ORİJİNAL MAKALE/ORIGINAL ARTICLE
J Turgut Ozal Med Cent 2015:22(3):152-7

Journal of Turgut Ozal Medical Center
www.jtomc.org

# The Relationship Between Waist Circumference, Wrist Circumference, and Body Mass Index in Carpal Tunnel Syndrome

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Abstract

**Objective:** Although waist circumference and body mass index have been reported to be risk factors in several diseases, there are few avalaible data on the relationship between waist circumference and carpal tunnel syndrome. We aimed to evaluate the relationship between waist and wrist circumferences, and body mass index in patients with carpal tunnel syndrome.

**Materials and Methods:** One hundred consecutive patients with carpal tunnel syndrome and 100 healthy volunteers were included in this study. Neurological examination and nerve conduction were performed. The patients and controls were compared in terms of age, sex, body mass index, wrist circumference, and waist circumference.

**Results:** The means of the waist and wrist circumferences and body mass index were significantly higher in patients than in controls (p=0,0001). There were statistically significant correlations between carpal tunnel syndrome and body mass index as well as waist and wrist circumferences of the patients (r=0.285, p<0.001; r=0.213, p=0.002; r=0.182, p=0.010 respectively). Morever, there were statistically significant differences in the wrist and waist circumferences between controls and patients with moderate to severe carpal tunnel syndrome group (p<0,05).

**Conclusion:** Our study showed significant relationship between carpal tunnel syndrome and the wrist and waist circumferences of patients. Thus, the roles of visceral and total body fat in carpal tunnel syndrome should be considered in future studies. Measuring waist and wrist circumference is a simple and inexpensive method that can be used in studies on carpal tunnel syndrome in addition to body mass index.

**Key Words:** Carpal Tunnel Syndrome; Body Mass Index; Wrist Circumference; Waist Circumference; Age.

## Karpal Tünel Sendromunda Bilek Çevresi, Bel Çevresi ve Vücut Kitle İndeksi Arasındaki İlişkiler

Özet

**Giriş:** Vücut kitle indeksi ve bel çevresi, çeşitli hastalıklarda risk faktörü olarak daha önce bildirilmiş olmasına rağmen, bel çevresiyle karpal tünel sendromu arasında bir ilişkiye dair çok az sayıda çalışma vardır. Bu çalışmada karpal tünel sendromlu hastalarda, bilek ve bel çevresiyle, vücut kitle indeksi arasındaki ilişkileri değerlendirmeyi amaçladık.

**Gereç ve Yöntemler:** 100 karpal tünel sendromulu ardışık hasta ve 100 sağlıklı gönüllü birey çalışmaya dahil edildi. Nörolojik muayene ve sinir iletim çalışmaları yapıldı. Karpal tünel sendromulu hasta ve kontroller yaş, cinsiyet, vücut kitle indeksi, bilek ve bel çevresi yönünden karşılaştırıldı.

**Bulgular:** Ortalama bel çevresi, ortalama bilek çevresi ve vücut kitle indeksi, karpal tünel sendromulu hastalarda kontrol grubuna göre anlamlı yüksekti (p=0.0001). Karpal tünel sendromu, vücut kitle indeksi ve bilek ve bel çevreleri arasında istatistiksel olarak anlamlı korelasyon mevcuttu (r=0.285, p<0.001; r=0.213, p=0.002; r=0.182, p=0.010). Ayrıca orta-ağır karpal tünel sendromlu hastalarla kontroller arasında bilek ve bel çevresi açısından istatistiksel olarak anlamlı fark mevcuttu (p<0.05).

**Sonuç:** Çalışmamız karpal tünel sendromuyla bilek ve bel çevresi arasında istatistiksel olarak anlamlı ilişki olduğunu gösterdi. Bel çevresiyle karpal tünel sendromu arasında bir ilişkiye dair bulgumuz nedeniyle, viseral ve tüm vücut yağının karpal tünel sendromundaki rolü gelecek çalışmalarda dikkate alınmalıdır. Bilek ve bel çevresi ayrıca vücut kitle indeksi, basit ve pahalı olmayan bir metod olarak karpal tünel sendromu çalışmalarında kullanılabilir.

