Original Article

Relationship of obesity indices with clinical severity and nerve conduction studies in females presenting with median nerve compression neuropathy at the wrist

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Abstract

Background: Carpal tunnel syndrome (CTS) is considered to be one of the most common peripheral nerve disorders with female preponderance which significantly reduces work efficacy and needs further research on its preventable factors, especially obesity. We studied the effects of obesity indices on Phalen's test duration and median nerve conduction study (NCS) parameters in patients presenting with CTS. **Methods:** We examined 229 female patients presenting with clinical features of CTS. Clinical examinations including Phalen's test, median NCSs, and body composition were evaluated. Obesity indices and electrophysiological parameters were compared. **Results:** There were significant associations of both body mass index (BMI) degrees and body fat percent (BF%) with clinical and NCS parameters with a linear relationship. BF% and BMI were strongly negatively correlated with Phalen's test duration (BF%; r = -0.334, BMI; r = -0.270 *P* = 0.001). On the other hand, BF% and BMI were positively correlated with median distal latency (BF%; r = 0.338, BMI; r = 0.372, *P* value = 0.001), M-latency (BF%; r = 0.264, BMI; r = 0.285, *P* = 0.001), median motor conduction velocity (MMCV) (BF%; r = 0.119, *P* = 0.072, BMI; r = 0.173, *P* = 0.009), median sensory conduction velocity (MSCV) (BF%; r = -0.195, *P* = 0.003, BMI; r = 0.327, *P* = 0.001), and sensory nerve action potential (SNAP amplitude) (BF%; r = -.239, BMI; r = -0.350, *P* = 0.001). **Conclusions:** Nerve conduction parameters are significantly affected by obesity degree defined by BMI and BF%. Therefore, combining BMI and BF% assessments gives more clinical information regarding CTS severity and management. The true predictive value of these indices needs to be elucidated further.

Keywords: Body fat percentage, body mass index, carpal tunnel syndrome, nerve conduction study, Phalen's test

Introduction

Carpal tunnel syndrome (CTS) is the most common compression neuropathy involving the median nerve when it is passing through the carpal tunnel causing abnormalities in electrophysiological impulses in the distal part of the nerve. This compression leads to pain, numbness, impaired sensory impulses in the distribution of nerves, and eventually to muscle weaknesses and wasting.[1]

Common risk factors that are associated with CTS include an increase in body weight, and hormonal disturbances including hypothyroidism, diabetes mellitus, and pregnancy.[1]

CTS is considered to be one of the most common peripheral nerve compression mononeuropathy accounting for approximately 5%

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of all neuropathies.[2-5] It affects females (especially middle-aged) more than males with a prevalence of 5.8% and 0.6%, respectively.[6,7] The diagnosis depends mainly on the clinical features. Clinical tests also include Phalen's test, Tinel's sign, carpal compression test, and hand elevation test. Even though these tests have a wide range of sensitivity ranging from 57-94% and specificity ranging from 51-97%, still nerve conduction studies (NCSs) are utilized as the gold standard to prove the diagnosis and severity of CTS.[1,8,9]

There are several body adiposity indices such as body mass index (BMI), waist-hip ratio (WHR), and body fat mass (BFM), that have been used extensively and have been correlated to various pathological states but in most cases, they are not adequate and have limited predictive value.[10-12] Instead, other predictors and indices have been introduced with higher accuracy including fat mass index (FMI), trunk fat mass index (TFMI), free fat mass index (FFMI), and body fat percentage (BF%).[10-12] One of the main limitations of fat mass and fat-free mass is using them in relation to the total body weight regardless of the weight content which usually gives false results as in subjects with protein malnutrition have similar fat mass when compared with healthy subjects.[13,14] Therefore, FMI and FFMI (FM or FFM divided by height squared, respectively) are used to overcome these limitations.[13,14]

Even though there is no specific cause of CTS and the studies regarding the involvement of metabolic syndromes are still controversial,[2] there is more recent evidence to correlate metabolic dysregulation such as poor glycemic control and dyslipidemia with CTS.[15,16]

World Health Organization (WHO) reports show an astonishing increase in overweight and obesity rates which continue to rise worldwide despite all educational and preventive measures.[17] In 2016, about 39% of people above 18 years were considered to be overweight, and 13% were obese.[17]

Therefore, our study aimed to study the effects of obesity degree, its indices, and BF% on clinical tests of median nerve compression and NCS parameters in patients presenting with median compression neuropathy at the wrist.

