helander et al., 2002)**.

The hand of human is the effecter organ of the upper limb; it is capable of performing countless actions owing to its function as prehension and precision. Hand is not only motor organ but also a very sensitive and accurate sensory receptor, which feeds back information essential for its own performance. Hand is greatly affected by diabetic musculoskeletal complication. Adequate muscle power is required for optimum productivity. Decreased muscle strength is a predictor of physical limitations **(Magee, 2002)**.

One of the many components to be considered in the examination of the hand function is HGS as it provides objective and quantifiable information regarding hand function **(Kuzala and Vargo, 1992)**. Less importance has been given to hand in diabetes mellitus, though hand function is crucial for productivity and quality of life **(Cosanova and Young, 2008)**.

Diabetic peripheral neuropathy (DPN) is one of the most common chronic complications of diabetes, affecting nearly half of T2DM patients **(Boulton et al., 2003)**. Distal symmetrical sensorimotor polyneuropathy is a common type of neuropathy in diabetes involving small and large fibers with insidious onset. Mainly, the first part affected is the distal parts of the lower extremities; leading to stocking hypoesthesia **(Boulton et al., 1983)**. Then, the distal parts of upper limbs are affected and finally the anterior aspect of trunk gets involved. The primary risk factor for diabetic neuropathy is hyperglycemia **(Shaw and Zimmet, 1999)**.

Nerve conduction studies (NCS) are electrodiagnostic tests which are used to evaluate the motor and sensory nerves conduction ability, and used as early indicator of neuropathy in diabetic patients **(Kanavi et al., 2011)**.

As the prevalence of diabetes and its complications is dramatically increasing in Arabic countries, there is a great need for comprehensive and early assessment and treatment of diabetic patients. Diabetic hand received less attention although its great importance in ADL, so early diagnostic and rehabilitative interventions, as HGS and NCV, are needed to counteract the weakness and limitation of hand function. So this study was conducted to evaluate the hand grip strength, nerve conduction velocity of the median nerve and the correlation between both variables in type 2 diabetic patients.

Subject, material and methods

(I) Subjects:

Thirty male type 2 diabetic patients participated in this study. They were selected from the out-patient clinincs in Kasr Al-Ainin Hospital, Cairo University. Thirty matching subjects represented the control group.

- **Inclusion criteria:**

1. T2DM with the duration of the disease from 5 to 10 years. Diagnosis of T2DM was based on the 2012 criteria for diagnosis by American Diabetes Association **(American Diabetes Association, 2012)**.
2. Their age ranged from 45 to 55 years.
3. Body mass index (BMI) ranged from 25 to 29.9 **(WHO, 1995)**.
4. Treated with oral hypoglycemic medications only.
5. Right-handed.
6. Not involved in an occupation that required manual handling or sports that may have conferred on them the advantage of a better handgrip.
7. Without limitation in performance of ADL or usage of walking aids.

- **Exclusion criteria:**

1. Major CNS dysfunction (e.g., hemiplegia or ataxia).
2. Major musculoskeletal disorders and complications, e.g., loss of body parts, rheumatoid arthritis, hand burn, joint stiffness... etc.
3. Patients who are taking insulin therapy.

(II) Material:

1. Hydraulic hand dynamometer - Dynatron (Dynatronics Corporation, Utah, USA) to measure HGS.
2. Straight backed chair without armrest
3. Standard weight and height scale (Koups) to calculate BMI.
4. Standard electromyographic equipment (Nihon Kohden, Neuropak S1) to measure NCV of the median nerve.
5. Digital skin thermometer.
6. Data collection sheet including consent form.

(III) Procedure:

This study was conducted at the Faculty of Physical Therapy, Cairo University. An informed consent was signed by all subjects before participation.

At the beginning of the study, demographic data (i.e., age, weight, height and the duration of diabetes) were obtained and recorded. Height and weight of subjects were measured on a height meter and a calibrated weighing scale, with the subjects not wearing shoes.

The measurement of handgrip strength:

Arm position for assessment of handgrip settled by The American Society of Hand Therapists was utilized. Each subject was positioned in a straight back chair without an arm rest with subject’s feet put flat on the ground. Arm position was demonstrated to all subjects. Each subject was asked to place the right hand on their right thigh and assume a position of shoulder adduction and neutral rotation, while elbow joint was in flexion for 90°, and the forearm and wrist were neutrally positioned, and the fingers flexed for the needed maximum contraction. They were instructed to breathe in through the nose and exhale through a pursed lip after a maximum grip effort was made. A demonstration of maximum handgrip strength was given to each subject before they were asked to do it themselves. Each subject was instructed to squeeze the handle of the dynamometer, which was placed vertically in their hands, as hard as possible. The period of the effort did not exceed 5 seconds. A period of 30 seconds rest was given between three trials for the dominant hand to be tested and the average of the three trials was taken **(Ezema et al., 2012)**.

