International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

A Study of Handgrip Strength in Patients with Type-2 Diabetes Mellitus and Its Association with Some Anthropometric Variables

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ABSTRACT

Introduction: The long-term diabetic status may affect the handgrip strength in patients with type-2 diabetes mellitus.
Objectives: The objectives of the present study were to arrest some anthropometric variables those which affect the handgrip strength of the patients with type-2 diabetes mellitus.
Materials and Methods: For this purpose, purposively selected 576 patients with type-2 diabetes mellitus (251 male and 325 female) of age group 35-60 years were taken from different hospitals of Amritsar. A total of 440 controls (152 males and 288 females) were also taken matching everything, except the disease condition, for comparisons. Nine anthropometric variables, i.e. dominant and non-dominant handgrip strength, height, weight, upper arm, waist and hip circumference, biceps skinfold and triceps skinfold were taken on each subject following standard techniques.
Results: The results showed significantly ($p<0.001$) lower mean values of dominant and non-dominant handgrip strength in diabetic patients, and significantly ($p<0.01$-0.001) higher mean values in three circumferential and two skinfold measurements than their control counterparts. Again, significant positive correlations ($p<0.01$-0.001) of dominant and non-dominant handgrip strength were observed with all the anthropometric variables, and significant negative correlations ($p<0.001$) with biceps and triceps skinfold in patients with type-2 diabetes mellitus.
Conclusion: It may be concluded significantly higher circumferential and skinfold measurements were predictive for the lower handgrip strength values in patients with type-2 diabetes mellitus.

Keywords: Handgrip strength. Selected anthropometric variables. Patients with type-2 diabetes mellitus.

INTRODUCTION

Individuals with longstanding type-2 diabetes mellitus experience limitations of upper limb function and physical disability. [1,2] The chronic complications that occur in diabetic patients decrease their quality of life. In diabetic individuals, the hand is an organ system that is primarily damaged, which is accompanied by impaired function and discomfort for the patients. Handgrip strength has been particularly seen to be related to overall fitness in individuals with diabetes mellitus and as an established marker for conditioning. [3] In old age people, the decrement in muscle mass and strength with advancing age is significantly associated with type-2 diabetes. [4,5] Due to loss of muscle strength, reduced handgrip strength is observed along with the development of physical disability in diabetes. [6,7] The development of physical disabilities in diabetic individuals makes them more disabled in self care tasks as compared to normal age matched individuals. Higher reduction of handgrip strength and agility is seen with increase in duration of type-2 diabetes. [8,9] Association of the duration of diabetes of more than 6 years and poor glycemic control with reduced muscle quality and higher prevalence of musculoskeletal conditions like carpel-tunnel syndrome, muscle atrophy and Dupuytren's contracture was observed by Deal. [10]

Decline in muscle strength with type-2 diabetes mellitus is observed in both males and females. [4] It is reported that men experience more rapid decline in muscle strength, mass and quality as compared to women with aging. [11-13] In older males, elevated fasting glucose levels are found to be more common than older females, but elevated post-challenge glucose levels in older females are greater as compared to older males. Study by Park *et al*. [14] suggested that males suffering from diabetes have lower appendicular muscle strength regardless of greater appendicular muscle mass, in comparison to non-diabetic males, but no such association was reported in females. Dysglycemia poses as a risk factor for decline in grip strength, an indicator for overall reduced muscle strength, especially in men and finally to the augmentation of functional limitations and physical impairments in older adults. [15] However, lesser attention has been paid to functioning of hand in type-2 diabetic patients as compared to diabetic foot and other diabetic complications. [16]

MATERIALS AND METHODS

Participants

The study was conducted in the Department of Physiotherapy, Guru Nanak Dev University, Amritsar, India, after taking Institutional ethical clearance and informed consent of the subjects in a time-span of one year. Study group consisted of 576 confirmed cases of type-2 diabetic mellitus (251 male, 325 female) with a mean duration of diabetes of more than 5 years, and were taken from various Hospitals of Amritsar. A total of 440 controls (152 male, 288 female) without any history of glucose intolerance were also taken for comparisons. The subjects ranged from age group 35-60 years. A total of 559 (97.05%) samples of the present study were right hand dominant. The Age of the subjects was estimated from their date of birth. The subjects with any history of pain and musculoskeletal problems in the shoulder, arm or hand, documented history of trauma or brachial plexus injury, or cervical radiculopathy in the previous 6 months of the commencement of the study were excluded from the study. The data were collected under natural environmental conditions in morning time.

