

# Overwhelming Association of Obesity in Electrophysiologically Positive Cases of CTS

## Elektrofizyolojik Karpal Tünel Sendromu Olgularında Obezite ile Güçlü İlişki

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### ABSTRACT

**Objective:** Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy seen in electrodiagnostic laboratories. Obesity and diabetes have a high prevalence in Kuwait. The objective of this study was to find out the most relevant associated factors in electrophysiologically positive cases of CTS from a referred population and their significance in Kuwait.

**Methods:** A sample of consecutive 154 patients referred for electrophysiological evaluation of CTS were initially evaluated clinically by set criteria and evaluated electrophysiologically. Associated factors such as obesity, age, gender, diabetes, hypothyroidism and vocational status were documented and their relation to CTS studied.

**Results:** There was a significant increasing trend in the percentage of electrophysiological positivity in CTS according to age and body mass index (BMI); 66.7% in the <40 years group to 93.1% in the ≥60 years group (p=0.002); and 37.5% in <25 BMI group, to 89.5% in ≥40 BMI group (p=0.002). The proportion of positive CTS among housewives were high (88.2%) and all housewives with CTS were either overweight or obese. Multivariate logistic regression analysis showed that BMI and age were the significant independent associated factors.

**Conclusion:** Screening of persons with high BMI for symptoms suggestive of CTS will help in identifying early cases of CTS for early intervention. A wider population based study may provide additional information regarding the risk factors for CTS in Kuwait.

**Keywords:** Carpal tunnel syndrome, combined sensory index, obesity, rehabilitation, Kuwait

### ÖZET

**Amaç:** Karpal tünel sendromu (KTS) elektrofizyoloji laboratuvarlarında en sık görülen tuzak nöropatidir. Obezite ve diyabetin sıklığı Kuveyt'te yüksektir. Bu çalışmanın amacı refere edilen popülasyonda elektrofizyolojik KTS olgularında ilişkili faktörleri ve bunun Kuveyt için önemini bulmaktır.

**Yöntemler:** Elektrofizyolojik KTS değerlendirmesi için refere edilen 154 ardışık hasta ilk olarak belirli klinik kriterlerle değerlendirilmiş ve elektrofizyolojik olarak incelenmiştir. Obezite, yaş, cinsiyet, diyabet, hipotiroidi ve mesleki durumu gibi ilişkili faktörler kayıt edilmiş ve KTS ile ilişkileri incelenmiştir.

**Bulgular:** Elektrofizyolojik KTS olgularının yüzdelerinde yaş ve beden kitle indekslerine (BKİ) göre anlamlı bir artma eğilimi görüldü: <40 yaş grupta %66.7, ≥60 yaş grupta %93.1 (p=0.002); ve BKİ<25 olan grupta %37.5, BKİ ≥40 olan grupta %89.5 (p=0.002). Ev hanımları arasında KTS oranı yüksek bulunmuştur (%88.2) ve KTS'li tüm ev hanımları ya fazla kilolu ya da obez idi. Çok değişkenli lojistik regresyon analizi sonuçları BKİ ve yaşın anlamlı bağımsız faktörler olduğu göstermiştir.

**Sonuçlar:** Yüksek BKİ'ne sahip kişileri KTS'yi düşündüren semptomlar açısından taramak KTS'nin erken tanı ve tedavisi için kolaylık sağlayacaktır. Daha geniş toplum temelli bir çalışma Kuveyt'te KTS için risk faktörlerine yönelik ilave bilgiler sağlayabilir.

**Anahtar sözcükler:** Karpal tünel sendromu, bileşik duyuşsal indeks, obezite, rehabilitasyon, Kuveyt

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## Introduction

Carpal tunnel syndrome (CTS) is an entrapment median neuropathy at the wrist, presenting with numbness or paresthesia and/or pain, with or without objective sensory or motor deficits depending upon the severity. In the outpatient setting, confirmation of the clinical diagnosis, grading of severity, and differentiation of CTS from peripheral neuropathy, cervical radiculopathy or proximal entrapment of median nerve often necessitates electrodiagnostic work up.