**Anahtar Kelimeler:** Karpal Tünel Sendromu; Vücut Kitle İndeksi; Bilek Çevresi; Bel Çevresi; Yaş.

## INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy in the general population, resulting from a compression of the median nerve at the level of the carpal tunnel (1). Some epidemiological studies have been carried out to identify risk factors for CTS. The most consistent risk factors identified in these studies have been gender (female), obesity, high body mass index (BMI, weight in kg/height$^2$ in meters), age (over 30), and repetitive motor activity (1). In addition to these factors, certain medical conditions like diabetes mellitus, thyroid disease, connective tissue disorders, amyloidosis, acromegaly, and pregnancy have also been accepted as risk factors for developing CTS (2). For instance, Werner et al. have found that BMI>29 was an independent risk factor for CTS (3).

Some studies have investigated the relationship between BMI, wrist circumference, and wrist ratio in CTS (4-8). Wrist ratio (wrist depth to wrist width ratio) was reported to be an independent risk factor for CTS (3, 7, 9-10). Wrist circumference was examined in a number of studies but the results were controversial. Whereas some studies reported no significant relationship between wrist circumference, carpal tunnel size, and presence of CTS (4, 11), other studies reported a significant relationship between wrist circumference and CTS (7, 8).

Waist circumference has been widely used as a simple anthropometric index to measure the degree of central obesity (12). Increased waist circumference independent from BMI was strongly associated with risk factors for many systemic diseases such as cardiovascular diseases, metabolic syndrome, and type 2 diabetes (13-15). Waist circumference is also one of the preferred predictors of these disorders (15-19). Although waist circumference has previously been reported as a risk factor along with BMI in several diseases, there is few avalaible data on the relationship between waist circumference and carpal tunnel syndrome.

In this study, we aim to evaluate the relationship between waist and wrist circumferences, and BMI in CTS since waist and wrist circumferences are simple anthropometric methods.

## MATERIAL and METHODS

### Subjects and evaluation

This case-control study was conducted between September 2009 and September 2010.

All patients were consecutively admitted to the Department of Neurology at the Faculty of Medicine, Inönü University. This study was performed in accordance with the Declaration of Helsinki. After a detailed explanation of the study, all subjects agreed to give their written informed consent.

One hundred patients with CTS and 100 control subjects were included in this study.

CTS was diagnosed both clinically and electrophysiologically. Typical clinical symptoms (nocturnal pain, paresthesia or numbness in the hands, symptoms provoked by sleep, and activity-related pain and paresthesia) and the presence of neurological deficits were evaluated.

All patients underwent neurologic examination. Both hands were examined for motor deficits, thenar atrophies, and sensory involvement in the area innervated by the median nerve. Tinnel's and Phalen's provocation tests were also performed. We did not rely solely on these tests to detect CTS. The diagnosis was based on typical clinical presentation, whether patients responded to non-surgical treatment without other evident neurological deficits, and appropriate electrophysiological findings.

In order to restrict our study to patients with purely idiopathic CTS, we excluded all patients with diabetes mellitus, rheumatoid arthritis, chronic renal failure, gout, thyroid diseases, hyperlipidemia, and history of wrist's fractur or space-occupying lesions.

### Electrophysiological examination

Standart nerve conduction studies (NCS) were performed with a Medelec-Oxford Synergy EMG machine (Oxford Instruments Medical, Surrey, UK) using a filter setting of 20 Hz–10 kHz and an analysis time of 50 ms. Impulses were recorded using surface electrodes. Conduction studies were performed in a warm room, such that the skin temperature of the extremities registered at 32°C or above. Skin temperature was measured at the site where nerve conduction velocity measurements (NCV) were taken.

Median motor and sensory (finger-wrist, wrist-elbow) nerve conduction velocities were measured in the bilateral upper extremities using the method described by Oh (20). We also performed both motor and sensory conduction studies of the ulnar nerve. Patients with abnormalities in ulnar motor or sensory conduction were not included in the study.

The electrophysiological criteria for the diagnosis of CTS were based on the parameters for electrodiagnostic studies established by the American Academy of Neurology, the American Association of Electrodiagnostic Medicine, and the American Academy of Physical Medicine and Rehabilitation (21).

Electrophysiological abnormalities were classified according to the severity of CTS into five stage scales: stage 1; abnormal segmental or comparative studies, stage 2; abnormal finger/wrist sensory conduction velocities, stage 3; abnormal finger/wrist sensory conduction velocities, and abnormal distal motor latencies, stage 4; absence of sensory response and abnormal distal motor latency, stage 5; absence of sensory and motor responses (22, 23, 24). Based on the electrophysiological staging, since the number of patients in the subgroups varied greatly, the groups at stage 1 and 2 were unified as the mild CTS patients; the groups at stages 3, 4, and 5 were combined and organised as moderate-severe CTS patients. Their statistical comparisons were evaluated over three groups including the control group as well.

