



## Association of Wrist Ratio, Body Mass Index, and Hand Grip Strength with Boston Carpal Tunnel Questionnaire Scores among Online Motorcycle Drivers

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### ABSTRACT

Carpal tunnel syndrome (CTS) is a common work-related musculoskeletal disorder associated with repetitive hand activities. Online motorcycle drivers are at increased risk due to prolonged gripping and repetitive wrist movements. Anthropometric factors and hand strength have been suggested as potential contributors to CTS, but evidence remains inconsistent, particularly in informal occupational groups. This study aimed to analyze the association between wrist ratio, body mass index (BMI), and hand grip strength with CTS symptoms based on the Boston Carpal Tunnel Questionnaire (BCTQ). An observational cross-sectional study was conducted involving 80 online motorcycle drivers selected using consecutive sampling. Wrist ratio, BMI, and hand grip strength were measured, while CTS symptoms were assessed using the BCTQ. Data was analyzed using univariate and bivariate statistical tests. CTS symptoms were identified in 48.8% of participants. A substantial proportion of participants were classified as overweight or obese (approximately 44%). Statistical analysis showed no significant association between wrist ratio, BMI, or hand grip strength and CTS symptoms ( $p > 0.05$ ). Wrist ratio, BMI, and hand grip strength were not significantly associated with CTS symptoms among online motorcycle drivers. These findings suggest that CTS is a multifactorial condition influenced by factors beyond basic anthropometric and strength measurements.



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### INTRODUCTION

Carpal tunnel syndrome (CTS) is one of the most common peripheral neuropathies associated with occupational activities and is characterized by pain, numbness, and paresthesia in the median nerve distribution due to compression within the carpal tunnel (Chairunnisa et al., 2021; Genova et al., 2020). CTS predominantly affects workers exposed to repetitive wrist movements, sustained gripping, vibration, and prolonged non-neutral wrist postures, making it a significant occupational health concern worldwide (Sari & Novendy, 2022; Utamy et al., 2020). The rapid expansion of online motorcycle transportation services has introduced distinct ergonomic challenges. Online motorcycle drivers are required to perform repetitive hand and wrist movements, including continuous gripping of handlebars, throttle control, and braking, often for extended working hours. These repetitive and sustained activities may increase intracarpal pressure and mechanical stress on the median nerve, thereby predisposing drivers to the development of CTS (Chairunnisa et al., 2021; Nurdasari & Rr. Arum Ariasih, 2021).

Previous studies have suggested that individual anatomical and anthropometric factors may influence CTS

risk. Increased body mass index (BMI) has been associated with elevated hydrostatic pressure and adipose tissue accumulation within the carpal tunnel, potentially leading to median nerve compression (Amalia et al., 2023; Raissi et al., 2025). Wrist ratio has also been proposed as an anatomical indicator reflecting carpal tunnel morphology and susceptibility to CTS, although evidence regarding its predictive value remains inconsistent across populations (Han et al., 2022). In addition, hand grip strength has been evaluated both as a functional consequence of CTS and as a potential risk marker; however, reported associations vary, particularly in populations with mild or early-stage symptoms (Baker et al., 2013; Sasaki et al., 2020; Singh & Srivastava, 2020).

Despite extensive research on CTS risk factors, studies examining the combined role of wrist ratio, BMI, and hand grip strength among online motorcycle drivers remain limited, especially in the Indonesian population. Moreover, objective anthropometric data specific to this occupational group are still scarce, limiting the development of evidence-based ergonomic and preventive interventions.

Therefore, this study aimed to analyze the association between wrist ratio, body mass index, and hand grip strength

with CTS symptoms assessed using the Boston Carpal Tunnel Questionnaire. The findings are expected to contribute to a more comprehensive understanding of CTS risk profiles among online motorcycle drivers and to inform future ergonomic and occupational health strategies. It was hypothesized that higher wrist ratio and body mass index (BMI) would be positively associated with CTS symptom severity. In contrast, greater hand grip strength would be inversely associated with CTS symptoms.

## METHODS

### Participant Characteristics and Research Design

This study employed an observational analytic design with a cross-sectional approach. The study was conducted in Palembang, Indonesia, from June to October 2023. The study population consisted of male online motorcycle drivers aged 18–50 years who were actively working at the time of data collection, reflecting the dominant demographic profile of online motorcycle drivers in the study area. Only male participants were included to reduce biological variability related to body composition. Participants were required to provide written informed consent before enrollment. Key characteristics assessed in this study included age, body mass index, wrist ratio, hand grip strength, and the severity of carpal tunnel syndrome (CTS) symptoms.

