**Biomedical Research Bulletin.** 2024;2(4):178-184
doi: 10.34172/biomedrb.2024.24
http://biomedrb.com

Original Article

# Association Between Clinical Severity of Carpal Tunnel Syndrome and Physical Characteristics, Including Body Mass Index, Total and Segmental Body Composition

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**Article History:**
**Received:** October 20, 2024
**Revised:** November 27, 2024
**Accepted:** December 21, 2024
**ePublished:** December 29, 2024

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**Abstract**

**Background:** Carpal tunnel syndrome (CTS) is pressure on a nerve in your wrist. It causes tingling, numbness and pain in your hand and fingers. You can often treat it yourself, but it can take months to get better. This study evaluated the body composition of individuals with mild to severe carpal tunnel syndrome (CTS) alongside healthy controls to assess the associated risk factors, namely obesity and elevated body mass index (BMI).

**Methods:** Overall, 160 participants were recruited, including 80 CTS patients referred to the Physical Medicine and Rehabilitation Research Center of Imam Reza hospital and 80 healthy controls within a year. The CTS group underwent comprehensive evaluation by a physical medicine specialist, examining physical parameters. CTS in patients was diagnosed using the Phalen's test, a positive Tinel sign, and electromyography-assisted examination. Additionally, the Boston Symptom Severity Scale and Boston Functional Status Scale Questionnaire were applied to assess the severity of CTS symptoms and their impact on daily functioning.

**Results:** The mean body weight and BMI of the participants in the CTS and control groups were 83.49 ± 11.71 and 33.76 ± 3.76, as well as 70.78 ± 8.29 and 28.44 ± 3.44, respectively. The CTS group exhibited a significantly higher percentage of body fat, soft lean mass, and total and segmental (arm) mass of body fat (MBF) compared to the control group. The severity of clinical symptoms in CTS patients revealed no significant correlation with their BMI. There was a statistically significant correlation between MBF and Boston functional status scores ($r = 0.317$, $P = 0.025$).

**Conclusion:** In general, our findings demonstrated that CTS patients had significantly higher BMI, total BPF, and arm segmental fat percentage than healthy controls.

**Keywords:** Body composition, Body mass index, Boston Questionnaire, Carpal tunnel syndrome

## Introduction

Carpal tunnel syndrome (CTS) occurs when the median nerve is compressed as it travels through the wrist. It is the most common peripheral nerve entrapment syndrome.[1] This debilitating disorder affects a wide range of age and profession groups, making it one of the most prevalent upper limb disorders.[2] CTS causes different symptoms, such as pain, numbness, tingling, and weakness, in the distribution of the median nerve, which includes the first three digits and the radial half of the fourth digit, and may be worse at night, waking up affected patients from sleep.[1,3-6] Due to its adverse impact on productivity and quality of life, this syndrome has garnered significant attention from the medical community.[7,8]

The symptoms of CTS can manifest solely in the wrist, impact the entire hand, or extend toward the shoulder.[9,10] Several tests, such as the Phalen, Tinel, manual carpal compression, hand elevation, and upper limb neurodynamic tests, can provoke its symptoms.[11,12] However, their sensitivity and specificity are only moderate when interpreted in the appropriate clinical context.[11,12] Electrodiagnostic is necessary for atypical symptoms and patients with moderate-severe symptoms that progress despite conservative treatment.[13-15]

Many factors have been studied in the etiology of CTS, including genetics, occupation, and repetitive motions.[16] In recent years, the body mass index (BMI) has become a topic of interest in CTS research.[17] It has been shown that an increase in weight can lead to CTS due to fluid accumulation in the tissue spaces of the carpal tunnel.[17] In obese patients, excess fat tissue in the carpal tunnel narrows the tunnel and increases intra-carpal canal pressure.[18]

Another study identified the wrist ratio, shape index, and higher BMI as independent risk factors for CTS.[19] However, the correlation between other measurements, such as wrist and waist circumferences, and CTS severity is not completely understood yet. Our research used a two-fold approach to compare BMI in CTS patients with a healthy control group. This approach adds depth and innovation to the field because most studies have traditionally focused on individual risk factors. By examining the interaction between BMI and CTS, this study aims to provide a more comprehensive understanding of the origins and offer potential approaches for more effective prevention and treatment strategies.

As the prevalence of CTS increases worldwide, it has become crucial to identify all potential contributing factors to develop informed strategies for prevention and management. Given the current obesity epidemic, BMI's role in CTS is of significant public health importance. Therefore, our research seeks to fill a critical knowledge gap by providing a deeper understanding of this correlation and improving the patient's quality of life. It has been attempted to examine the association between anthropometric indices and body composition indices with clinical symptoms in patients with CTS.