### Control group

The control group was selected from among the healthy volunteers. The same procedures regarding examinations and evaluations were applied for each of the subjects in the control group. The control subjects did not have any clinical manifestations suggestive of CTS. On neurological examination, all control subjects were normal. Their nerve conduction studies were performed as described above. The exclusion criteria for the study group were also used for the control group.

### Assessment of variables

The following clinical variables were recorded: age, gender, height, body weight, circumference of wrist, and circumference of waist.

BMI was calculated as bodyweight divided by the square of height ($kg/m^2$).

Wrist circumference was measured on the side of hand which performed NCS in the patients with CTS. In the control group, wrist circumference of the dominant hand was measured, and NCS was carried out. Weight, height, wrist, and waist circumferences were recorded twice for each individual by trained personnel following WHO's recommendations (19).

The patients with CTS and controls were compared in terms of age, gender, BMI, circumference of wrist, and circumference of waist.

### Statistical Analysis

Statistical analyses were performed using commercial software (PASW ver.18, ID: 33478001 SPSS inc. Chicago, IL). Pearson's chi-square test was used to compare gender among groups. The continuous variables were presented as mean and standard deviation. Categorical variables were presented in counts and percentages. Kolmogorov-Smirnov test was used to evaluate whether the distribution of continuous variables was normal. Accordingly, it was seen that all variables displayed a normal distribution. Therefore, two independent sample t tests were used to compare the continuous variables between the control and CTS groups. One-way ANOVA was used to compare the same variables among the control, mild CTS, and the moderate-severe CTS groups. When ANOVA results were significant, Sheffe test or Tamhane were used in respect of the results of Levene homogenity tests in the paired comparison. Spearman's correlation coefficient was used to determine the relation between CTS and BMI and the circumferences of waist and wrist. Values of $p < 0.05$ were considered to indicate statistical significance.

## RESULTS

One hundred patients with CTS (male/female, 7/93; mean age, 44.57 ± 8.57 years) and 100 controls (male/female, 13/87; mean age, 43.41 ± 8.57 years) were included in the study.

### Comparison of clinical variables between the groups

No significant differences were observed between the groups in terms of age, or gender (p, 0.427; p, 0.239, respectively).

The mean waist circumference, mean wrist circumference, and BMI were significantly higher in patients with CTS compared to the control group (p, 0.0001). Morever, there was a statistically significant correlation between CTS and BMI and circumferences of waist and wrist (r=0.285, p<0.001; r=0.213, p=0.002; r=0.182, p=0.010, respectively).

Comparison of clinical variables between groups is presented in Table 1.

**Table 1.** Comparison of age, gender, body mass index, circumferences of waist and wrist between patients with carpal tunnel syndrome and controls.

| | | n | Mean ± SD | p |
|---|---|---|---|---|
| **Age[1] (years)** | Control group | 100 | 43.41 ± 11.77 | 0.427* |
| | CTS | 100 | 44.57 ± 8.57 | |
| **Gender[2] (female/male)** | Control group | 100 | 87/13 | 0.239** |
| | CTS | 100 | 93/7 | |
| **Body mass index[1] ($kg/m^2$)** | Control group | 100 | 29.76 ± 5.67 | **<0.001*** |
| | CTS | 100 | 32.99 ± 5.46 | |
| **Waist circumference[1] (cm)** | Control group | 100 | 91.47 ± 14.64 | **0.002*** |
| | CTS | 100 | 97.42 ± 12.12 | |
| **Wrist circumference[1] (cm)** | Control group | 100 | 16.58 ± 1.43 | **0.011*** |
| | CTS | 100 | 17.11 ± 1.47 | |

([1]Values represent mean □ standart deviation (SD); [2]Values represent numbers (in percentages); CTS, carpal tunnel syndrome; *t test; ** chi-square test).

### Comparison of clinical variables between the electrophysiologically evaluated CTS subgroups and controls

No significant difference in terms of age or gender was observed in classified subgroups that have been identified as moderate-severe CTS and mild CTS groups compared to the control group (p: 0.677 and p: 0.309, respectively).