Individuals were excluded if they had a history of chronic kidney disease, diabetes mellitus, thyroid disorders, rheumatoid arthritis, lupus, or other systemic conditions known to be associated with CTS. Participants with a history of wrist trauma or those undergoing hemodialysis were also excluded. These criteria were applied to minimize potential confounding factors that could independently influence median nerve function and the development of CTS, thereby enhancing the internal validity of the study. CTS symptoms were assessed using the Boston Carpal Tunnel Questionnaire (BCTQ), a validated patient-reported outcome instrument that evaluates symptom severity and functional status, although this study does not provide a clinical or electrodiagnostic diagnosis. The study protocol was reviewed and approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sriwijaya (Protocol No: 200-2023)

### Sample Size and Sampling Procedures

Participants were recruited using a consecutive sampling method, in which all eligible drivers encountered during the data collection period were invited to participate until the required sample size was achieved.

Sample size was determined using the single-proportion formula, assuming a 95% confidence level ( $Z = 1.96$ ), an expected proportion of 0.82 derived from prior studies (Utami et al., 2023), and a margin of error of 10%. The minimum required sample size was calculated to be 56 participants.

### Variables

Wrist ratio was calculated as the ratio of wrist depth to width, measured with a standardized measuring tool. Measurements were taken for both the dominant and non-dominant hands. BMI was calculated as weight (kg) divided by height squared ( $m^2$ ) and categorized according to standard BMI classifications based on the WHO criteria (Novosad et al., 2013). Pain intensity was assessed using a visual analog scale

(VAS) reflecting wrist-related pain experienced during daily activities over the past two weeks. Hand grip strength was measured using a hand dynamometer Camry EH101 Digital Hand Dynamometer Grip Strength Meter. Measurements were performed for both hands, and values were categorized into weak, normal, or strong based on the device-specific reference ranges provided in the manufacturer's manual (Camry, n.d.). CTS symptoms were assessed using the Boston Carpal Tunnel Questionnaire (BCTQ), which consists of two subscales evaluating symptom severity and functional status. Each item is scored on a 5-point Likert scale, with higher scores indicating greater symptom severity. Participants were classified as having CTS symptoms when the BCTQ score was greater than 11. This study was conducted as part of a joint research project, and a more detailed description of the BCTQ has been reported by Islamia et al. (Islamia et al., 2024).

### Data Analysis

Data were collected through structured interviews, questionnaire administration, and direct physical measurements. All data collectors received standardized training prior to data collection to ensure measurement consistency. Data were processed and analyzed using Statistical Package for the Social Sciences (SPSS). Univariate analysis was conducted to describe participant characteristics and variable distributions. Bivariate analysis was performed to assess associations between wrist ratio, BMI, hand grip strength, and CTS symptoms using the chi-square test or Fisher's exact test, as appropriate. A p-value of  $<0.05$  was considered statistically significant. All analyses were prespecified based on the study objectives.

## RESULTS OF STUDY

Based on Table 1, the general respondent profile indicates that the sample was composed primarily of individuals in the productive adult age range, with a mean age of 38.7 years ( $SD = 11.1$ ), suggesting that the participants were active workers with a relatively wide age distribution. In terms of wrist anthropometry, the mean wrist ratio for the right hand ( $0.69$ ;  $SD = 0.14$ ) and the left hand ( $0.68$ ;  $SD = 0.13$ ) was highly similar, indicating that the morphological characteristics of the right and left wrists were relatively balanced in this sample. A similar pattern was observed for hand grip strength, with the mean grip strength of the right hand ( $31.5$  kg;  $SD = 9.5$ ) being slightly higher than that of the left hand ( $30.8$  kg;  $SD = 9.4$ ), although the difference was small. Meanwhile, the mean BCTQ Symptom Severity Scale (SSS) score of  $13.23$  ( $SD = 3.77$ ) and the mean BCTQ Functional Status Scale (FSS) score of  $8.10$  ( $SD = 0.376$ ) suggest that, overall, symptom severity and functional impairment in this sample tended to be low, particularly because the variation in FSS scores was very small compared with the other variables, implying that the respondents' functional condition was relatively homogeneous.