Handgrip strength measurement

The handgrip strength measurement was done using a standard adjustable digital handgrip dynamometer (Takei Scientific Instruments Co., LTD, Japan) at standing position with shoulder adducted and neutrally rotated and elbow in full extension. The dynamometer was held freely without support, not touching the subject's trunk. The subjects were asked to exert maximum force on the dynamometer thrice from their hand and the average maximum value in kilograms was recorded. Handgrip dynamometer was calibrated before each assessment. Thirty seconds time interval was maintained between each handgrip strength testing.

Anthropometric Measurements: Six anthropometric variables, viz. height, weight, upper arm circumference, waist circumference, hip circumference, biceps skinfold and triceps skinfold were taken on each subject following standard techniques [17] and were measured in triplicate with the median value used as the criterion. The height was recorded by using anthropometric rod in cm. The body weight was measured by digital standing scales (Model DS-410, Seiko, Tokyo, Japan) to the nearest 0.1 kg. Upper arm, waist and hip circumferences were measured by steel tape in cm. Biceps and triceps skinfold measurements were done by using Harpenden skinfold calliper in mm.

Statistical analysis

Descriptive statistics (mean ± standard deviation) were determined for the directly measured variables. Student's t-test was applied to compare the data. Correlation coefficients of dominant handgrip strength and non-dominant handgrip strength with selected anthropometric variables were determined using SPSS (Statistical Package for Social Science) version20.0. A 5% level of probability was used to indicate statistical significance.

RESULTS

Table 1 showed the comparison of handgrip strength and selected anthropometric variables in patients with type 2 diabetes mellitus and controls. Patients with type-2 diabetes mellitus had significantly lower (p<0.001) dominant and non-dominant handgrip strength but significantly higher (p<0.01-0.001) upper arm, waist and hip circumference and biceps and triceps skinfold than their control counterparts.

Comparison of handgrip strength and selected anthropometric variables in diabetic males and control males was shown in table 2. Male patients with type-2 diabetes mellitus had significantly lower (p<0.001) dominant and non-dominant handgrip strength but significantly higher (p<0.03-0.001) weight, upper arm, waist and hip circumference and biceps and triceps skinfold than their control counterparts.

Table 3 highlighted the comparison of handgrip strength and selected anthropometric variables in diabetic females and control females. Female patients with type-2 diabetes mellitus had significantly lower (p<0.001) dominant and non-dominant handgrip strength but significantly higher (p<0.01) waist circumference than their control counterparts.

Table 1. Comparison of handgrip strength and selected anthropometric variables in patients with type 2 diabetes mellitus and controls

Variables	Diabetic patients (n=576)		Controls (n=529)		t-value	p-value
	Mean	SD	Mean	SD		
Dominant handgrip strength (kg)	18.91	5.59	21.42	9.65	5.10	<0.001
Non-dominant handgrip strength (kg)	16.29	5.49	18.24	6.24	5.19	<0.001
Height (cm)	162.69	8.91	161.82	8.82	1.54	0.13
Weight (kg)	71.61	11.93	70.11	12.85	1.90	0.06
Upper arm circumference (cm)	30.50	3.71	29.75	4.64	2.81	<0.01
Waist circumference (cm)	99.28	10.44	95.72	11.42	5.09	<0.001
Hip circumference (cm)	107.42	9.50	105.74	11.06	2.56	<0.01
Biceps skinfold (mm)	25.58	7.11	24.39	7.71	2.49	<0.01
Triceps skinfold (mm)	35.22	7.41	33.73	8.39	2.95	<0.001

Comparison of handgrip strength and selected anthropometric variables between diabetic males and females was shown in table 4. Male patients with type-2 diabetes mellitus had significantly higher (p<0.04-0.001) in all the variables studied, except upper arm circumference than their female counterparts.

Table 2. Comparison of handgrip strength and selected anthropometric variables in diabetic males and control males

Variables	Diabetic males (n=251)		Control males (n=241)		t value	p value
	Mean	SD	Mean	SD		
Dominant handgrip strength (kg)	23.23	5.16	26.82	6.09	6.09	<0.001
Non-dominant handgrip strength (kg)	20.35	5.32	23.61	6.34	5.35	<0.001
Height (cm)	171.68	5.53	171.88	4.70	0.37	0.71
Weight (kg)	77.09	12.02	73.82	11.51	2.61	<0.01
Upper arm circumference (cm)	30.78	3.83	28.91	3.97	4.53	<0.001
Waist circumference (cm)	101.52	10.32	96.75	9.23	4.56	<0.001
Hip circumference (cm)	108.46	9.18	105.67	8.16	3.01	<0.001
Biceps skinfold (mm)	23.64	6.92	21.92	6.33	2.44	<0.02
Triceps skinfold (mm)	33.13	7.41	31.36	7.44	2.25	<0.03