However, there was a statistically significant difference between the three groups with regards to BMI, waist, and wrist circumferences (p<0.001, p:0.008 and p:0.005, respectively). When the pairwise comparison was carried out, there was a statistically significant difference for BMI and waist circumferences between the control and patients' groups (p<0.05) albeit no statistically significant difference was found between the mild CTS group and the moderate-severe CTS group (p>0.05). Again, there was statistically significant difference for wrist and waist circumferences between the control and moderate-severe CTS groups (p<0.05), but no statistically significant difference was found between the mild CTS group and the other groups (p>0.05). Comparison of clinical variables between groups is presented in Table 2.

**Table 2.** Comparison of age, body mass index, circumferences of waist and wrist between subgroups of carpal tunnel sydrome and controls.

| | | n | Mean ± SD | *p* |
|---|---|---|---|---|
| **Age (years)** | Control group | 100 | 43.41 ± 11.77 | 0.677* |
| | Mild CTS | 59 | 44.24 ± 9.14 | |
| | Moderate and severe CTS | 41 | 45.05 ± 7.76 | |
| | Total | 200 | 43.99 ± 10.28 | |
| **Body mass index (kg/m²)** | Control group | 100 | 29.76 ± 5.67 | **<0.001**** |
| | Mild CTS | 59 | 32.96 ± 5.62 | |
| | Moderate and severe CTS | 41 | 33.03 ± 5.29 | |
| | Total | 200 | 31.37 ± 5.79 | |
| **Waist circumference (cm)** | Control group | 100 | 91.47 ± 14.64 | **0.008***** |
| | Mild CTS | 59 | 96.97 ± 10.79 | |
| | Moderate and severe CTS | 41 | 98.05 ± 13.94 | |
| | Total | 200 | 94.44 ± 13.73 | |
| **Wrist circumference (cm)** | Control group | 100 | 16.58 ± 1.43 | **0.005***** |
| | Mild CTS | 59 | 16.86 ± 1.37 | |
| | Moderate and severe CTS | 41 | 17.47 ± 1.55 | |
| | Total | 200 | 16.85 ± 1.47 | |

(CTS, carpal tunnel syndrome; * ANOVA test; **Spearman's correlation; ***Sheffe test).

## DISCUSSION

Our study showed that increased waist and wrist circumferences are associated with CTS besides higher BMI. The relationship between obesity and higher BMI with CTS has been reported previously (1, 3, 5). Although BMI was related to total body fat, waist circumference reflected central obesity or visceral fat. In general population, waist circumference was noted to be a reliable predictor of visceral fat and vascular risk profile. Balcı et al. have reported that metabolic syndrome, which is related to waist circumference, was found to be three times more common in patients with CTS, and CTS was more severe in patients with metabolic syndrome when compared with those without metabolic syndrome (25). The present study shows that waist circumference and BMI are associated with all subgroups of CTS when compared to the control group. It seems that central obesity and total body fat may have a similar role in CTS.

In the literature, the association between obesity and higher BMI was explained to be due to increased fat deposition in the carpal tunnel as mechanical compression (1, 3, 7). The accumulation of fat tissues in the carpal tunnel probably increases the hydrostatic pressure due to the translocation of blood volume from the legs to the arms in the recumbent position as well as synovial thickening in obese people through the canal compresses the median nerve (2, 3, 7). On the other hand, the other theory in the pathogenesis on CTS is microvascular insuffiency (26). There are few studies on the relationship between microvascular disturbance and waist circumference (27, 28). Kramer Aguiar et al. have reported that microvascular dysfunction could be predicted by waist circumference on young overweight/obese women, reinforcing the relationship between obesity related microvascular/metabolic disturbances (27). We think that our findings on the relationship between waist circumference and CTS support the microvascular insuffiency theory in the pathogenesis of CTS along with the mechanic compression theory. Future studies on the association between vascular risk profile and CTS are needed to reinforce data presented on our population.

Whereas waist circumference and BMI were associated with all subgroups of CTS electrophysiologically, wrist circumference was associated with the moderete-severe CTS group in our study. There are few studies in the literature focusing on the association between wrist circumference and CTS. Mogk and Keir have studied the carpal tunnel measurement in three-dimensional models with MRI, and reported a significant relationship between wrist circumference and carpal tunnel cross-sectional area (8). Bleecker et al. have identified no significant relationship between wrist and carpal tunnel dimensions (4). Moghtaderi et al. have found that lesser wrist circumference reveals significant statistical difference while comparing all cases with CTS and normal controls, and wrist circumference was not significantly associated with the presence of CTS. They also reported that disease severity was not significantly associated with sex, BMI, wrist ratio, or circumference (7). On the other hand, in the present study, wider wrist circumference in moderete-severe CTS group was found statistically significant in the control group, which could be explained by mechanic compression. Komurcu et al. have reported that the waist circumferences of groups with mild, medium, and severe CTS severity were found to be significantly higher in comparison to the normal reference group (29). Mondelli et al. have identified that high waist circumference/waist-to-hip-ratio doubles the risk of CTS as this risk is further increased if overweight/obese subjects also have very high waist circumferences or high waist-to-hip-ratios (30). Moreover, Plastino et al. have reported that waist circumference and body mass index were significantly increased in the CTS group (31).

