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Anthropometric Characteristics of the Hand in Patients with Carpal Tunnel Syndrome

Karpal Tünel Sendromlu Hastalarda Elin Antropometrik Özellikleri

Ezgi AYDIN[a], Özlem YILMAZ TAŞDELEN[a], Fatma Gül YURDAKUL[a], Funda Seher ÖZALP ATEŞ[b], Hatice BODUR[a]

[a]Ankara Numune Training and Research Hospital, Clinic of Physical Medicine and Rehabilitation, Ankara, Türkiye

[b]Manisa Celal Bayar University Faculty of Medicine, Department of Biostatistics and Medical Informatics, Manisa, Türkiye

This study was presented as an oral presentation at Turkish Rheumatology E-Congress November 13-15, 2020, Antalya, Türkiye.

ABSTRACT Objectives: This study aimed to examine the impact of hand anthropometric features on the development and severity of carpal tunnel syndrome (CTS). **Material and Methods:** Demographic characteristics of CTS patients (n=212) and healthy controls (n=75) were recorded. CTS diagnosis was established through clinical and electrophysiological assessments. Wrist width, wrist depth, palmar width, hand length, and 3rd finger length were measured. Additionally, the wrist ratio (wrist depth/width), digit index (3rd finger length/hand length×100), hand shape index (palmar width/hand length×100), and hand length/height ratio (hand length/height×100) were calculated and compared. **Results:** No significant differences were observed between the CTS and control groups regarding gender, age, height, dominant hand, educational background, or occupation (p>0.05). However, body weight and body mass index (BMI) were significantly higher in the CTS group (p=0.006 and p<0.001, respectively). The wrist ratio and hand length/height ratio were similar between groups (p>0.05). The CTS group exhibited a significantly lower hand shape index and a significantly higher digit index (p<0.001), indicating relatively narrower palms and longer 3rd fingers compared with the overall hand length. Multivariable logistic regression analysis identified a high digit index (B=0.437; p<0.001), low hand shape index (B=-0.321; p<0.001), low hand length/height ratio (B=-0.165; p<0.001), and high BMI (B=0.147; p<0.001) as independent risk factors for CTS. No significant differences in anthropometric indices were found between the mild, moderate, and severe CTS subgroups (p>0.05). **Conclusion:** A narrow and short palm may be a risk factor for idiopathic CTS development.

Keywords: Carpal tunnel syndrome; anthropometric; wrist ratio; digit index; hand shape index

ÖZET Amaç: Bu çalışmanın amacı, elin yapısal özelliklerinin karpal tünel sendromu (KTS) şiddetinde etkili olup olmadığını araştırmaktır. **Gereç ve Yöntemler:** Çalışmaya KTS bulunan 212 hasta ve kontrol grubu olarak da 75 sağlıklı gönüllü dâhil edildi. KTS tanısı klinik ve elektrofizyolojik yöntemlerle konuldu. Demografik bilgileri kaydedildi, el bileği genişliği, derinliği, avuç genişliği, el uzunluğu, üçüncü parmak uzunluğu ölçüldü ve el bileği oranı (el bileği derinliği/genişliği), parmak indeksi (üçüncü parmak uzunluğu/el uzunluğu×100), el şekli indeksi (palmar genişlik/el uzunluğu×100) ile el uzunluğu/boy oranları (el uzunluğu/boy×100 değerleri) hesaplandı ve 2 grup arasında karşılaştırıldı. **Bulgular:** Gruplar arasında cinsiyet, yaş, boy, dominant taraf, öğrenim durumu ve meslek/yapılan iş açısından fark saptanmadı (p>0,05). KTS grubunda vücut ağırlığı ve beden kitle indeksi (BKİ) anlamlı düzeyde daha fazla bulundu (p=0,006 and p<0,001), el bileği oranı ve el uzunluğu/boy oranı ise gruplarda benzerdi (p>0,05). KTS grubunda el şekil indeksi anlamlı düzeyde düşük ve parmak indeksi anlamlı düzeyde yüksek bulundu (p<0,001). Buna göre KTS grubunda elin uzunluğuna kıyasla avuçlar dar, üçüncü parmaklar uzundu. Ayrıca çoklu lojistik regresyon analizine göre yüksek parmak indeksi (B=0,437; p<0,001), düşük el şekil indeksi (B=-0,321p<0,001), düşük el uzunluğu/boy indeksi (B=-0,165; p<0,001) ve yüksek BKİ (B=0,147; p<0,001) KTS oluşumunda bağımsız risk faktörleri olarak bulundu. Hafif, orta ve ileri KTS grupları arasında ise incelenen indeksler açısından fark bulunmadı (p>0,05). **Sonuç:** Kısa ve dar avuç içine sahip olmak idiyopatik KTS oluşumunda risk faktörü olabilir.