In Table 2, the category distribution further reinforces the general pattern observed in Table 1. For Body Mass Index, the largest group was normal (38.8%), followed by overweight (30.0%), whereas obesity categories were present overall but were not dominant. This indicates that the respondents' nutritional status was fairly varied, although it was concentrated primarily within the normal to overweight range. In the CTS Symptom Severity (BCTQ) section, more than half of the respondents were classified as asymptomatic

(51.2%), and nearly all of the remainder were classified as mild (46.3%), whereas only 2.5% were classified as moderate, and no respondents were classified as severe or very severe. This pattern suggests that symptom severity in the sample was generally very mild. This pattern becomes even more apparent in the Functional Status (BCTQ) results, in which 92.5% of respondents were classified as asymptomatic and only 7.5% as mild, with no moderate-to-severe functional impairment observed. The Pain Intensity (VAS) data showed a similar trend, with the majority of respondents reporting no pain (76.7%), followed by moderate pain (14.0%) and mild pain (2.3%). Overall, Table 2 indicates that although some respondents reported mild CTS symptoms, most of the sample remained at a low level of complaints and functional disturbance.

**Table 1.** Descriptive Statistics of Age, Wrist Ratio, Hand Grip Strength and CTS Symptom among Online Motorcycle Drivers

Variable	Mean	SD
Age (years)	38.7	11.1
Wrist ratio (right)	0.69	0.14
Wrist ratio (left)	0.68	0.13
Hand grip strength (right, kg)	31.5	9.5
Hand grip strength (left, kg)	30.8	9.4
BCTQ Symptom Severity Scale (SSS)	13.23	3.77
BCTQ Functional Status Scale (FSS)	8.10	0.376

**Table 2.** Distribution of Body Mass Index, CTS Symptoms, Functional Status, and Pain Intensity

Variable	Frequency (n)	Percentage (%)
<b>Body Mass Index</b>		
Underweight	14	17.5
Normal	31	38.8
Overweight	24	30.0
Obesity class I	8	10.0
Obesity class II	0	0
Obesity class III	3	3.8
<b>CTS Symptom Severity (BCTQ)</b>		
Asymptomatic	41	51.2
Mild	37	46.3
Moderate	2	2.5
Severe	0	0
Very severe	0	0
<b>Functional Status (BCTQ)</b>		
Asymptomatic	74	92.5
Mild	6	7.5
Moderate-severe	0	0
<b>Pain Intensity (VAS)</b>		
No pain	66	76.7
Mild pain	2	2.3
Moderate pain	12	14.0

In Table 3, the association between wrist ratio and CTS symptoms is presented for both the right and left wrists, and both sides show the same pattern. For the right wrist, respondents with a normal wrist ratio (<0.75) included 39 individuals (48.7%) without symptoms and 35 individuals (43.8%) with symptoms, whereas in the high ( $\geq 0.75$ ) category there were 2 individuals (2.5%) without symptoms and 4

individuals (5.0%) with symptoms. The exact same pattern also appears for the left wrist. Descriptively, the proportion of respondents with a high wrist ratio appears slightly greater in the symptomatic group than in the asymptomatic group; however, the number of cases in this category was very small. The p-value of 0.426 indicates that this distribution difference was not statistically significant, whereas the OR of 2.229 with a 95% CI of 0.384–12.923 suggests a tendency toward higher odds, although the confidence interval is very wide. This indicates that the observed association was unstable and cannot be considered statistically convincing. As presented, Table 3 primarily reflects the absence of a strong relationship between wrist ratio and CTS symptoms in this sample.

**Table 3.** Association between Wrist Ratio and CTS Symptoms

Wrist Ratio	CTS Symptoms Absent n (%)	CTS Symptoms Present n (%)	p-value	OR (95% CI)
<b>Right wrist</b>				
Normal (<0.75)	39 (48.7)	35 (43.8)	0.426	2.229 (0.384 – 12.923)
High ( $\geq 0.75$ )	2 (2.5)	4 (5.0)		
<b>Left wrist</b>				
Normal (<0.75)	39 (48.7)	35 (43.8)	0.426	2.229 (0.384 – 12.923)
High ( $\geq 0.75$ )	2 (2.5)	4 (5.0)		