CTS is the most common entrapment neuropathy seen in electrodiagnostic laboratories (1). Lifetime risk of developing carpal tunnel syndrome is approximately 10% (2). The prevalence reported in a study from the United Kingdom was from 4.7 to 7.2% based on motor latency and 10.7% to 18.9% based on motor or sensory latency (3). A study from Netherlands documented prevalence of CTS as 9% in adult women, and less than 0.6% in adult men (4). The prevalence of CTS in US adults was estimated as 1.55% in 1988 (5).

The known common risk factors for carpal tunnel syndrome are female gender, increased age, diabetes, and vocations involving vibration and repetitive hand movements. Obesity is being discussed as an important risk factor by many authors (6-13).

Two of the risk factors listed above, namely obesity and diabetes have a high prevalence in Kuwait. Literature evidence documents increasing prevalence of obesity in Kuwait and obesity is becoming a major health problem in Kuwait (14). The prevalence of overweight and obesity increased among Kuwaitis between 1980-81 and 1993-94, probably due to the effects of modernization, affluence, increased food consumption, and advances in technology, and consequent sedentary lifestyles. The rate of temporal changes in body mass index (BMI) and obesity were higher, by comparison, in Kuwait than in selected other countries (15). About 15% of the adult Kuwaiti population has type 2 diabetes (16).

Pubmed search for "Carpal Tunnel Syndrome AND Kuwait" did not yield any articles. Hence it was proposed to undertake a prospective preliminary study on CTS in patients referred to the EMG lab of Physical Medicine and Rehabilitation Hospital, Kuwait. The objective of this study was to find out the significance of associated factors for CTS in the referred sample and to determine the significance of these findings in Kuwait.

## Materials and Methods

All the patients referred to EMG laboratory of Physical Medicine & Rehabilitation hospital with a clinical diagnosis or suspicion of CTS during the period from January 2006 to December 2007 was enrolled for the study. The study was approved by Research Committee of Physical Medicine & Rehabilitation Hospital. Informed consent was obtained from all the patients. Demographic data, clinical history and detailed clinical examination were elicited as per the proforma prepared for this study. Clinical features including symptoms (pain and/or paresthesia in the whole hand/median distribution, nocturnal awakening, flick sign), provocative tests (Phalen's, Carpal compression test, Reverse Phalen's, Tinel's sign); and motor or sensory deficits in median nerve distribution were recorded. Data such as age, gender, occupation, height and weight, hypothyroidism, diabetes were elicited. Occupational status was recorded and classified according to the International Standard Classification of Occupations - December 2007. Housewives and retired persons who do not come under the purview of the above classification were included as separate groups. Body mass index (BMI) was calculated using the formula  $\text{weight (kg)}/\text{height}^2 \text{ (m}^2\text{)}$  and was graded as per the WHO - International Classification of adult underweight, overweight and obesity according to BMI: Normal 18.5-24.99, Overweight 25-29.99, Obese Class I 30-34.99, Obese Class II 35-39.99, Obese Class III  $\geq 40$ .

EMG equipment by Nicolet (VIKING SELECT, GERMANY) was used for this study. Hand temperature was maintained between 32°C and 34°C, and hot packs were used to warm hands with lower temperature. Patients with clinical evidence of peripheral neuropathy were subjected to electrophysiologically study both in upper and lower limbs and proven cases of peripheral neuropathy were excluded. Combined sensory index (CSI) with sensitivity of 83.1% and specificity of 95.4% for CTS (17) was used in this study for the electrophysiologically diagnosis of CTS along with motor conduction, and EMG for confirmation of CTS in cases of absent SNAP from median nerve, and for grading of severity (Stevens classification) (17). As the difference in latency of median to radial and ulnar nerves is used for computing CSI, the inter-subject variability due to height, age, temperature, tissue volume conduction, and digital circumference can be reduced or eliminated.