Anahtar Kelimeler: Karpal tünel sendromu; antropometrik; el bileği oranı; parmak indeksi; el şekli indeksi

Correspondence: Özlem YILMAZ TAŞDELEN
Ankara Numune Training and Research Hospital, Clinic of Physical Medicine and Rehabilitation, Ankara, Türkiye
E-mail: dr.ozlemyilmaz@gmail.com

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Carpal tunnel syndrome (CTS) is the most common peripheral nerve entrapment syndrome, affecting approximately 3% of the adult population.[1,2] It results from compression of the median nerve within the carpal tunnel. While repetitive hand use, diabetes mellitus, obesity, hypothyroidism, pregnancy, and rheumatoid arthritis are well-known risk factors, anatomical variations in hand structure have recently been explored for their role in the development of idiopathic CTS.[3] Previous studies suggest a higher wrist ratio (a squarer wrist) as an independent CTS risk factor, although findings regarding other hand structures remain inconsistent.[4-11]

This study investigates whether the wrist ratio, hand shape index, digit index, and hand length/height ratio differ between idiopathic CTS patients and healthy individuals and examines their correlation with nerve conduction studies.

MATERIAL AND METHODS

Ethical approval was obtained from the Ethics Committee of Scientific Research Evaluation Commission Numune Training and Research Hospital (date: March 4, 2015 no: 2015-964). The study included 212 CTS patients (73.9%) and 75 healthy controls (26.1%). All procedures adhered to the Declaration of Helsinki, and informed consent was obtained from all participants. Demographic data, including age, gender, body weight, height, body mass index (BMI), dominant hand, occupation, and educational background, were recorded. The exclusion criteria comprised cervical disc herniation, radiculopathy, polyneuropathy, prior wrist or neck surgery (including CTS surgery), wrist fractures, inflammatory or endocrine diseases, chronic renal failure, cancer, and pregnancy.

Electromyographic evaluation was performed using the Nihon Kohden 2-MEB 7102-K (Nihon Kohden, Japan) machine under standardized conditions (skin temperature ≥32°C, ambient temperature 22-24°C).

Motor Nerve Conduction Studies of the Median Nerve: Supramaximal stimulations with 0,1 msn duration were performed at the wrist and elbow using bipolar surface electrodes, and recordings were performed from the abductor pollicis brevis muscle with a surface bar electrode located 5 cm distal to the distal stimulation point at the wrist. Distal latency was measured from the onset of the compound muscle action potential (CMAP).

Sensory Nerve Conduction Studies of the Median Nerve: These studies were conducted at palm-wrist and 2nd finger-wrist segments with the orthodromic method using surface electrodes. The duration of the stimulus was 0.1 msn and intension of it was 10-30 mA. Supramaximal responses were recorded. Latency was measured from the peak of the sensory nerve action potential (SNAP).

To exclude polyneuropathy, F wave study of median nerve, motor and sensory nerve conduction and F-wave studies of the ulnar nerve at the upper extremity and motor and sensory (superficial peroneal and sural nerves) nerve conduction and F-wave studies of the peroneal or tibial nerves at the lower extremity were performed with similar technics.