In Table 4, the relationship between BMI and CTS symptoms was analyzed after BMI had been grouped into two broad categories, namely underweight/normal and overweight/obesity class I–III. The results show that in the underweight/normal group, there were 24 respondents (30%) without symptoms and 21 respondents (26.25%) with symptoms. In the overweight/obesity group, there were 17 respondents (21.25%) without symptoms and 18 respondents (22.5%) with symptoms. This distribution appears relatively balanced between the two groups, with no striking difference. The p-value of 0.673 indicates that there was no statistically significant association between BMI category and CTS symptoms in the presented data. Meanwhile, the OR of 1.210 with a 95% CI of 0.500–2.931 indicates that the direction of the association tended to be positive but was very weak, and the confidence interval crossing 1 suggests that the effect was uncertain. Thus, as presented in Table 4, BMI does not show a clear pattern of association with CTS symptoms.

In Table 5, the relationship between hand grip strength and CTS symptoms also does not show a strong difference. For the right hand, in the weak group there were 29 respondents (36.3%) without symptoms and 24 respondents (30.0%) with symptoms, whereas in the normal-strong group there were 12 respondents (15.0%) without symptoms and 15 respondents (18.8%) with symptoms. The p-value of 0.480 indicates no statistically significant association, while the OR of 1.510 with a 95% CI of 0.595–3.836 suggests a slight tendency toward increased odds, although this remained uncertain. For the left hand, the weak group consisted of 34 respondents (42.5%) without symptoms and 27 respondents (33.8%) with symptoms, whereas the normal-strong group consisted of 7 respondents (8.8%) without symptoms and 12

respondents (15.0%) with symptoms. The p-value of 0.192 again indicates no significant association, with an OR of 2.159 and a 95% CI of 0.748–6.233, which also crosses 1. Descriptively, this table shows that symptom distribution was present across both grip strength categories, and no sufficiently large difference appears to support a clear association.

**Table 4.** Association between Body Mass Index and CTS Symptoms

BMI Category	CTS Symptoms Absent n (%)	CTS Symptoms Present n (%)	p-value	OR (95% CI)
Underweight, Normal	24 (30%)	21 (26.25%)	0.673	1.210 (0.500-2.931)
Overweight, Obesity Class I-III	17 (21.25%)	18 (22.5%)		

**Table 5.** Association between Hand Grip Strength and CTS Symptoms

Hand Grip Strength	CTS Symptoms Absent n (%)	CTS Symptoms Present n (%)	p-value	OR (95% CI)
<b>Right hand</b>				
Weak	29 (36.3)	24 (30.0)	0.480	1.510 (0.595-3.836)
Normal-Strong	12 (15.0)	15 (18.8)		
<b>Left hand</b>				
Weak	34 (42.5)	27 (33.8)	0.192	2.159 (0.748-6.233)
Normal-Strong	7 (8.8)	12 (15)		

The overall pattern suggests that this sample was dominated by respondents with mild or no CTS symptoms, minimal functional impairment, and largely absent pain. The exposure variables measured—namely wrist ratio, BMI, and hand grip strength—showed some descriptive variation, but in the bivariate, all associations yielded p-values greater than 0.05 and relatively wide confidence intervals. Therefore, based on the tables as presented, there does not appear to be a strong or consistent relationship between wrist ratio, BMI, or hand grip strength and CTS symptoms among the online motorcycle drivers included in this sample.

## DISCUSSION

This study demonstrated a high prevalence of CTS symptoms among online motorcycle drivers, with nearly half of the participants reporting symptoms based on the BCTQ. This finding supports previous reports indicating that online motorcycle drivers represent a high-risk occupational group due to prolonged exposure to repetitive wrist movements and sustained gripping activities (Chairunnisa et al., 2021; Sari & Novendy, 2022).

Despite the substantial prevalence of CTS symptoms, no significant association was found between wrist ratio and CTS symptoms. Although wrist ratio has been proposed as an anatomical risk indicator reflecting carpal tunnel morphology (Han et al., 2022), the present findings suggest that wrist ratio alone may not sufficiently explain CTS occurrence in this population. CTS is widely recognized as a multifactorial condition influenced not only by anatomical factors but also by biomechanical load, work duration, and ergonomic exposure (Peshin et al., 2022; Utamy et al., 2020). The absence of significant associations between anthropometric and strength-related variables and BCTQ outcomes suggests that occupational ergonomic exposures, such as repetitive wrist motion, vibration, and sustained non-neutral wrist posture, may play a more dominant role in symptom development in this population (Genova et al., 2020; Lund et al., 2019; You et al., 2014).