## Methods

### *Study Type and Participants*

This case-control study was conducted in the Outpatient Physical Medicine and Rehabilitation Clinic of Imam Reza Hospital of Tabriz university of medical sciences, Tabriz, Iran, between September 2019 and April 2020. The controls were recruited from the clinic staff, healthy volunteers, and their friends using a convenient sampling method. A physiatrist evaluated CTS patients by either Tinel's or Phalen's test and evidence of median neuropathy in the nerve conduction study (NCS) at the wrist level. Before participation, each patient provided written informed consent. The study protocol was reviewed and approved by the Local Ethics Committee of Tabriz University of Medical Science, and all experiments were conducted in accordance with relevant ethical standards. All participants signed a detailed informed consent form prior to the study.

### *Selection Criteria*

Consecutive case series were recruited, consisting of patients who had overt numbness and pain in three and a half fingers along the radius. These patients had an established diagnosis through positive NCS, which was determined by reduced median nerve conduction values ( $<50$ m/s) and/or increased motor latency ( $>4$ m/s). The exclusion criteria for the CTS patients were a medical history of rheumatoid arthritis, previous corticosteroid treatment, medical history of hypothyroidism, amyloidosis, and acromegaly, and evidence of ulnar neuropathy at the wrist level. The other exclusion criteria included previous wrist fractures, cervical radiculopathy, and clinical signs or electrodiagnostic results indicating the existence of neurological disorders such as polyneuropathy or hereditary neuropathy.

The Boston carpal tunnel questionnaire had to indicate no signs or symptoms of CTS for participants in the control group, and their electrodiagnostic study had to show no abnormal findings. The exclusion criteria for the control group were identical to those for the case group.

### *Clinical Diagnostic Tests*

The Phalen's test, a common clinical diagnostic maneuver, involves flexing the wrist at 90 degrees and holding it in this position for 60 seconds. The onset or exacerbation of numbness, tingling, or pain in the affected fingers is considered a positive test.

The Tinel sign test involves gently tapping or percussing the area over the suspected nerve compression site. A positive test is characterized by the patient experiencing a tingling sensation, often described as pins and needles or an "electric shock", radiating along the path of the tested nerve.

Electrodiagnostic testing, including electromyography/nerve conduction velocity tests, is used to confirm the diagnosis. This involves assessing the electrical activity of the median nerve and associated muscles in the affected hand, helping identify the extent and severity of nerve compression.[20]

### *Sample Size Calculation*

The estimation of the total sample size for the study was 164 participants, which was conducted using G*Power (version 3.1.2.). The number of participants for each group with a ratio of controls to cases of 1:1 was calculated to be 70 based on the data from a study conducted by Chen et al on the correlation between BMI and CTS, mean (m)1 = 25.9, (m)2 = 23.5, standard deviation (SD)1 = SD2 = 4.5, and a power of 85%.[21] To account for any unfinished surveys, an additional 15% was added to the estimated sample size.

### *Data Collection*

Demographic and clinical data such as age, gender, weight, BMI, average Boston total score, average Boston symptom severity, average Boston's functional status scores, and history of diseases were obtained from all patients (Table 1). The Boston questionnaire was applied to evaluate the functional status and severity of symptoms.[22] The Symptoms Severity Scale is composed of 11 items that evaluate the severity, frequency, time, and type of symptoms. The Functional Status Scale measures the impact of the syndrome on daily activities. Each item is rated on a scale of 1 (no symptoms/difficulties) to 5 (the most severe symptoms/unable to perform any activity).[23,24] The Persian version of the Boston CTS Questionnaire (BCTQ) is a reliable and valid tool for assessing the functional and symptomatic aspects of CTS.[25]

The patients' weight was recorded with a precision of 0.5 kg using Seca scales while wearing minimal clothing and no shoes. The wall height meter was used to measure height with a precision of 0.1 cm. Moreover, BMI was computed by dividing weight in kg by the square of height in meters. Additionally, bioelectrical impedance analysis was employed to measure body composition using the Zeus 9.9 BC analyzer system, which provides measurements of percent body fat (PBF), mass of body fat (MBF), and soft lean mass (SLM).