The limitation of our study is the fact that wrist ratio was not used along with wrist circumference. In this study, wrist circumference was prefered since it was a simple and inexpensive measurement method like waist circumference. Further investigation with alternative tecniques will help to identify the potential relationship between wrist circumference and carpal tunnel size and CTS. Another limitation of the current study is the use of electrophysiological findings rather than clinical diagnosis to categorise the patients into mild and moderate-severe CTS groups.

Although the relationship between BMI and CTS was important and well-known, our study showed that there was a statistically significant relationship between CTS and circumferences of wrist and waist, as well. The role of visceral and total body fat in CTS should also be considered in the future studies. Evaluating waist and wrist circumferences along with BMI may be simple and inexpensive method that can be used in studies on CTS.

**Acknowledgments:** The authors would like to give special thanks to Unal Erkorkmaz for carrying out the statistical analyses.

**relatDisclaimer:** The authors of this article declare no conflict of interest.

## REFERENCES

1. Becker J, Nora DB, Gomes I, Stringari FF, Seitensus R, Panosso JS, et al. An evaluation of gender, obesity, age and diabetes mellitus as risk factors for carpal tunnel syndrome. Clin Neurophysiol 2002;9:1429-34.
2. Radecki PA. A gender specific wrist ratio and likelihood of a median nevre abnormality at the carpal tunnel. Am J Phys Med Rehabil. 1994;73:157-62.
3. Werner RA, Albers JW, Franzblau A, Armstrong TJ. The relationship between body mass index and the diagnosis of carpal tunnel syndrome. Muscle Nerve 1994;17:632–6.
4. Bleecker ML, Bohlman M, Moreland R, Tipton A. Carpal tunnel syndrome: role of carpal canal size. Neurology 1985;35:1599–604.
5. Kouyoumdjian JA, Morita MD, Rocha PR, Miranda RC, Gouveia GM. Body mass index and carpal tunnel syndrome. Arq Neuropsiquiatr 2000;58(2A):252-6.
6. Boz C, Ozmenoglu M, Altunayoglu V, Velioglu S, Alioglu Z. Individual risk factors for carpal tunnel syndrome: an evaluation of body mass index, wrist index and hand anthropometric measurements. Clin Neurol Neurosurg 2004;106:294-9.
7. Moghtaderi A, Izadi S, Sharafadinzadeh N. An evaluation of gender, body mass index, wrist circumference and wrist ratio as independent risk factors for carpal tunnel syndrome. Acta Neurol Scand 2005;112:375-9.
8. Mogk JPM, Keir PJ. Wrist and carpal tunnel size and shape measurements: Effects of posture. Clinical biomechanics 2008;23:1112-20.
9. Tanaka S, Wild DK, Cameron LL, Freund E. Association of occupational and non-occupational risk factors with the prevalence of self-reported carpal tunnel syndrome in a national survey of the working population. Am J Ind Med 1997;32 550–6.
10. Lam N, Thurston A. Association of obesity, gender, age and occupation with carpal tunnel syndrome. Aust N Z J Surg 1998;68:190–3.
11. Uchiyama S, Itsubo T, Yasutomi T, Nakagawa H, Kamimura M, Kato H. Quantitative MRI of the wrist and nevre conduction studies in patients with idiopathic carpal tunnel syndrome. J Neurol Neurosurg Psychiat 2005; 76: 1103-08.
12. National Institutes of Health, Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults-the evidence report. Obes Res 6 1998;6 (Suppl. 2): 51S–209S.
13. 13.Ryan MC, Farin HMF, Abbasi F, Reaven GM. Comparison of Waist Circumference Versus Body Mass Index in Diagnosing Metabolic Syndrome and Identifying Apparently Healthy Subjects at Increased Risk of Cardiovascular Disease. Am J Cardiol 2008;102:40-6.