Nerve Conduction Velocity (NCV) measurement:

The NCV was measured with equipment for EMG recording (Nihon Kohden, Neuropak S1). Skin thermometer will be used to ensure that skin temperature is approximately 32°C.

Measurement of nerve conduction velocity was done using surface electrodes for stimulation and recording. Conductive gel was used on electrodes which were secured in place with adhesive tape. Motor NCV was measured for the right median nerve. Motor NCV was measured by firstly stimulating a peripheral nerve and then recording the response from abductor pollicis brevis muscle. The equipment measures the time for the stimulating impulse to go from the site of stimulation to that of recording; i.e., the latency expressed in milliseconds (ms). NCV across the nerve could be measured by stimulation in two different sites along that nerve. Distance in millimeter (mm) between the different electrodes for stimulation was recorded. Also, difference in latencies (ms) was measured and ratio is depicted as nerve conduction velocity (m/s) **(Morten et al., 2010; Neha et al., 2013)**.

Data analysis:

After data collection, statistical analysis was done using SPSS (Version 17). The mean and standard deviation were presented as descriptive statistics. The independent t-test was used to assess the significance in difference regarding HGS and NCV in study and control group. Pearson’s coefficient was calculated to study the correlation between HGS and NCV in the study group and its correlation to the duration of the disease.

Results:

The subjects in both groups were comparable as regards their demographic and anthropometric parameters, as shown in table (1); there was no significant difference between study and control groups.

Table 1: Demographic and anthropometric data of both groups (mean±S.D.).

	Study group (n=30)	Control group (n=30)	P-value
Age (years)	49.8±3.06	48.43±2.43	0.0602*
BMI (kg/m^2)	27.82±1.48	27.12±1.25	0.0545*

*non-significant

Results showed that the mean values of HGS measurements of the study group were significantly decreased in comparison to the control group ($p < 0.0001$). Also, there was a statistically significant decrease of the mean values of NCV measurements of the study group in comparison to the control group ($p < 0.0001$), (table 2).

Table 2: Mean values of HGS of both groups (mean±S.D.).

Measurement	Study group (n=30)	Control group (n=30)	t-value	P-value
HGS (Kg)	29.74 ± 4.23	43.09 ± 3.88	12.73	< 0.0001**
Motor NCV (median nerve) (m/s)	42.65 ± 3.26	54.11 ± 3.46	13.19	< 0.0001**

**significant

A strong positive correlation, by Pearson's correlation coefficient (r=0.88), was noted between HGS and motor NCV of the median nerve in the study group. A negative correlation between the duration of diabetes and both HGS and NCV was noted in the study group (r= -0.84) and (r= -0.76) respectively (Table 3).

Table 3: Correlation between HGS, NCV and the duration of diabetes of the study group.

HGS	NCV	R	t-value	P-value
29.74 ± 4.23	42.65 ± 3.26	0.88	10.03	<0.0001**
Duration of diabetes	HGS			
7.08 ± 1.44	29.74 ± 4.23	- 0.84	-8.14	<0.0001**
Duration of diabetes	NCV			
7.08 ± 1.44	42.65 ± 3.26	- 0.76	- 7.31	<0.0001**

**significant

Discussion:

The aim of this work was to investigate HGS and median nerve motor NCV in diabetic patients and whether there is a correlation between both variables and its relation to the duration of diabetes.

Diabetic complications are related to deficient metabolic control and duration of the disease **(Franklin, 2004)**. Dysfunctions of the hand are mainly related to duration of DM rather than to glycemic control or concomitant diabetic complications **(Gamstedt et al., 1993)**.

Body mass index (BMI) has an influence on HGS. In the present study, the mean BMI was comparable in the study group and control group. The mean values of HGS were significantly lower in study group compared with the control group (p<0.0001). This finding is in accordance with studies by Cetinus et al., (2005) and Sayer et al.(2005) who showed that the mean grip strength in diabetic patients was 41.8 kg, while in normal non-diabetic subjects it was 44.7 kg (P=0.002). Muscle weakness has been associated with T2DM, even among subjects with high body mass indices **(Bohannon, 2001; Clerke and Clerke, 2001)**.