The diagnosis and severity of CTS were decided according to this classification:

Mild CTS: Slowing sensory nerve conduction velocity and decrease in SNAP amplitude at the palm-wrist and 2nd finger-wrist segments while motor nerve conduction studies of the median nerve were normal.

Moderate CTS: Addition to slowing sensory nerve conduction velocity and decrease-SNAP amplitude at the palm-wrist and 2nd finger-wrist segments prolongation of the median distal motor latency.

Severe CTS: Addition to prolongation of median distal motor latency absence of 1 or more median SNAPs and decrease or absence of median motor CMAP amplitude and denervation potentials on needle electromyography.[12]

The mediolateral and dorsovolar diameter measurements of the wrist were performed as described by Johnson et al.[13] Hand's anthropometric measurements were performed according to the methods described by Kouyoumdjian and Chroni by the same investigator with a manual caliper (Vernier brand).[14,15] With regard to these descriptions;

Wrist depth was measured as the anteroposterior

distance at the level of the distal flexor wrist crease;

Wrist width was measured as the mediolateral distance at the level of the distal flexor wrist crease.

The 3rd digit length was measured as the distance of the proximal flexor crease of the 3rd digit to the tip of the same digit.

The palmar length was measured as the distance of the volar surface between the distal flexor crease of the wrist and the proximal crease of the 3rd digit.

Hand length was calculated as the sum of the 3rd digit length and the palmar length.

The palmar width was measured as the maximum distance of the volar surface between the 2nd and 5th metacarpal heads.

- Indices were calculated as follows:
- Wrist ratio=wrist depth/wrist width
- Digit index=3rd finger length/hand length×100
- Hand shape index=palmar width/hand length×100

Hand length/height ratio=hand length/height×100 (Figures 1, Figure 2).

The functional status and symptom severity were assessed using the Boston Carpal Tunnel Questionnaire. This scale was developed in 1993 by Levine et al. for examining patients who have undergone surgery for carpal tunnel syndrome.[16] It has 2 distinct scales: the Symptom Severity Scale, which includes 11 questions, and the Functional Status Scale containing 8 query. Patients replied to both of them on a 5-point rating scale by themselves. The total score is calculated by dividing the total score by the number of questions. Higher scores indicate a worse status. The validity and reliability of its Turkish language version was proved by Sezgin et al.[17]

In the patient group, if the individual had unilateral CTS, the affected hand was included; if the individual had bilateral CTS, the more severe affected hand was included; if the patient had bilateral CTS of equal severity, the dominant hand was included in the statistical analysis. In the control group, the dominant hand was included in the statistical analysis.

STATISTICAL ANALYSIS

All statistical analyses were performed using SPSS for Windows 11.5 (SPSS Inc., Chicago, IL, USA). Normality was assessed using the Shapiro-Wilk test. Continuous variables were expressed as mean±standard deviation or median (minimum-maximum), while categorical variables were summarized as frequencies (percentages). Student's t-test or the Mann-Whitney U test was used to compare the 2 groups, and analysis of variance or Kruskal-Wallis tests were used for multiple group comparisons. Nominal variables were evaluated using Pearson's chi-square or Fisher's exact test. The Spearman correlation coefficients assessed the relationships between the continuous variables. A 2-tailed p value <0.05 was considered statistically significant. Variables with