Statistical analyses were carried out using Statistical Package for Social Sciences, v.17.0 (SPSS Inc., Chicago, USA). The level of statistical significance was set at 0.05. The chi-square test or chi-square test for linear trend were

used to assess the association between two qualitative variables wherever appropriate. When more than 20% cells have expected numbers less than 5, the chi-squared test was replaced by Fisher's exact test. Quantitative variables were compared between electrophysiologically positive and negative groups using independent samples t-test or Mann-Whitney U-test depending on the normality of the variable. The multiple logistic regression analysis was used to estimate the association of different factors in electrophysiologically positive cases of CTS after controlling confounding between them. The variables gender, age, BMI (integer values were used because of small number in the normal BMI group), diabetes, and hypothyroidism were included in the model to control for confounding. The adjusted odds ratios and their 95% CI for associated factors were reported.

## Results

Table 1 shows the characteristics and proportion of electrophysiologically positive CTS in the study sample. The mean age was 50.1±10.3 years (range 16 - 77 years), and the mean BMI was 33.9±6.1, with 118 patients (76.6%) belonging to the ≥30 kg/m<sup>2</sup> (class I obesity and above) category. CTS was electrodiagnostically positive in 125 (81.2%) subjects. The proportion of CTS was high in females 84.2% compared to males 70.6%, but not statistically significant, p=0.074. There was a highly significant increasing trend in the percentage of positive CTS according to increasing age, 66.7% in the <40 years group to 93.1% in the ≥60 years group (p=0.002). There was also a highly significant increasing trend in the positivity of CTS with increasing BMI; 37.5% in <25 BMI group, 75% in 25-29.99 BMI group, 84.8% in 30-39.99 BMI group, and 89.5% in ≥40 BMI group (p=0.002). There was a significant difference in the proportion of positive CTS according to vocational status. A high percentage of CTS was observed in the elementary workers, retired persons and technicians, but these groups were small in number. Also, the proportion of positive CTS among housewives was high (88.2%). The positive CTS among persons with and without diabetes mellitus as well as hypothyroidism were not statistically significant. There was no significant difference in the proportion of positive CTS between the Kuwaitis and expatriates population.

A highly significant difference was observed between electrophysiologically positive and negative groups in their mean age and BMI values. The mean age was 51.5±9.8 years in the positive CTS group compared to 44.0±10.5 years in negative group, p<0.001 using student t-test. The mean BMI was 34.8±5.9 kg/m<sup>2</sup> and 30.2±5.4 kg/m<sup>2</sup> respectively in positive and negative groups, p<0.001 using Mann-Whitney U-test.

**Table 1. Characteristics and proportion of positive CTS among 154 patients referred for electrophysiological examinations to the Physical Medicine and Rehabilitation Hospital, 2006-07.**

Variable	All n=154 n (%)	Positive CTS n=125 n (%)	p-value
<b>Gender</b>			0.074 <sup>a</sup>
Male	34 (22.1)	24 (70.6)	
Female	120 (77.9)	101 (84.2)	
<b>Nationality</b>			0.746 <sup>a</sup>
Kuwaitis	104 (68.9)	84 (80.8)	
Expatriates	47 (31.1)	39 (83.0)	
<b>Age in years</b>			0.002 <sup>b</sup>
<40	21 (13.8)	14 (66.7)	
40-	55 (36.2)	40 (72.7)	
50-	47 (30.9)	42 (89.4)	
≥60	29 (19.1)	27 (93.1)	
<b>Body mass index (kg/m<sup>2</sup>)</b>			0.002 <sup>b</sup>
<25	8 ( 5.2)	3 (37.5)	
25-	28 (18.2)	21 (75.0)	
30-	99 (64.3)	84 (84.8)	
≥40	19 (12.3)	17 (89.5)	
<b>Profession</b>			0.018 <sup>c</sup>
Managers	5 ( 3.3)	2 (40.0)	
Professionals	27 (17.6)	17 (63.0)	
Technician/Machine operators	9 ( 5.9)	8 (88.9)	
Clerical support workers	13 ( 8.5)	10 (76.9)	
Service sales workers	4 ( 2.6)	3 (75.0)	
Elementary occupation	6 ( 3.9)	6 (100)	
Retired	13 ( 8.5)	12 (92.3)	
House wives	76 (49.7)	67 (88.2)	
<b>Diabetes mellitus</b>			0.530 <sup>a</sup>
Yes	40 (26.1)	34 (85.0)	
No	113 (72.9)	91 (80.5)	
<b>Hypothyroidism</b>			0.690 <sup>b</sup>
Yes	11 ( 7.2)	10 (90.9)	
No	141 (92.8)	114 (80.9)	