### *Data Analysis*

The data were analyzed using SPSS software (version 18.0), which was developed by SPSS Inc. in Chicago, IL. The mean ± SD was employed to present quantitative variables, while numbers (percentages) were used to present qualitative variables. The Kolmogorov-Smirnov test was utilized to assess the distribution of quantitative data. The measured variables between the two groups were compared using the independent samples t-test and Mann-Whitney U test. The Pearson/Spearman correlation coefficient was applied to determine the correlation between variables and pain severity in the case group. Logistic regression analysis was performed to identify factors that affect the risk of CTS. Statistically significant values were reported as $P < 0.05$.

## Results

### *Baseline Characteristics*

A total of 80 patients, participated in this study, including 16 male and 64 female. The case group had an average age of 47.32 ± 8.04 years, while the control group consisted of 80 healthy individuals with an average age of 47.63 ± 9.46 years, out of whom 52 were females and 28 were males. Based on the results (Tables 1 and 2), there were no significant differences in terms of the demographic data between the two groups ($P > 0.05$).

### *Anthropometric and Body Composition Parameters*

The CTS group had a mean body weight and BMI of 83.49 ± 11.71 kg and 33.76 ± 33.76 kg/m$^2$, respectively. Meanwhile, the control group had a mean body weight and BMI of 70.78 ± 8.29 kg and 28.44 ± 3.44 kg/m$^2$, respectively, showing a significant difference ($P < 0.001$). In the case group, 10 patients (20%) were overweight, 18 patients (36%) had obesity grade 1, 16 individuals (32%) had obesity grade 2, and 4 individuals (8%) had obesity grade 3. Based on the results, those with CTS demonstrated significantly elevated levels of body composition parameters of PBF ($P > 0.001$), SLM ($P > 0.001$), and MBF (arms and body, $P > 0.001$, $P = 0.006$, respectively) when compared to the control group (Table 2).

### *Relationship Between Body Mass Index and the Severity of Clinical Symptoms*

The obtained data revealed that there was no significant correlation between the severity of clinical symptoms (i.e., numbness, wrist pain, paresthesia, and tingling) in CTS patients and their BMI ($P > 0.05$, Table 3). The assessment of BMI and body composition parameters' correlation with the Boston total score, symptom severity, and functional status scores in CTS patients represented a weak correlation between MBF and Boston functional status scores (r = 0.317, $P = 0.025$) (Table 4).

## Discussion

Expanding our comprehension of the multifaceted origins of CTS, our investigation explored the intricate correlation between BMI and CTS. According to our findings, elevated BMI had a significant association with the occurrence of CTS. It was further revealed that CTS patients present notably higher levels of BMI overall and arm segmental PFB than those who are healthy. Additionally, no substantial correlation was observed between BMI and the severity of clinical symptoms in patients with CTS. Our outcomes support prior research, highlighting recent weight gain as a risk factor for CTS caused by increased fluid accumulation within the carpal tunnel.[17,26,27] Excessive adipose tissue in obese individuals leads to increased pressure in the intracarpal canal, compressing the median nerve.[18]

CTS is a condition with an unknown cause, but several risk factors have been identified, including diabetes, thyroid disease, wrist fracture, age, and female gender.[28]

**Table 1.** Demographic Characteristics of Patients With CTS and the Control Group

| Variables | Patients (n = 80) | Healthy Control (n = 80) | *P* Value |
|---|---|---|---|
| Age | 47.32 (8.04) | 47.63 (9.46) | 0.73 |
| Gender | | | |
| Female | 64 (80%) | 52 (55%) | 0.15 |
| Male | 16 (20%) | 28 (45%) | |
| Weight | 83.49 (11.71) | 70.78 (8.29) | < 0.001 |
| BMI | 33.76 (5.06) | 28.44 (3.44) | < 0.001 |
| Boston total score | 2.61 (0.61) | | |
| Boston symptom severity score | 2.19 (0.67) | | |
| Boston functional status score | 2.92 (0.66) | | |
| History of diseases | | | |
| No | 70 (87.5%) | 72 (90%) | 0.85 |
| History of diabetes | 8 (10%) | | |
| History of hypothyroidism | 2 (2.5%) | | |

*Note*. BMI: Body mass index; CTS: Carpal tunnel syndrome.

**Table 2.** Comparison of Body Composition Parameters Between Patients With CTS and Control Group

| Variables | Patients (n = 80) | Healthy Control (n = 80) | *P* Value |
|---|---|---|---|
| PBF | 36.84 (7.42) | 26.41 (3.37) | 0.001 > |
| MBF (arm) | | | |
| Right | 3.62 (1.55) | 3.12 (1.27) | 0.001 > |
| Left | 3.71 (1.79) | 3.10 (1.56) | |
| MBF (body) | 31.48 (9.08) | 25.46 (4.78) | 0.006 |
| SLM | 47.60 (6.29) | 39.45 (6.54) | 0.001 > |

*Note*. CTS: Carpal tunnel syndrome; MBF: Mass of body fat; PBF: Percent of body fat; SLM: Soft lean mass.