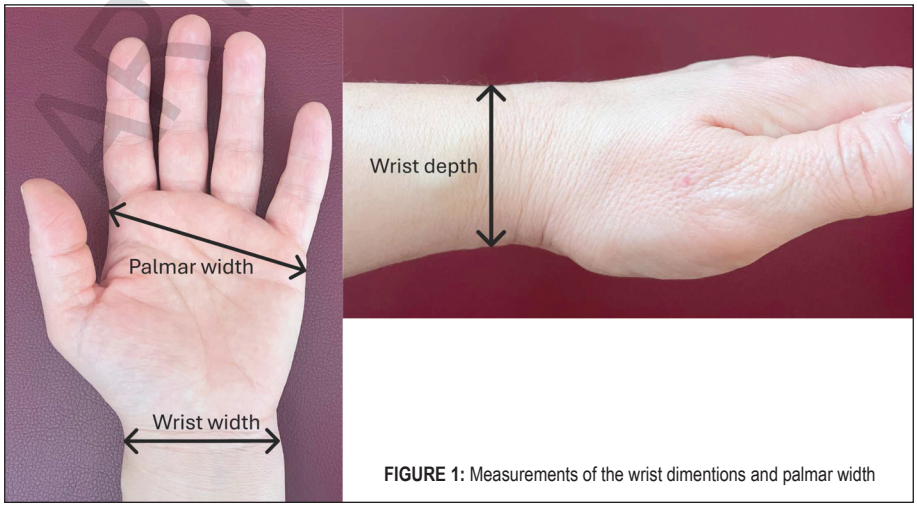

FIGURE 1: Measurements of the wrist dimentions and palmar width

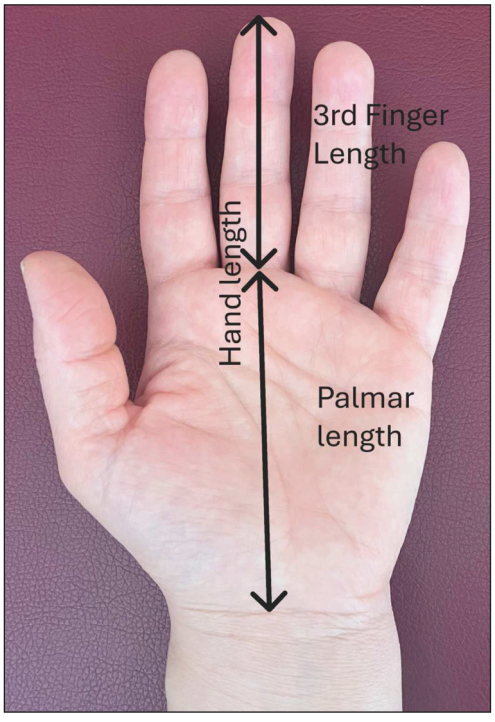

FIGURE 2: Measurement of the palmar, 3rd finger, and hand length

p<0.25 in univariate analysis were entered into a multivariate logistic regression model using the Forward Logistic Regression method.

RESULTS

The demographic and some clinical characteristics of the study groups are shown in Table 1. The CTS and control groups were similar with respect to sex, age, height, dominant hand, education, and occupation. The patient group had significantly higher body weight and BMI than the control group.

Wrist ratio and hand length/height ratio were not found to be different between the patients with CTS and the controls (p=0.210 and p=0.243 respectively). The digit index was significantly high and the hand shape index was significantly low in the CTS group. In other words, the third fingers were longer and the palms were narrower in comparison to the hands' length in the CTS group (Table 2). A correlation be-

TABLE 1: Demographic characteristics of the study group

	Patients (n=212)	Controls (n=75)	p value
Sex (F/M)	187/25 (88-12%)	66/9 (88-12%)	0.962
Age ($\bar{X}$±SD)	50.7±10.6	48.1±12.6	0.084
Body height (cm) median (minimum-maximum)	158 (143-180)	160 (145-183)	0.148
Body weight (kg) median (minimum-maximum)	78 (40-120)	70 (45-115)	0.006
BMI median (minimum-maximum)	30.6 (17.5-52.6)	27.6 (20.4-44.6)	<0.001
Dominant hand (R/L)	203 (95.8%)/9 (4.2%)	68 (90.7%)/7 (9.3%)	0.139
Educational background (n, %)			
Illiterate	32 (15.1)	11 (14.7)	
Primary school	142 (67)	47 (62.7)	0.640
High school	27 (12.7)	14 (18.7)	
Collage	11 (5.2)	3 (4)	
Occupation (n, %)			
Housewife	128 (60.4)	45 (60)	
Officer/secretary	30 (14.2)	13 (17.3)	
Worker	14 (6.6)	7 (9.3)	
Cleaning worker	25 (11.8)	3 (4)	0.110
Cook	14 (6.6)	4 (5.3)	
Tailor	1 (0.5)	2 (2.7)	
Driver	0 (0)	1 (1.3)	
CTS side (n, %)			
Right hand	64 (30.2)		
Left hand	39 (18.4)		
Bilateral	109 (51.4)		