14. Christian AH, Mochari H, Lori J. Mosca LJ. Waist Circumference, Body Mass Index, and Their Association With Cardiometabolic and Global Risk. J Cardiometab Syndr 2009;4:12–9.
15. Wang YF, Rimm EB, Stampfer MJ, Willett WC, Hu FB. Comparison of abdominal adiposity and overall obesity in predicting risk of type 2 diabetes among men. Am J Clin Nutr 2005;81:555-63.
16. Snijder MB, Zimmet PZ, Visser M, Dekker JM, Seidel JC, Shaw JE. Independent and opposite associations of waist and hip circumference with diabetes, hypertension and dyslipidemia. The AusDiab Study Int J Obes 2004;28:402-9.
17. Megnien JL, Denarie N, Cocaul M, Simon A, Levenson J. Predictive value of waist to hip ratio on cardiovascular risk events. Int J Obes 1999;23:90-7.
18. Chen L, Peeters A, Magliano DJ. Anthropometric measures and absolute cardiovascular estimates in Australian Diabetes, Obesity and Lyfestyle (AusDiab) Study. Eur J. Cardiovasc Prev Rehab 2007;14:740-5.
19. WHO. Physical status: The use and interpretation of anthropometry. Report of a WHO Expert Committee. 1995;854:1-453. Geneva, WHO. WHO Technical Report Series. Ref Type: Report.
20. American Academy of Neurology, American Association of Electrodiagnostic Medicine, American Academy of Physical Medicine and Rehabilitation: Practice parameter for electrodiagnostic studies in carpal tunnel syndrome (summary statement). Neurology 1993;43:2404–05.
21. Oh S. Anatomical guide for common nerve conduction studies. In: Oh Shin MD, ed. Clinical Electromyography: Nerve Conduction Studies. Baltimore: Park Press, 1984:65-85.
22. Mondelli M, Reale F, Sicurelli F, Padua L: Relationship between the self-administered Boston questionnaire and electrophysiological findings in follow-up of surgically-treated carpal tunnel syndrome. J Hand Surg (Br) 2000;25:128–34.
23. Mondelli M, Passero S, Giannini F: Provocative tests in different stages of carpal tunnel syndrome. Clin Neurol Neurosurg 2001;103:178–83.
24. Giannini F, Cioni R, Mondelli M, Padua R, Gregori B, D'Amico P, et al. A new clinical scale of carpal tunnel syndrome: validation of the measurement and clinical-neurophysiological assessment. Clin Neurophysiol 2002;113:71–77.
25. Balci K, Utku U. Carpal tunnel syndrome and metabolic syndrome. Acta Neurol Scand 2007; 116: 113–7.
26. Aroori S, Spence RAJ. Carpal tunnel syndrome. Ulster Med J 2008;77:6-17.
27. Kraemer-Aguiar L, Maranhao PA, Cyrino FZGA, Bouskela E. Waist circumfrence leads to prolonged microvascular

hyperemia response in young overweight/obese women. Microvasc Res 2010;80:427-32.
28. Kraemer-Aguiar L, Maranhao PA, Sicuro FL, Bouskela E. Microvascular dysfunction: a direct link among BMI, waist circumference and glucose homeostasis in young overweight/obese normoglycemic women? Int J Obes (Lond) 2010;34:117-7.
29. Komurcu HF, Kilic S, Anlar O. Relationship of age, body mass index, wrist and waist circumferences to carpal tunnel syndrome severity. Neurol Med Chir (Tokyo) 2014;54:395-400.
30. Mondelli M, Aretini A, Ginanneschi F, Greco G, Mattioli S. Waist circumference and waist-to-hip ratio in carpal tunnel syndrome: acase-control study. J Neurol Sci. 2014;338(1-2):207-13.
31. Plastino M, Fava A, Carmela C, De Bartolo M, Ermio C, Cristiano D, et al. Insulin resistance increases risk of carpal tunnel syndrome: a case-control study. J Peripher Nerv Syst. 2011;16:186-90.

Received/Başvuru: 09.06.2014, Accepted/Kabul: 10.10.2014

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**For citing/Atıf için**

Unaldi HK, Kurt S, Cevik B, Mumcuoglu I, Sumbul O. The relationships among waist circumference, wrist circumference, and body mass index in carpal tunnel syndrome. J Turgut Ozal Med Cent 2015;22:152-7 DOI: 10.7247/jtomc.2014.2206