p: values are generated by, a: chi-square test, b: chi-square test for linear trend and c: Fisher's exact test to compare between confirmed and not confirmed cases. Numbers may not add up to the total due to missings.

The high proportion of positive CTS observed in the younger age (<40 years), older age (≥60 years), housewives, and persons without diabetes and hypothyroidism in our sample prompted us to do stratified analysis of these groups with respect to their BMI status (Table 2). Out of the

**Table 2. Obesity status of electrophysiologically positive CTS cases among young, old, house wives, non-diabetes or non-hypothyroid patients.**

Variable	Positive CTS n (%)
<b>Age &lt;40 years (n=14)</b>	
<b>Body mass index (kg/m<sup>2</sup>)</b>	
<25	1 ( 7.1)
25-	3 (21.4)
30-	8 (57.2)
≥40	2 (14.3)
Mean±SD	35.0±9.5
<b>Age ≥ 60 years (n=27)</b>	
<b>Body mass index (kg/m<sup>2</sup>)</b>	
<25	0 ( 0.0)
25-	2 ( 7.4)
30-	21 (77.8)
≥40	4 (14.8)
Mean±SD	36.0±4.8
<b>Housewives (n=67)</b>	
<b>Body mass index (kg/m<sup>2</sup>)</b>	
<25	0 ( 0.0)
25-	8 (11.9)
30-	49 (73.2)
≥40	10 (14.9)
Mean±SD	35.7±5.2
<b>Non-diabetes (n=91)</b>	
<b>Body mass index (kg/m<sup>2</sup>)</b>	
<25	2 ( 2.2)
25-	17 (18.7)
30-	63 (69.2)
≥40	9 ( 9.9)
Mean±SD	34.2±5.7
<b>Non-hypothyroid (n=114)</b>	
<b>Body mass index (kg/m<sup>2</sup>)</b>	
<25	3 ( 2.6)
25-	18 (15.8)
30-	78 (68.4)
≥40	15 (13.2)
Mean±SD	34.7±5.8

14 patients with positive CTS in the younger age group (<40 years), only one had BMI in the normal range and all others were either overweight or obese (mean 35.0±9.5). In subjects with age ≥60 years and with positive CTS, all were either overweight or obese (mean 36.0±4.8). All housewives with positive CTS were either overweight or obese (mean 35.7±5.2). Among the positive CTS patients without diabetes 97.8% were either overweight or obese (mean 34.2±5.7). In the positive CTS patients without hypothyroidism 97.4% were either overweight or obese (mean 34.7±5.8).

There were an increasing proportion of bilateral electrophysiologically positive CTS according to the increasing age as well as BMI. In the higher age groups, overweight and obese categories, bilateral manifestations outnumbered unilateral manifestations (Table 3).

Table 4 shows that age and BMI of patients were the significant factors associated with electrophysiologically positive CTS by univariate analysis. The multivariate logistic regression analysis confirmed these variables as the independent significant factors associated with positive CTS after confounding for other variables. The chance for a patient with age 50-59 years to have positive CTS was 5.5 times more than a patient with age less than 40 years (adjusted odds ratio = 5.46, 95% CI 1.24 - 23.95,

**Table 3. Prevalence of unilateral or bilateral CTS according to age and BMI of 154 patients referred for electrophysiological examinations to the Physical Medicine and Rehabilitation Hospital, 2006-07.**