Reduction in grip strength is associated with poor glycemic control and increased systemic inflammatory cytokines such as tumor necrosis factor a (TNF-a) and interleukin-6(IL-6) which have detrimental effects on muscle function **(Jayaraj and Parmar, 2013)**. Insulin resistance may have been responsible for the muscle weakness **(Sayer et al., 2005)** and, therefore, the decreased grip strength. A decreased HGS in individuals with T2DM has been independently reported **(Rantanen et al., 1999; Leveille et al., 2004)**.

However, Anderson et al., (1997) and Andersen et al., (2004) showed that hand grip strength is not compromised in long-standing T2DM. These differences in the reports may be due to the lack of baseline record of grip strength in all the studies, thereby making it impossible for the change in grip strength after the onset of diabetes to be determined. Furthermore, no data exists on muscle quality at baseline, which may have an important mediating role in determining future muscle quality of individuals with T2DM.

Hand function in diabetes is influenced by a variety of pathologies. The median nerve of the hand, whose integrity is vital to normal hand function, maybe affected by metabolic disturbances, ischemia and/or entrapment neuropathies. Nevertheless pathology in this nerve often goes unrecognized. Median nerve dysfunction would be expected to cause impaired hand function in the form of decreased muscle strength, pain and impaired sensation and in consequence to lead to an increased risk of burns and hand ulceration **(Morbach et al., 2001)**.

In our study, there was a significant reduction in motor NCV of the median nerve in the study group compared to control group ($p<0.0001$). This finding is consistent with results of Tupković et al., (2007) who reported that motor NCV of the median and ulnar nerves is reduced in diabetic patients with and without retinopathy compared to controls.

Hyperglycemia causes a non-enzymatic covalent bonding of glucose with proteins that alters their structure &inhibits their functions. These glycosylated proteins can lead to diabetic neuropathy **(Brownlee, 1992)[1,2]**. Hyperglycemia also increases intracellular diacylglycerol, which activates protein kinase C (PKC); that causes increased vascular permeability, impaired nitricoxide (NO) synthesis &compromise nerve regeneration **(Sheetz and King, 2002)**. Elevated levels of glucose results in activation of polyol or aldose reductase pathway. Excessive activation of polyol pathway leads to increased levels of sorbitol & increased activity of oxygen free radicals. It decreases dihydronicotinamide adenine dinucleotide phosphate (NADPH), NO &glutathione, as well as increases osmotic stress on the cell membrane. By impairing Na^+- K^+ ATPase activity it causes nodal swelling and other structural changes **(Greene and Lattimer, 1983; Greene et al., 1984)**.

The main finding of this study indicates that hand dysfunctions as evaluated by hand grip strength measurement and electrophysiological recordings of nerve conduction velocity (NCV) for the median nerve for the dominant hand in diabetic patients were positively correlated ($r=0.88$)($p<0.0001$). At the same time, both HGS and NCV was negatively correlated to the duration of diabetes ($r=-0.84$ and -0.76) respectively.

These results come in agree with that study by Hamid et al.,(2011) who found a correlation between motor and sensory NCV of the median nerve and pinch and hand grip strength in women. Distal symmetrical neuropathy which may present sub-clinically is responsible for distal muscle weakness and therefore attributes to low grip strength **(Goodpaster, 2008; Lesniewski, 2003)**.

The present study provides additional support for these findings in demonstrating that deficits in median nerve conduction are associated with lower muscle strength and functional performance of the hand and consequently the activity of daily life.

A possible limitation of this study is the sample size. The study, however, has clinical implications for rehabilitation teams because individuals with longstanding diabetes are at increased risk of developing physical disability. If hand grip assessments are done for diabetic patients at the time of diagnosis and routine monitoring incorporated during clinical visits, the development of disability can be detected and preventive modalities like resistive training exercise programs can be instituted to decelerate the rate of deterioration of muscle function before functional disability is advanced.

Conclusion and recommendations

The physiological properties of nerve & muscle are modified due to pathophysiological changes resulting from diabetes. Distal sensorimotor polyneuropathy, the most common complication of DM, may cause severe morbidity. In the present study, results showed a significant reduction in HGS and motor NCV of the median nerve when compared with normal control subjects. There was a strongly positive correlation between the reduction in HGS and the reduction in motor NCV of the median nerve, and both were negatively correlated to the duration of diabetes. This physical limitation may contribute to low productivity in people with T2DM. Therefore, early medical and physical therapy intervention may show better out come in hand function in diabetic patients.

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