Methods

Participants, setting, and sampling strategies

This is a cross-sectional study in which we recruited a total of 229 patients referred to a neurophysiology clinic with clinical features of CTS. The Institutional Review Board of the College of Medicine, King Saud University approved the study (IRB No: E-21-5967). Written informed consent was obtained from each patient. Participants were adult females, with an age range of 18-65 years, referred with symptoms of CTS to the clinical physiology department at King Abdul Aziz University Hospital, Riyadh, Saudi Arabia between November 2020 and February 2022.

Inclusion and exclusion criteria

Inclusion criteria were female patients presenting with CTS confirmed by clinical symptoms including numbness and/or pain in the distribution supplied by the median nerve, positive Phalen's test, carpal tunnel compression test, and NCS findings with no previous surgical treatments. The American Academy of Neurology (AAN), American Society of Electromyography (ASE), and American Academy of Physical Medicine and Rehabilitation (AAPMR) recommended protocols and guidelines were followed for the electrodiagnostic studies of upper limbs. The exclusion criteria were male patients, traumatic hand injuries, or surgical procedures of the hand and forearm, rheumatoid problems, malignancy, pregnancy, and tenosynovitis.

Clinical tests: Phalen's, Tinel's test, and carpal tunnel compression test

In Phalen's test, the patient was asked to hold both hands with complete palmar flexion of the wrist, flexion of the elbow, and pronation of the forearm with a positive result if symptoms were reproduced in 1 min. To perform the carpal tunnel compression test, pressure was applied between the thenar and hypothenar eminence for 30 s by the examiner with supination of the patient's arm with a positive result if symptoms were reproduced in 30 s. Afterward, an NCS was performed to prove the diagnosis. We used a Nicolet NCS and electromyography (EMG) setup (The Nicolet EDX with Natus Elite Software, Orlando, Florida, USA) to perform sensory and motor nerve conduction tests. We used orthodromic sensory nerve conduction measurements from the index, middle, and little fingers to the wrist, with recordings over the surface of the median proximal distribution to the distal wrist crease.[18]

Body composition analysis

For the analysis of the body composition, bioelectrical impedance analysis (BIA TANITA, USA) was used. The body composition analyzer performs the calculation of each tissue by using the electrical impedance differences between the tissues with eight tactile electrodes attached to the hands and feet. The subjects were categorized according to BMI into six groups: BMI < 18.5; underweight, BMI 18.5-24.9; normal, BMI 25.0-29.9; overweight, BMI 30.0-34.9; Obesity class I, BMI 35.0-39.9; Obesity class II, and BMI 40.0+; Extreme obesity class III.

Data analysis

Analysis was performed using IBM SPSS 21 version statistical software. We used to describe the variable. We used the Chi-square test to compare proportions and frequencies while the Student's *t*-test to compare continuous variables in terms of Phalen's test duration and median nerve parameters. A P value of ≤0.05 at 95% confidence was used to measure the statistical significance. We determined the correlations of body adiposity indices, with Phalen's test and NCS parameters by using Spearman's correlation analysis.

Results

Table 1 represents the demographic characteristics of all the 229 subjects recruited with CTS. It shows the mean age of the subjects, BMI, and Phalen's test duration.

A comparison of Phalen's test duration and median nerve electrophysiological parameters in different classes of BMI is expressed in Table 2. A statistically significant negative association was observed between obesity degrees and Phalen's test duration ($P < 0.001$) and a decrease in Phalen's duration with an increase in the obesity degree. It also shows a statistically significant negative relationship between obesity degree and sensory nerve action potential (SNAP amplitude), median sensory conduction velocity (MSCV), and median motor conduction velocity (MMCV) with a decrease in velocity and SNAP amplitude with an increase in obesity degree ($P < 0.001$). On the other hand, there is a positive significant association between obesity degree and median nerve distal latency ($P < 0.001$).