Table 3. Comparison of handgrip strength and selected anthropometric variables in diabetic females and control females

Variables	Diabetic females (n=325)		Control females (n=288)		t value	p value
	Mean	SD	Mean	SD		
Dominant handgrip strength (kg)	16.04	3.69	18.57	9.96	4.27	<0.001
Non-dominant handgrip strength (kg)	13.60	3.63	15.40	3.89	5.94	<0.001
Height (cm)	156.72	4.74	156.51	5.05	0.54	0.59
Weight (kg)	67.98	10.39	68.15	13.10	0.18	0.86
Upper arm circumference (cm)	30.32	3.61	30.20	4.90	0.36	0.72
Waist circumference (cm)	97.79	10.26	95.18	12.40	2.85	<0.01
Hip circumference (cm)	106.73	9.66	105.77	12.33	1.07	0.29
Biceps skinfold (mm)	26.86	6.95	25.70	8.05	1.92	0.06
Triceps skinfold (mm)	36.62	7.08	34.99	8.60	2.57	<0.01

Table 4. Comparison of handgrip strength and selected anthropometric variables in diabetic males and females

Variables	Diabetic males (n=251)		Diabetic females (n=325)		t value	p value
	Mean	SD	Mean	SD		
Dominant handgrip strength (kg)	23.23	5.16	16.04	3.69	18.90	<0.001
Non-dominant handgrip strength (kg)	20.35	5.32	13.60	3.63	17.54	<0.001
Height (cm)	171.68	5.53	156.72	4.74	33.63	<0.001
Weight (kg)	77.09	12.02	67.98	10.39	9.38	<0.001
Upper arm circumference (cm)	30.78	3.83	30.32	3.61	1.41	0.16
Waist circumference (cm)	101.52	10.32	97.79	10.26	4.13	<0.001
Hip circumference (cm)	108.46	9.18	106.73	9.66	2.09	<0.04
Biceps skinfold (mm)	23.64	6.92	26.86	6.95	5.29	<0.001
Triceps skinfold (mm)	33.13	7.41	36.62	7.08	5.51	<0.001

Table 5 showed the correlation of dominant and non-dominant handgrip strength with selected anthropometric variables in diabetic males and females. Statistically significant positive correlations ($p<0.05$-0.001) of dominant and non-dominant handgrip strength in the diabetic patients were observed with all the anthropometric variables, and negative correlation ($p<0.05$) with biceps skinfold.

Table 5: Correlation of dominant and non-dominant handgrip strength with selected anthropometric variables in diabetic males and females

Variables	Dominant Handgrip Strength			Non-dominant Handgrip Strength		
	DM	DF	DM+DF	DM	DF	DM+DF
	r	r	r	r	r	r
Height (cm)	0.015	0.224**	0.591**	0.037	0.247**	0.557**
Weight (kg)	0.187**	0.259**	0.395**	0.143*	0.235**	0.363
Upper arm circumference (cm)	0.089	0.162**	0.134**	0.048	0.143*	0.111*
Waist circumference (cm)	0.210**	0.130*	0.238**	0.183**	0.132*	0.227**
Hip circumference (cm)	0.014	0.082	0.094**	-0.024	0.063	0.071
Biceps skinfold (mm)	-0.045	0.144**	-0.101*	-0.054	0.106	-0.113**
Triceps skinfold (mm)	0.014	0.211**	-0.061	-0.044	0.167**	-0.093*

DM= Diabetic Males, DF= Diabetic Females, * Indicates $p<0.05$, ** Indicates $p<0.001$

DISCUSSION

Handgrip strength is a valid predictor of reduction in cognition, functional status and mortality. [18] Reduction in handgrip strength values anticipates the increased dependence and decrease in intellectual abilities. [19] These properties make handgrip strength as a good marker of physical fitness, social and mental health. [20] In the present study, lower handgrip strength values were observed in the diabetic group (both males and females) in comparison to controls following the findings of the previous studies by Leenders *et al.*, [21] Ezema *et al.* [22] and Centinus *et al.* [4] Helmersson *et al.* [23] attributed this reduction in muscle strength in diabetics as compared to age matched healthy individuals to increased insulin tissue resistance and hyperglycemia, which resulted in the reduction in the number of mitochondria in the muscle cells or a decrease in glycogen synthesis and elevated levels of circulating systemic inflammatory cytokines [such as Tumour Necrosis Factor (TNF-α) and Interleukin-6]. Reduction in skeletal muscle strength can also be due to glycosylation of skeletal muscle proteins, actin and myosin. Muscle strength and performance can also be impaired due to insulin resistance as it acts as a regulator for muscle protein breakdown.

