RELATIONSHIP BETWEEN CARPAL TUNNEL SYNDROME AND WRIST ANGLE IN COMPUTER WORKERS

Chin-Wei Liu, Tien-Wen Chen,1 Ming-Cheng Wang,1 Chia-Hsin Chen, Chia-Ling Lee, and Mao-Hsiung Huang

Department of Physical Medicine and Rehabilitation, Kaohsiung Medical University Hospital, and 1Department of Physical Medicine and Rehabilitation, Kaohsiung Municipal Hsiao Kang Hospital, Kaohsiung, Taiwan.

Carpal tunnel syndrome (CTS) is the most widely known entrapment neuropathy. The aim of this study was to assess the incidence of CTS in a group of computer workers by typical symptoms, median nerve conduction studies, and their combinations. The posture of extended wrists while typing on a computer keyboard seems to be a predisposing factor for CTS. However, the correlation between wrist extension angle and the incidence of CTS is not well known. Forty-five subjects (mean age, 38.8 ± 7.8 years) who used a computer for more than 6 hours daily in a medical center in southern Taiwan were studied. All completed questionnaires to ascertain their age, employment duration, dominant hand, and the severity of symptoms. Physical examinations (Tinel’s sign and Phalen’s test) were performed by a physician. The maximal wrist extension angle when typing on a computer keyboard was also measured by the same physician. Nerve conduction studies were performed on each subject to determine the severity of CTS. Results showed that the incidence of CTS in the computer workers was 16.7% (15 of 90 hands). Twelve subjects showed electrodiagnostic evidence of CTS: it involved the dominant hand in seven, the non-dominant hand in two, and bilateral hands in three. The severity of clinical symptoms was compatible with the findings of the nerve conduction studies. Among the major predisposing factors, we found significant correlation between CTS development and the wrist extension angle while typing on a computer keyboard. Computer workers who kept their wrists extended by more than 20° were at greater risk of developing CTS.

Key Words: carpal tunnel syndrome, computer worker, nerve conduction study, wrist angle

(Revised: August 11, 2003 Accepted: October 27, 2003 Address correspondence and reprint requests to: Dr. Mao-Hsiung Huang, Department of Physical Medicine and Rehabilitation, Kaohsiung Medical University Hospital, 100 Shih-Chuan 1 st Road, Kaohsiung 807, Taiwan. E-mail: maohuang@ms24.hinet.net

Carpal tunnel syndrome (CTS) is the most common and widely known peripheral entrapment neuropathy [1,2]. Typical symptoms and signs are numbness, tingling or burning pain in the median nerve-innervated finger (anterior surface of the first three digits and the radial portion of the ring finger), and nocturnal pain and paresthesia [1,3,4].

Patients with CTS often complain of wrist and arm pain associated with paresthesia in the hand [5]. Weakness in abduction of the thumb and thenar atrophy can also be found in severe CTS. Pain and paresthesia are aggravated by repetitive use of the hands [6]. These symptoms often occur during the night and awaken patients. In addition, atypical presentations of CTS are common. The hands may be clumsy and there may be a loss of dexterity. Change in cold sensitivity of the fingers has also been described [7].

There are two provocative tests for CTS. Tinel’s sign may be provoked by tapping over the median nerve at the wrist, and Phalen’s sign by holding the wrists passively flexed. However, they are reported to have limited diagnostic
value. Estimates of the sensitivities of Phalen’s test and Tinel’s sign vary from 25% to 75%, and the specificities from 47% to 90% [4]. Median nerve conduction studies (NCS) are reported to be the “gold standard” for diagnosing CTS due to their high sensitivity [7,8]. In the present study, CTS was confirmed based on patients’ symptoms, physical examinations (Tinel’s sign and Phalen’s test), NCS, and their combinations [9–12].

Many risk factors of CTS are known; independent risk factors include gender, obesity, and age. Diabetes mellitus may be a weak risk factor. Female gender, body mass index greater than 30, age between 41 and 60 years, and diabetes mellitus are found significantly more frequently than other factors among CTS patients [13,14]. Cigarette smoking and jobs exposing workers to excessive vibration were also found to significantly increase the risk of CTS [15]. Among people who make repetitive use of wrist flexors and fingers and have extreme wrist postures, CTS might develop at a higher frequency than among people who do not [16]. CTS is noted in people who work as cashiers, butchers, supermarket checkout staff, construction workers, sheet metal workers, and computer workers [3,10,17], but the real risk factor for CTS among computer users is unclear. The aim of this study was to investigate the risk factors for CTS among computer workers in order to prevent the occurrence of CTS.

**MATERIALS AND METHODS**

Patients who had diabetes mellitus, thyroid disease, rheumatoid arthritis, cervical radiculopathy, history of wrist injury, or who were pregnant at the time of the study were excluded. Forty-five subjects, randomly selected from each department of the hospital, who were identified as frequent computer users (6–8 hours per day) were studied. They were asked to complete a questionnaire to gather basic information such as their age, dominant hand, employment duration, severity of symptoms, and if they experienced any painful sensation in the involved hands.