Similarly, body mass index was not significantly associated with CTS symptoms in this study. While several studies have reported obesity as a risk factor for CTS due to increased hydrostatic pressure within the carpal tunnel (Amalia et al., 2023; Raissi et al., 2025), the absence of a significant relationship in this study may reflect population-specific factors, differences in fat distribution, or the predominance of occupational biomechanical stress over metabolic factors.

Hand grip strength was also not significantly associated with CTS symptoms. Although CTS may lead to reduced grip strength due to median nerve dysfunction (Baker et al., 2013; Sasaki et al., 2020), grip strength reduction is often more pronounced in advanced disease stages. Most participants in this study presented with mild symptoms and minimal functional impairment, which may explain the lack of detectable strength differences. These findings suggest that BCTQ may capture early subjective symptoms that are not yet reflected in objective functional impairment or pain intensity, highlighting the importance of early screening in occupational populations. This aligns with previous reports suggesting that grip strength may not be a sensitive indicator for early CTS detection (Singh & Srivastava, 2020).

Overall, the findings highlight that CTS among online motorcycle drivers is likely driven by a complex interaction of occupational exposure and individual factors rather than single anthropometric or strength parameters. These results underscore the importance of ergonomic interventions, work-rest cycle regulation, and early symptom screening rather than reliance on anthropometric screening alone. From an occupational health perspective, these findings highlight the importance of preventive strategies targeting ergonomic risk factors. Practical interventions may include education on maintaining neutral wrist positioning, implementing scheduled microbreaks during driving, promoting grip variation strategies, and minimizing sustained wrist flexion or extension. Several limitations of this study should be acknowledged. In this study, CTS was defined based on patient-reported symptoms assessed using the Boston Carpal Tunnel Questionnaire (BCTQ), rather than clinical or electrodiagnostic confirmation. As BCTQ is not a gold-standard diagnostic tool, misclassification of CTS status may have occurred, which could have attenuated the observed associations. Occupational factors such as daily working hours, duration of employment, riding posture, and vibration exposure were not quantitatively assessed and may act as unmeasured confounders. These limitations may affect the generalizability and interpretation of the findings. Therefore, the non-significant findings in this study should not be interpreted as evidence of no association, but rather as

inconclusive results that warrant further investigation with larger sample sizes and more robust diagnostic approaches.

## CONCLUSIONS AND RECOMMENDATION

This study demonstrates that carpal tunnel syndrome (CTS) symptoms are prevalent among online motorcycle drivers. However, no statistically significant evidence of an association was found in this study between wrist ratio, body mass index, and hand grip strength with CTS symptoms assessed using the Boston Carpal Tunnel Questionnaire. These findings indicate that CTS in this occupational group is not adequately explained by isolated anthropometric or strength-related parameters. The study contributes novel evidence that challenges the utility of single-parameter physical screening for CTS risk among informal workers and reinforces the multifactorial nature of CTS, in which occupational and biomechanical exposures likely play a more dominant role. Future studies should employ longitudinal designs and integrate detailed ergonomic and occupational exposure assessments, including work duration, posture, and vibration exposure. The incorporation of objective diagnostic modalities alongside patient-reported outcomes is recommended to strengthen CTS risk stratification and support the development of targeted preventive interventions in occupational health.

## DECLARATION

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This research received **no specific grant** from any funding agency in the public, commercial, or not-for-profit sectors.

### Conflicts of interest

The authors declare that **they have no conflicts of interest** or competing interests related to this study.

### Ethics approval and consent to participate

The study protocol was reviewed and approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sriwijaya (Protocol No: 200-2023)

### Consent for publication

Not applicable.

### Availability of data and materials

Data are available upon request.

### Availability of data and materials

Not applicable

### Artificial Intelligence-Assisted Technology

The authors declare that **no artificial intelligence-assisted technologies** were used in the conception, data analysis, interpretation, or writing of this manuscript. (If applicable: AI-assisted tools were used solely for language editing purposes, and all scientific content was reviewed and approved by the authors.)

### Authors' contributions:

**Rulan Adnindya** contributed to study conception and design, data collection, data analysis, and manuscript drafting.

**Syarinta Adenina** contributed to data collection and statistical analysis.

**Tri Suciati** contributed to supervision and critical revision of the manuscript. All authors read and approved the final manuscript.

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