**Table 3.** Body Mass Index and the Severity of Clinical Symptoms in Patients With CTS

| Clinical Symptoms | Mean BMI | *P* Value |
|---|---|---|
| Night numbness | | |
| No | 31.90 (5.19) | |
| Mild | 33.36 (5.60) | |
| Modest | 39.39 (5.69) | 0.79 |
| Severe | 35.08 (4.69) | |
| Very severe | 28.80 | |
| Numbness during the day | | |
| No | 0 (0) | |
| Mild | 33.58 (7.10) | |
| Modest | 33.25 (4.86) | 0.74 |
| Severe | 34.81 (7.8) | |
| Very severe | 28.80 | |
| Paresthesia and tingling | | |
| No | - | |
| Mild | 31.83 (4.30) | |
| Modest | 33.28 (5.97) | 0.37 |
| Severe | 35.80 (4.01) | |
| Very severe | - | |
| Wrist pain | | |
| No | 29.97 (7.44) | |
| Mild | 30.40 | |
| Modest | 34.12 (5.27) | 0.38 |
| Severe | 34.95 (3.87) | |
| Very severe | - | |
| Muscle weakness | | |
| No | 33.65 (8.13) | |
| Mild | 30.46 (2.46) | |
| Modest | 36.61 (3.81) | 0.14 |
| Severe | 32.43 (5.97) | |
| Very severe | - | |

*Note*. BMI: Body mass index; CTS: Carpal tunnel syndrome.

Research has indicated that CTS may be linked to high BMI and could have a considerable impact on its onset.[29] Komurcu et al reported that waist circumference was significantly higher in patients with CTS than in the healthy group and identified a significant correlation between CTS severity and age, BMI, and waist circumference.[29]

Our results also demonstrated that the BMI of CTS patients was significantly higher than that of the control group. Nonetheless, no notable association was detected between BMI and the severity of symptoms or the level of functional ability. This may be due to the difference in sample size between our study and the study performed by Komorcu et al.[29] According to research, having a BMI of more than 30 kg/m$^2$ can result in the accumulation of fat in the carpal canal. This can lead to hydrostatic pressure on the median nerve located within the carpal tunnel in the wrist.[30] The cause-and-effect relationship between higher BMI values and increased risk of CTS still needs to be fully understood. Our findings confirmed that patients with CTS had significantly higher percentages of total body fat, SLM, and MBF arm, as well as a different body composition of MBF and SLM compared to the healthy group. Mondelli et al concluded that anthropometric measurements are not effective screening tests for identifying individuals at high risk of CTS. However, they reported that the hand/wrist ratio has moderate accuracy in detecting at-risk populations.[31] Thiese et al revealed a significant correlation between CTS and a square wrist.[32] They also discovered that the relationship between wrist ratios and both CTS and abnormal NCS results was strongly influenced by BMI.[32] Based on the results of a study conducted by Razavi et al, there was no correlation between lipid profile and high BMI with the severity of CTS, as determined by either the Boston CTS Questionnaire or electrodiagnostic findings.[33] Nonetheless, they found a correlation between the female gender and the severity of CTS symptoms.

**Table 4.** Correlation Between Body Mass Index and Body Composition Parameters With Boston Total Score, Symptom Severity, and Functional Status Scores in Patients With Carpal Tunnel Syndrome

| | | BMI | MBF | LBM | SLM | | MBF (Arm) | | | SLM (Arm) | -0.030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Boston total score | Correlation coefficient | 0.116 | 0.178 | -0.009 | 0.004 | Right | Correlation coefficient | 0.112 | Right | Correlation coefficient | 0.836 |
| | | | | | | | *P*-value | 0.440 | | *P*-value | -0.089 |
| | *P*-value | 0.424 | 0.216 | 0.948 | 0.978 | Left | Correlation coefficient | 0.155 | Left | Correlation coefficient | 0.541 |
| | | | | | | | *P*-value | 0.283 | | *P*-value | -0.068 |
| Boston symptom severity score | Correlation coefficient | -0.006 | 0.102 | -0.016 | -0.001 | Right | Correlation coefficient | 0.076 | Right | Correlation coefficient | 0.640 |
| | | | | | | | *P*-value | 0.602 | | *P*-value | -0.121 |
| | *P*-value | 0.969 | 0.483 | 0.911 | 0.994 | Left | Correlation coefficient | 0.102 | Left | Correlation coefficient | 0.404 |
| | | | | | | | *P*-value | 0.483 | | *P*-value | -0.035 |
| Boston functional status score | | 0.203 | 0.317 | -0.004 | 0.003 | Right | Correlation coefficient | 0.206 | Right | Correlation coefficient | 0.807 |
| | | | | | | | *P*-value | 0.152 | | *P*-value | -0.081 |
| | | 0.158 | 0.025 | 0.976 | 0.976 | Left | Correlation coefficient | 0.245 | Left | Correlation coefficient | 0.577 |
| | | | | | | | *P*-value | 0.087 | | *P*-value | |