Variable	Not positive CTS n=29 n (%)	Positive CTS		p-value
		Unilateral n=41 n (%)	Bilateral n=84 n (%)	
<b>Age in years</b>				0.044 <sup>a</sup>
<40	7 (33.3)	7 (33.3)	7 (33.3)	
40-	15 (27.3)	11 (20.0)	29 (52.7)	
50-	5 (10.6)	15 (31.9)	27 (57.5)	
≥60	2 ( 6.9)	7 (24.1)	20 (69.0)	
<b>Body mass index (kg/m<sup>2</sup>)</b>				0.037 <sup>b</sup>
<25	5 (62.5)	2 (25.0)	1 (12.5)	
25-	7 (25.0)	5 (17.9)	16 (57.1)	
30-	15 (15.2)	30 (30.3)	54 (54.5)	
≥40	2 (10.5)	4 (21.1)	13 (68.4)	

**p:** values are generated by **a:** chi-square test and **b:** Fisher's exact test. Numbers may not add up to the total due to missings.

**Table 4. Factors associated with electrophysiologically positive CTS by logistic regression analyses among 154 patients referred for electrophysiological examinations to the Physical Medicine and Rehabilitation Hospital, 2006-07.**

Variable	Univariate analysis			Multivariate analysis		
	Crude Odds ratio	95% CI	p-value	Adjusted Odds ratio	95% CI	p-value
<b>Gender</b>						
Male (reference)	1.00			1.00		
Female	2.22	0.91 - 5.37	0.078	1.08	0.38 - 3.07	0.879
<b>Age in years</b>						
<40 (reference)	1.00			1.00		
40-49	1.33	0.45 - 3.94	0.603	1.49	0.47 - 4.81	0.500
50-59	4.20	1.15 - 15.37	0.030	5.46	1.24 - 23.95	0.025
≥60	6.75	1.24 - 36.91	0.028	5.76	0.91 - 36.50	0.063
<b>BMI</b>	1.18	1.08 - 1.30	<0.001	1.17	1.06 - 1.30	0.002
<b>Diabetes</b>						
No (reference)	1.00			1.00		
Yes	1.37	0.51 - 3.67	0.531	0.50	0.15 - 1.64	0.253
<b>Hypothyroid</b>						
No (reference)	1.00			1.00		
Yes	2.37	0.29 - 19.30	0.421	1.95	0.20 - 19.40	0.570

CI: Confidence interval for odds ratio.

p=0.025). Similarly, a patient with one unit increment in BMI will have 17% more chance to have positive CTS (adjusted odds ratio = 1.17, 95% CI 1.06 - 1.3, p=0.002). The significance of age ≥60 years in univariate analysis disappeared in multivariate analysis and also the p value of the variable gender increased from 0.078 to 0.879 when adjusted by other variables in the multivariate analysis.

## Discussion

Our study was undertaken in a sample of patients referred for electrophysiologic confirmation of clinically suspected CTS. In our sample, the proportion of electrophysiologically positive CTS was 81.2 % with a male to female ratio of 1:4.2. This ratio is in agreement with the male to female ratios reported by various authors - 1:5.4 from Jordan (18), 1:5.6 from Oman (19), 1:7.4 from Brasil (9). In spite of the increased proportion of females, there was no significant influence of female gender on positivity for CTS by univariate and multivariate analysis in our study. We believe that this finding should be interpreted considering the lesser number of male patients, and also the fact that our study was based on a sample of referred patients.

Modernization and life style changes have reportedly increased the prevalence of obesity in Kuwait. Consistent

with this, we found that 76% of the subjects in this study were obese. Among the patients with positivity for CTS, 80.8% were having obesity class I or above (BMI ≥30) and the mean BMI in positive group was significantly high compared to the negative group. Multivariate logistic regression analysis confirmed that BMI and age were the independent significant factors associated with positive CTS. Every unit increment in BMI was found to increase the chances for electrophysiologically positivity of CTS by 17%. This significant finding is similar to that of many other studies using BMI as a continuous variable, 12 % (8), 11% (11), 8% (20). Many authors have highlighted the increase in risk for CTS with increasing BMI, the magnitude of risk varying depending on different populations studied (3, 6, 12, 20-23). The occurrence of carpal tunnel syndrome in obesity has been postulated to be due to a reduction in the carpal tunnel space by accumulation of adipose tissue and increase in tunnel pressure with resultant neural compromise, resulting in focal demyelination initially followed by ischemia and denervation (9, 17, 24).