Table 3 reveals a comparison of Phalen's test duration and median nerve electrophysiological parameters in BF%-defined obesity (Desired BF% <35, High BF% ≥35). A statistically significant negative association between BF% and Phalen's test duration ($P = 0.002$) (i.e., decrease in Phalen duration with high BF%) is shown in Table 3. In addition, it also shows a statistically significant negative relationship between BF% and compound muscle action potential (CMAP amplitude) ($P = 0.003$), MMCV ($P = 0.030$), sensory conduction velocity ($P = 0.016$), and SNAP amplitude ($P = 0.001$). On the other hand, there is a positive significant association between BF% and median nerve distal latency ($P < 0.001$).

Table 4 reveals the relative Pearson's correlation coefficients of BMI and BF% in relation to Phalen's test duration and median nerve electrophysiological parameters. It shows that Phalen's test duration has a significant negative correlation with BMI ($P < 0.001$), CMAP amplitude ($P = 0.043$), MMCV ($P < 0.009$), MSCV ($P < 0.001$), and SNAP amplitude ($P < 0.001$). On the other hand, BMI was positively significantly correlated to median distal latency ($P < 0.001$) and M-latency ($P < 0.001$). BF% is negatively correlated to Phalen's test duration ($P < 0.001$), CMAP amplitude ($P = 0.043$), MMCV ($P < 0.009$), MSCV ($P = 0.004$), and SNAP amplitude ($P < 0.001$) but it was positively significantly correlated to median distal latency ($P < 0.001$) and M-latency ($P < 0.001$).

Table 1: Characteristics of the subjects of the sample (*n*=229)

Variable	Mean	Standard Deviation	Range Minimum-Maximum
Age (years)	47.8	10.8	21-80
Height (meters)	1.5	0.1	1.5-1.8
Weight (kg)	79.9	17.1	46.2-128.6
BMI (kg/m^2)	31.5	6.3	16.2-49.5
TBFM (kg)	30.9	11.0	3.4-61.3
BF%	37.9	8.1	7.1-52.7
Phalen's duration (s)	25.3	13.8	8-80
Median distal latency (ms)	4.1	1.3	2.5-9.9
M-latency (ms)	4.0	1.6	0.6-11.9
CMAP amplitude (mv)	8.2	3.1	0.2-17.9
MMCV (m/s)	52.9	5.7	37-68
MSCV (m/s)	43.7	8.1	26-67
SNAP AMP (uV)	44.6	29.9	3.0-138.6

Data are presented as mean and standard deviation. BMI: Body mass index, TBFM: Total body fat mass, TBFFM: Total body free fat mass, TBW: Total body water, CMAP amplitude: Compound muscle action potential, MMCV: Median motor conduction velocity, MSCV: Median sensory conduction velocity, SNAP: Sensory nerve action potential, s: seconds, ms: milliseconds

Discussion

The present study provides an insight into the causative association of obesity indices with clinical features and electrodiagnostic studies in patients presenting with features of CTS. It is well known that CTS is more common in the working population than general population with a prevalence of 8%,[19] and is, even more, higher with other causes like rheumatoid disorders, fractures of the distal radius, and osteoarthritic changes of the wrist.[20,21] Other risk factors including metabolic syndromes such as diabetes and obesity play major roles in the causation of CTS.[22,23] Recent pieces of evidence suggest that markers of adiposity like BF% have even higher predictive value than elevated BMI and diabetes mellitus which are considered independent risk factors of CTS. Therefore, controlling weight should be part of the treatment strategy of CTS.[22,24]

This study emphasizes the effects of obesity degree classes on one of the important CTS clinical bedside tests (Phalen's test). According to the literature, our study is considered the first study

Table 2: Comparison of Phalen's test duration and median nerve electrophysiological parameters in different classes of BMI (*n*=229)