**Nerve conduction studies**

NCS were performed using an electrodiagnostic machine (Keypoint version 2.11, Medtronic Dantec, Skovlund, Denmark) by the same technician for all subjects under isothermal conditions to maintain the skin temperature at 30°C. The NCS filter was set at 10 Hz to 10 KHz for motor studies and 20 Hz to 2 KHz for sensory studies. In an attempt to make the most of the NCS data, the diagnosis of CTS was based on certain widely accepted assumptions. First, sensory fibers are involved early in the majority of patients, and sensory abnormalities precede motor abnormalities. Second, slower conduction velocities are worse than faster ones [18]. Third, CTS, which typically involves demyelination, may be associated with secondary axonal loss. A demyelinating lesion at the carpal tunnel always results in slowing of the velocity of nerve conduction and prolongation of the distal latency. If the demyelination results in conduction block or secondary axonal loss, the amplitudes will also be decreased [5]. Fourth, the clinical severity of CTS and the NCS data are directly proportional to each other.

The electrodiagnostic criteria for the diagnosis of CTS were modified as follows from Lo et al [1] and Bland [18]: median digit II and ulnar digit V sensory latency must differ by greater than 0.4 ms; median distal motor latency must be greater than 4.0 ms; median sensory velocity must be less than 40 m/sec.

The severity of CTS depends on motor latency and sensory velocity. Greater prolongation of motor latency and greater decrease in sensory conduction velocity indicate more severe CTS.

**Measurement of pain severity**

Patients with CTS often complain of wrist and arm pain associated with paresthesia of the affected hand. The pain may be localized to the wrist, or it may radiate to the forearm, arm, or rarely, the shoulder [5]. It is difficult to assess the severity of pain clinically. We used the visual analog scale (VAS) in subjects who suffered wrist pain. The VAS scores ranged from 0 to 10, representing no pain to pain as severe as possible. If the tested person merely felt discomfort, this was recorded on the VAS as one. We considered VAS scores greater than two to be meaningful pain sensations.

**Wrist angle measurement**

A computer keyboard that requires workers to bend their wrists is a common cause of CTS among computer users. The maximal extension of wrists during work was measured using goniometry, and the data were recorded as an average of three measurements. For goniometry, the angle between the index metacarpal in maximal extension of the wrist when typing and the axis of the forearm in the pronation position was measured as the wrist angle.

**Statistical analysis**

After data collection from the questionnaires, correlation analyses were performed for age, duration of employment,
dominant hand, VAS score, and wrist angle. Pearson’s correlation was used to analyze the correlation of the above factors with the latency of motor evoked potential and the velocity of sensory conduction.

**RESULTS**

This study investigated 45 subjects (total of 90 hands) with a mean age of 38.8 ± 7.8 years and an average employment duration of 14.6 ± 8.1 years. Physical examination results showed that the frequency of hand paresthesia among these computer users was 15.6% of hands, which was substantial; Tinel’s sign was positive in 11.1% of hands, and Phalen’s test was positive in 10.0% of hands (Table 1).

NCS findings consistent with CTS were seen in 12 of 45 subjects: it involved the dominant hand in seven, the non-dominant hand in two, and bilateral hands in three. Electrodiagnostic evaluation resulted in a diagnosis of CTS in 16.7% (15/90) of hands. Table 2 shows the findings of the two provoked tests (Tinel’s sign and Phalen’s test) and NCS. The sensitivities and specificities of Tinel’s sign and Phalen’s test are shown in Table 3.

There was no significant correlation between CTS development and duration of employment (\( r = 0.220, p = 0.146 \)). Regarding median motor latency, we found a significant positive correlation with wrist angle while typing on a computer keyboard (\( r = 0.461, p = 0.02 \)) (Figure 1). There was a significant negative correlation of median sensory velocity with wrist angle (\( r = 0.480, p = 0.001 \)) (Figure 2).

Table 4 summarizes the electrodiagnostic results according to the two subgroups of positive or negative CTS findings. There are differences between these two subgroups in median motor latency, sensory velocity, and motor and sensory amplitudes.

The data indicate that the larger the wrist angle when typing on a keyboard, the higher the risk of developing CTS. Wrist angle extension of greater than 20° has the potential to bring about CTS. Table 5 summarizes the electrodiagnostic findings in subjects with or without wrist angle extension greater than 20°.

In addition, there was significant positive correlation between the severity of wrist pain (VAS score) and median motor latency (\( r = 0.717, p < 0.05 \)) (Figure 3). A highly

| Table 1. Summary of physical examination findings in a total of 90 hands |
|-----------------------------|-----------------------------|
| Findings                    | No. of hands (%)            |
| No finding                  | 76 (84.4)                   |
| Tinel’s sign (+)            | 10 (11.1)                   |
| Phalen’s test (+)           | 9 (10.0)                    |
| Hand paresthesia            | 14 (15.6)                   |

| Table 2. Relationship between two provocative tests and nerve conduction study (NCS) findings |
|-----------------------------------------------|-----------------------------|
| NCS (+)                                      | NCS (-)                     |
| Tinel’s sign (+)                             | 7                            | 3             |
| Tinel’s sign (-)                             | 8                            | 72            |
| Phalen’s test (+)                            | 6                            | 3             |
| Phalen’s test (-)                            | 9                            | 72            |

**Figure 1. Correlation between median nerve motor latency and wrist angle.**

\[
Y = 0.038 \times (X + 3.402)
\]

\( r = 0.461 \)
negative correlation between severity of wrist pain (VAS score) and median sensory velocity was also found ($r = 0.653, p < 0.05$) (Figure 4). This means that the clinical severity of wrist pain is significantly correlated with both motor latency and sensory conduction velocity. These results are compatible with our previous assumptions [19].