Age was the other significant factor for electrophysiologic positivity for CTS in this study, the mean age being 51.5±9.8 years in positive group. This finding is similar to that reported by Becker J et al. (9). Using data from the Dutch national surveys for the year 1987 and 2001, Bongers FJ reported that the peak

incidence rate of CTS was found to be in the 46-64 years age group in both the study periods (25). Two studies from the middle east, one from Jordan, where 82% of their patients were found to be younger than 55 years (18) and another from Oman with a mean age of 41 years (19) also reported similar findings. We found that, the chance for a patient with age 50-59 years to have positive CTS was 5.5 times more than a patient with age less than 40 years. Interestingly, the significance of age  $\geq 60$  years found in univariate analysis disappeared in multivariate analysis. This we feel could be due to the fact that all subjects with positivity for CTS in  $\geq 60$  years group were either overweight or obese. A significantly increasing trend in the prevalence of bilateral presentation in positive CTS, with increasing age and BMI was also brought out in this study. This finding is similar to the study by Bland JD, which found that bilateral CTS cases were associated with a slightly higher mean BMI than unilateral CTS (7).

A higher prevalence of diabetes in patients who underwent CTS release was reported previously (26). Some other authors (22, 27-29) also have reported a positive association between diabetes mellitus and CTS. In our study, diabetes did not show a significant association with CTS. Similar findings were reported in some other studies (9, 30, 31). Stamboulis et al. reported no increased representation of diabetes in CTS patients (31). The lack of association of diabetes with electrophysiologically positive CTS that was observed in our study we feel could be due to the overwhelming influence of BMI. It should be noted that exclusion of peripheral neuropathy in our study might have diluted the association of diabetes with CTS.

Insignificant association found between positive CTS and hypothyroidism in our study could be again due to the fact that BMI was high in persons without hypothyroidism also.

In our study, almost half of the referred subjects were housewives, and 88.2% of them had positive CTS, which prompted us to further analyze the influence of obesity on this group. All housewives with CTS were either overweight or obese (Mean BMI was  $35.7 \pm 5.2$  in housewives with positive CTS and  $32.1 \pm 3.5$  in housewives without CTS). This finding again substantiates our concept of an increasing association of obesity in electrophysiologically positive CTS. There were only smaller numbers of subjects in other vocational groups.

The significant association of obesity with CTS brought out in our study, as well as an increase in the prevalence of CTS in sub groups like housewives, non-diabetic, non-hypothyroid, and younger age group (<40 years) (all these groups with increased BMI) reiterates the

major influence of obesity in the electrophysiologically positivity for CTS.

A major limitation of this study was that the sample was not a population based one and consisted of patients referred by a physiatrist from a tertiary hospital, and hence it makes it difficult to assume direct statistical correlation of absolute risk. However, the findings of association of BMI and age in patients with positive CTS brought out in this study, is significant. A larger population based study should be able to throw more light on the complex association of CTS with BMI and diabetes.

Our study emphasizes the significant association of obesity and age in electrophysiologically positive cases of CTS. One unit increment in BMI increased the chance of a positive electrophysiologically diagnosis of CTS by 17% in this referred population. Diabetes mellitus was not found to be a significant factor in our study. A wider population based study may provide additional information regarding the risk factors for CTS in Kuwait and the complex association between CTS, BMI and diabetes. Screening of persons with high BMI for symptoms suggestive of CTS and having a high index of suspicion for the possibility of CTS will help in identifying early cases of CTS for early intervention and resultant reduction in morbidity.

## Conflict of interest

The authors declare no conflict of interest associated with this manuscript.

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