*Note*. BMI: Body mass index; CTS: Carpal tunnel syndrome; MBF: Mass of body fat; PBF: Percent of body fat; SLM: Soft lean mass; LBM: Lean body mass.

Furthermore, the results of a study by Wei et al confirmed that wrist joint index and higher BMI were associated with increased median distal latency in electrodiagnosis tests. An independent risk factor for CTS in manual laborers was a wrist joint index of greater than 0.73.[34]

There was no significant correlation between the average BMI and the Boston total score, Boston symptom severity, and functional status scores in the current study. The Boston Questionnaire was used to evaluate the CTS group's symptom severity and functional status. However, since the patients were self-assessing using this questionnaire, their responses may not have been entirely accurate. Our findings are consistent with those of previous research, linking the risk of CTS to BMI and weight gain. CTS patients were found to have a considerably higher BMI, and its effect on CTS was mostly direct.[35] However, obesity or type 2 diabetes could have an indirect impact on the association between BMI and CTS.[36] Mansour et al found that one-third of the patients with 112 CTS were overweight or obese, while two-thirds had a normal weight. The average age of the patients was 54 years. The study also revealed that the incidence of obesity was 34%.[37] It is important to include weight loss measures in the targeted treatment for patients with CTS. This is because obesity is a contributing factor to the severity and pathogenesis of CTS.[37] According to a meta-analysis of 58 studies, being overweight raised the risk of CTS by 1.5 times (pooled confounder-adjusted odds ratio [OR] = 1.47, 95% confidence interval [CI]: 1.37–1.57, n = 1,279,546), while obesity doubled it (adjusted OR = 2.02, 95% CI: 1.92–2.13, n = 1 362 207). Every one-unit increase in BMI increased the risk of CTS by 7.4% (adjusted OR = 1.074, 95% CI: 1.071–1.077, n = 1 258 578).[38]

Our study builds on previous research by examining the relationship between wrist and waist circumferences and the severity of CTS, an important factor to consider in the manifestation of CTS symptoms. While previous studies identified wrist ratio, shape index, and higher BMI as independent risk factors for CTS,[19] our research focused on specific anthropometric measures to gain a more comprehensive understanding of CTS origins. By comparing CTS patients with a healthy control group, our study could contribute to the evolving knowledge of CTS research. Our results confirm previous findings and offer valuable insights into the multifaceted nature of CTS etiology. Our research has public health implications, as the rise of CTS globally is a concern. Understanding the role of BMI in CTS is critical, and our study fills a critical knowledge gap that could inform preventive measures and therapeutic interventions. However, it is essential to acknowledge the limitations of our study, including the observational nature of our study design and the sample size. Accordingly, future research with larger and more diverse cohorts could further validate and expand upon our findings.

## Conclusion

It was revealed that people with CTS have higher levels of BMI, PBF, SLM, and total and segmental (arm) MBF compared to healthy individuals. However, no significant correlation was observed between BMI and the severity of clinical symptoms in CTS patients. Upcoming research with a larger sample size and more diverse follow-ups could further validate and expand upon our findings. Addressing these limitations will enhance the robustness and applicability of our findings in effective CTS prevention and management.

### Acknowledgements

The authors would like to acknowledge the Physical Medicine and Rehabilitation Research Center staff at Tabriz University of Medical Sciences for their invaluable support in conducting this research.

### Authors' Contribution

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### Competing Interests

The authors declare no competing interests.

### Ethical Approval

The study was approved by the Local Ethics Committee of Tabriz University of Medical Science (IR.TBZMED.REC.1397.156), and all experiments were conducted according to the relevant guidelines. All participants signed a detailed informed consent form prior to the study.

### Funding

The authors declare that they received no financial support throughout the study.

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