**DISCUSSION**

A previous report estimated that the prevalence of CTS in the UK was 7% of the general population [20]. Another study estimated that 3.72% of the general population in the USA had clinical CTS [21]. Although Stevens et al reported that the incidence of CTS among computer users was 3.5% [22], similar to the incidence in the general US population, the incidence of CTS among computer users at our facility was 16.7% (15 of 90 hands). The different results with respect to other reports may depend on case inclusion criteria and the occupational activities of the population at risk.

Of the 12 subjects with NCS findings consistent with CTS, five presented with obvious wrist pain, while the other seven’s symptoms were obscure. It is probable that hand numbness always presents in CTS patients, but wrist pain or a tingling sensation is not present at an early stage. It is reported that repetitive activities in the workplace not only affect the median nerve across the carpal tunnel but also the ligaments, synovia, tendons, and muscles, producing pain and local tenderness at the wrist [5]. Pain in this location may suggest the possibility of a musculoskeletal disorder contributing to the patient’s symptoms. Musculoskeletal history, physical examination, and electrodiagnostic studies will help distinguish between these disorders and atypical presentations of CTS. Therefore, a diagnosis that is based only on symptoms may be confusing. This is why the diagnosis of CTS is based on electrodiagnostic findings. Although their accuracy may vary among laboratories and physicians, electrodiagnostic studies are usually highly sensitive and specific for CTS.

There was no obvious correlation between the length of employment of the subject in the medical facility and the presence of CTS. This result is in agreement with the report by Nathan et al that the length of employment has no influence on impairment of sensory conduction [23].

We know that repetitive movement is a risk factor for CTS. Repetitive manual tasks increase mechanical stress on the median nerve and results in elevated carpal tunnel pressure, ischemia, and, finally, histologic changes of the median nerve and connective tissue within the carpal tunnel [24–26]. However, there is another risk factor that should be noted. In this study, we found that there was a significant correlation between wrist angle and the frequency of CTS. The computer users who typed with a wider wrist angle had a higher risk of CTS (especially when the angle was > 20°).

![Figure 2. Correlation between median nerve sensory velocity and wrist angle.](image)

### Table 4. Mean (± standard deviation) electrodiagnostic findings of the median nerve in subjects with and without carpal tunnel syndrome (CTS)

<table>
<thead>
<tr>
<th></th>
<th>CTS $n = 15$</th>
<th>No CTS $n = 75$</th>
<th>Total $n = 90$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal motor latency, ms</td>
<td>4.71 ± 0.74</td>
<td>3.76 ± 0.30</td>
<td>3.92 ± 0.54</td>
</tr>
<tr>
<td>Sensory velocity, m/s</td>
<td>32.24 ± 5.39</td>
<td>45.85 ± 5.46</td>
<td>43.59 ± 7.44</td>
</tr>
<tr>
<td>Motor amplitude, mV</td>
<td>7.44 ± 1.17</td>
<td>8.07 ± 1.45</td>
<td>7.96 ± 1.42</td>
</tr>
<tr>
<td>Sensory amplitude, µV</td>
<td>16.07 ± 6.29</td>
<td>25.71 ± 7.95</td>
<td>24.06 ± 8.48</td>
</tr>
</tbody>
</table>
CTS is one of the most costly occupational musculoskeletal disorders in terms of lost work time, restricted work days, surgery, and rehabilitation [17]. Reducing the duration, frequency or intensity of exposure to forceful repetitive work, extreme wrist postures, and vibration is likely to result in a reduction in the incidence or severity of CTS in working populations [16].

To reduce the risk of CTS, we suggest that the best wrist posture while typing on a computer keyboard is to keep the wrist horizontal. For preventive medicine, people who are at high risk of CTS should avoid incorrect wrist positioning while typing to decrease occupation-related injuries.

There are limitations to our study. First, our study population was predominantly women. Based on a recent study comparing CTS features among men and women [22], it is not clear whether our results can be generalized to the male population. Second, we used an electrodiagnostic standard for diagnosing CTS. Although we understand that this standard is far from being universally accepted, we know of no published study that demonstrates a clinical standard with predictive capability superior to that of electrodiagnosis. Third, there is inevitable but acceptable error when using goniometry to measure wrist angle.

ACKNOWLEDGMENT

The authors thank Ms. Yu-Ying Lin for technical assistance in the electromyography laboratory.

REFERENCES