The findings of the study also revealed lower values also dominant and non-dominant handgrip strength in diabetic females as compared to diabetic males, supporting the previous findings of Gill *et al.* [24] and Chilima and Ismail. [25] Similar findings were also reported by Mathiowetz *et al.* [26] who stated that males were stronger than females in both the 6-19 year old group and the adult group, along with Crosby *et al.* [27] and Balogun *et al*. [28] who also concluded that males had higher handgrip strength than females. This difference in muscular strength in diabetic males and females could be attributed to differences in body composition between males and females as well as differences in upper body strength, as the women have the tendency of lower proportion of lean tissue distribution in the upper body as compared to men. [29] Males also tend to have larger muscle fibres in the upper and lower extremities as compared to women. Another reason for lower handgrip strength in diabetic females in comparison to diabetic males could be the difference related to hormonal etiologies. As compared to the contraction of type-IIa and type-IIb fibers, the contraction of type-I fibers relies more on glucose entry and metabolism, and are more responsive to insulin particularly in women lowering values of handgrip strength in diabetic females. The impaired muscle function in elderly women could also be attributed to age related decline in maximal unloaded shortening velocity of type-I fibers. [30]

The values of circumferential measurements were reported to on the higher side in diabetic males and females, as compared to the respective control group. Circumferential measurements are considered to be the markers of central obesity and are associated with incidence of type-2 diabetes mellitus. [31] The circumferential measurements have an edge over measurements of body mass index and weight alone, as the visceral fat tissue performs many functions, including endocrine functions. [32,33] The inappropriate distribution of fat shows stronger relation with type-2 diabetes mellitus in contrast to increment in body mass index solely. According to Hartwig *et al*., [31] waist to hip ratio is a weak indicator of incident diabetes, which might be due to its weak correlation with visceral fat in comparison to waist circumference. Hip circumference is an important element of waist to hip ratio and can act as an important indicator of visceral organs and abdominal fat. [34] In the study diabetic males presented higher values of circumferential measurements in comparison to diabetic females, which was in agreement with the study conducted by Ford *et al*. [35] who reported that males presented higher values of waist circumference as compared to females, the mean values of waist circumference being larger than 6cm in men than women.

The values of biceps and triceps skinfold were on the higher side in the diabetic group as described by present study and in favour of the findings of the study by Selvi *et al.* [36] which stated that skinfold thickness depends on the duration of type-2 diabetes mellitus, with increase in skinfold thickness measurements at biceps and triceps in diabetic individuals with duration of disease of less than ten years but reduction in skinfold thickness with duration of disease extending above ten years. It may be due to increase efflux of free fatty acids from the adipose tissue, due to absence of insulin or due to decreased sensitivity to insulin. The present study also depicted higher values of biceps and triceps skinfold in diabetic females in contrast to diabetic males. According to Feldman *et al*., [37] diabetes is accompanied by centripetal distribution of subcutaneous fat, mainly in diabetic females than diabetic males. The study followed the findings of Mc Rae *et al.* [38] and Himes *et al*. [39] describing the significant difference in mean values of skinfold compressibility among men but less corresponding variability in women skinfold compressibility due to differences in the distribution of fibrous tissue and blood vessels in the subcutaneous tissue mediated through genetic and/or hormonal differences in men and women.

CONCLUSION

The study depicted lower handgrip strength values in patients with T2DM, both in males and females as compared to controls. The study also highlighted the selected anthropometric variables that have strong impact on the handgrip strength values. The determination of handgrip strength is of great significance in rehabilitation of hand. It predicts the patient's preliminary restrictions and provides with quick assessment of patient's progress throughout the treatment and helps in planning proper hand exercise programmes for the patients with T2DM, to cope with the disabilities of their day-to-day lives.

Study Limitation

The major study limitation was that the samples were selected only from Amritsar in the age group from 35-60 years. The study also excluded, people suffering from any disease other than type-2 diabetes. Also, due to lack of baseline record of grip strength, it was impossible to determine the change in handgrip strength after the onset of diabetes.

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How to cite this article: Sandhu R, Koley S. A study of handgrip strength in patients with type-2 diabetes mellitus and its association with some anthropometric variables. Int J Health Sci Res. 2018; 8(10):82-89.

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