F: Female; M: Male; SD: Standard deviation; BMI: Body mass index; CTS: Carpal tunnel syndrome; L: Left; R: Right

TABLE 2: Comparison of the anthropometric measurements between the patients and the controls					
	Patients		Controls		
	n	Median (minimum-maximum)	n	Median (minimum-maximum)	p value
Wrist ratio	210	0.71 (0.60-0.87)	75	0.71 (0.62-0.81)	0.210
Digit index	208	41.61 (37.2-45.9)	74	41.17 (37.5-45.3)	**<0.001**
Hand Shape Index	209	48.87 (41.7-59.3)	75	50.88 (43.5-69.2)	**<0.001**
Hand length/heigth ratio	209	106.82±4.39	75	107.54±4.99	0.243

SD: Standard deviation

tween the Boston Symptom Severity and Functional Status Scales and digit and hand shape indicis was also investigated but a meaningful relation was not found. (There was a very weak negative correlation was found between Digit Index and Symptom Severity Scale; r=-0.1775, p=0.014)

There was not a relation between BMI and wrist ratio, Digit Index and hand length/height ratio, and a very weak relation was found between BMI and Hand Shape Index in correlation analyses; therefore, it was decided that it is not necessary to rule out the effect of BMI in comparisons of the CTS and control groups regarding anthropometric characteristics.

Additionaly no difference was found between the mild, moderate and severe CTS groups regarding wrist ratio, hand shape index, digit index and hand length/height ratio (Table 3).

Although there was no difference in the wrist ratio between the CTS and control groups, in the patient group, negative weak correlations were found between the wrist ratio and median sensory nerve conduction velocities at both the palm-wrist and 2nd finger-wrist segments. As the wrist ratio increased (the wrist became squarer), the sensory conduction speeds decreased (r=-0.156 p=0.024 for the palm-wrist segment, r=0.147 p=0.034 for the 2nd finger-wrist segment). However, there was no significant correlation between wrist ratio and median motor distal latency (r=0.055 p=0.426) and median SNAP amplitudes at the palm-wrist and 2nd finger-wrist segments (r=-0.043 p=0.534 for palm-wrist r=-0.019 p=0.783 for 2nd finger-wrist).

Multivariable logistic regression analysis identified higher BMI (B=0.147), higher digit index (B=0.437), lower hand shape index (B=-0.321) and lower hand length/height ratio (B=-0.165) are independent risk factors (p<0.001). One unit increase in BMI increases the risk of CTS by 15.8% 1 unit increase in "digit index" increases the risk of CTS by 54.8%. One unit increase in "hand shape index" and "hand length/height ratio" decreased the risk of CTS by 27.5--5.2%, respectively (Table 4).

DISCUSSION

This study demonstrates that patients with CTS have relatively longer 3rd fingers and narrower palms compared to controls, while wrist ratios remain similar. Additionally, BMI, digit index, hand shape index,

TABLE 3: Comparison of the anthropometric measurements between the severity subgroups							
	Mild		Moderate		Severe		
	n	Median (minimum-maximum)	n	Median (minimum-maximum)	n	Median (minimum-maximum)	p value
Wrist ratio	52	0.71 (0.63-0.87)	133	0.70 (0.60-0.80)	25	0.72 (0.63-0.83)	0.718
Digit index	52	41.56 (38.59-45.80)	132	41.64 (37.19-45.94)	24	41.54 (39.41-45.56)	0.953
Hand length/ height ratio	52	107.38±4.33	132	106.79±4.33	25	105.82±4.78	0.342
Hand Shape Index	52	48.71±3.11	132	48.89±2.98	25	49.99±3.37	0.200