Parameters	Phalen's test duration (s)	Median distal latency (ms)	CMAP Amplitude (mv)	M-latency (ms)	MMCV (ms)	MSCV (ms)	SNAP Amp (uV)
N	34.5±0.2	3.3±0.1	10.1±0.4	3.3±0.1	55.1±0.8	47.8±1.4	58.0±6.8
OW	23.0±1.4	3.6±0.1	9.7±0.4	3.6±0.1	53.2±0.6	44.3±0.8	54.1±3.6
Ob1	27.3±2.1	4.3±0.1	8.6±0.3	4.4±0.2	52.0±0.6	44.9±1.1	36.4±3.3
Ob2	20.6±1.4	4.6±0.2	8.1±0.5	4.0±0.1	51.0±1.1	39.8±1.2	40.2±4.2
Ob3	21.7±2.2	4.6±0.2	9.8±0.6	4.9±0.4	53.7±0.9	40.1±1.1	27.5±3.0
All cases	25.3±0.9	4.1±0.0	9.2±0.2	4.0±0.1	52.9±0.3	43.7±0.5	44.6±2.0
P	<0.001**	<0.001**	0.017**	<0.001**	0.016**	<0.001**	<0.001**

Data are represented as mean and standard error, **P*<0.05, ***P*<0.01, N=BMI 20-24.9, OW=25-29.9, OB1=30-34.9, OB2=35-39.9, OB3=40 and more, CMAP=Compound muscle action potential, MMCV=Median motor conduction velocity, MSCV=Median sensory conduction velocity, SNAP=Sensory nerve action potential, s= seconds, ms=milliseconds

Table 3: Comparison of Phalen's test duration and median nerve electrophysiological parameters in BF%-defined obesity (Desired BF% <35, High BF% > or =35)

Parameters	Phalen's test duration (s)	Median distal latency (ms)	CMAP amplitude (mv)	M-latency (ms)	MMCV (ms)	MSCV (ms)	SNAP amplitude (uV)
BF% <35 (*n*=80)	31.4±1.6	3.5±0.1	9.4±0.2	3.5±0.1	53.8±0.5	45.6±1.0	51.3±4.0
BF% ≥35 (*n*=149)	22.0±1.0	4.4±0.1	9.1±0.2	4.3±0.1	52.4±0.5	42.6±0.5	40.8±2.2
P	0.002**	<0.001**	0.003**	<0.001**	0.030**	<0.016**	0.001**

Data are represented as mean and standard error, **P*<0.05, ***P*<0.01, CMAP=Compound muscle action potential, MMCV=Median motor conduction velocity, MSCV=Median sensory conduction velocity, SNAP=Sensory nerve action potential, s=Seconds, ms=Milliseconds

Table 4: Pearson's correlation coefficients of body mass index and BF% in relation to Phalen's test duration and median nerve electrophysiological parameters (*n*=229)

Parameter	BMI	BF%
Phalen's test duration (s)	-0.270*	-0.334*
Median distal latency (ms)	0.372*	0.388*
CMAP amplitude (mv)	-0.134*	-0.079
M-latency (ms)	0.285*	0.264*
MMCV (ms)	-0.173*	-0.119
MSCV (ms)	-0.327*	-0.195*
SNAP amplitude (uV)	-0.350*	-0.239*

*Statistically significant. BMI=Body mass index, BF% = Body fat percent, CMAP=Compound muscle action potential, MMCV=Median motor conduction velocity, MSCV=Median sensory conduction velocity, SNAP=Sensory nerve action potential, s=Seconds, ms=Milliseconds

that correlated obesity degree precisely and BF% with Phalen's test duration and median nerve parameters. We identified that Phalen's test duration is negatively correlated to both TBFM as well as FMI (more negatively to FMI).

Majumdar *et al*. and Naik *et al*. have studied the effects of obesity in general on MMCV and found a decrease in velocity as well as amplitude with an increase in latency of the nerve but without categorizing obesity degree.[24,25] In our study, there was a significant decrease in the sensory as well as motor conduction velocities of the median nerve with the increase in the obesity degree along with the decrease in the amplitude of the nerve.

One of the weaknesses of this study is evaluating obesity degree with only one clinical test of CTS. It would be a great idea to evaluate and correlate the effect of obesity with a variety of bedside clinical tests of median nerve compression such as Tinel's test, Carpal compression test, and hand elevation test.

Conclusions

NCS parameters and Phalen's test duration are significantly affected by obesity degrees defined by BMI and BF%. Therefore, combining BMI and BF% assessments gives more clinical information regarding CTS severity and management. The true predictive value of these indices needs to be elucidated further in large-scale studies.

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Conflicts of interest

There are no conflicts of interest.

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