SD: Standard deviation

TABLE 4: The results of multivariable logistic regression analysis

	Multivariable Logistic Regression Analysis			
Risk factors for CTS	**B**	**OR**	**95 % CI for OR**	**p value**
BMI	0.147	1.158	1.084-1.237	**<0.001**
Digit Index	0.437	1.548	1.234-1.941	**<0.001**
Hand Shape Index	-0.321	0.725	0.645-0.816	**<0.001**
Hand length/height ratio	-0.165	0.848	0.785-0.915	**<0.001**

CTS: Carpal tunnel syndrome; OR: Odds ratio; BMI: Body mass index; CI: Confidence interval

and hand length/height ratio were identified as independent risk factors for CTS.

Previous studies have reported a positive association between the wrist ratio and idiopathic CTS, with a cut-off value of 0.7 identified in several studies.[4,5,7-10] Lim et al. found that a wrist index of 0.7 or greater was significantly associated with idiopathic CTS in 2008.[18] Hlebs et al. reported that CTS formation increased 42-fold with a wrist index of 0.7 or greater.[6] Lastly a square-shaped wrist (wrist ratio≥0.7) was defined as a predictor of CTS in a meta-analysis published in 2015.[19] However, wrist ratios were similar and predominantly square in both groups in our study (median values are greater than 0.7). This discrepancy may be attributed to the older average age of our study population (50.7 years in the CTS group vs. 48.1 in controls), as age-related changes in wrist morphology may influence the wrist ratio. However, this hypothesis requires further investigation. Nevertheless, in the Hlebs' study, the average ages were 53-54 in the CTS and control groups; they reported significantly higher squarer wrist index in the CTS group (0.73-0.74 in the CTS versus 0.67-0.68 in the control group).[6] Also, we could not find any study about aging and wrist thickening in the literature.

The body mass index of the CTS group was significantly higher, and the positive relation between high BMI and CTS is well known; our results were in accordance with previous reports.[4-6,9,10,20,21]

In our study, the digit index was significantly higher; in other words, the 3rd fingers were longer or the palms were shorter in comparison to the hand's length in the CTS group. Previously, only 1 study reported a higher digit index. In this study, Boz et al. reported a higher digit index only in female CTS patients; in males, there was no difference.[7] We did not compare by gender, but female patients were the majority in our study group. Rather, there are more studies reporting similarity.[4,6] A higher digit index indicates a relatively shorter palm. We also found lower Hand Shape Index in the CTS group. That means the patients have narrower palms compared to the hands' length. When it is considered together; area of the palms was smaller in the CTS group. Reports regarding the shape index are conflicting. Chiotis reported lower shape index values in patients with CTS, but Boz and Sharifi-Mollayyousefi reported higher shape index values and Hlebs reported similar shape index in the CTS groups.[4,6-8] Thus, the area of the palm may play a role rather than 1 dimension.

Although the hand length/height ratio was not found to be different between the groups; it was found to be an independent risk factor in the logistic regression analyses. Our finding is in concordance with previous studies.[4,6,7]

In our study, it was also investigated whether there is a difference between the mild, moderate and severe CTS groups in terms of examined antropometric measurements, but there was no difference. This is an unexpected result but in accordance with the literature.[4,7] In other words, the formal structure of the hand is not effective on the progression of CTS according to our study results.

Repetitive and/or forceful movements of the wrist are also known to be associated with CTS. Forceful hand use was the most important factor in the development of CTS in workers in a large prospective cohort study.[22] In our study, we did not assess the extent to which the subjects were exposed to such movements outside their occupations. This is an important limitation of our study.

CONCLUSION

Patients with CTS had a higher digit and BMI and a lower Hand Shape Index compared with the control group. Thus, those with narrow and short (relatively long 3rd fingers) palms should be more aware of modifiable risk factors such as higher body weight to avoid developing CTS.

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