Hand workload, computer use and risk of severe median nerve lesions at the wrist

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Abstract

Objective. To evaluate the effect of hand workload, especially computer use, on the incidence of severe, idiopathic median nerve lesions at the wrist (MNLW) in patients with idiopathic CTS.

Methods. Data were prospectively collected for 444 patients with classic or probable CTS who were of working age and referred to our electrodiagnostic (EDX) laboratories. Clinical items recorded were age, gender, intensity of hand workload, BMI and bilaterality of the MNLW. EDX data recorded were results of needle examination of the abductor pollicis brevis (APB), distal motor latency (DML) to the APB and orthodromic sensory conduction velocity. MNLW was considered severe if the DML to the APB was ≥6.0 ms. Patients were divided into two groups: those exhibiting at least one severe MNLW or not. They were classified into three categories according to occupational activity related to the intensity of hand workload: (i) non-workers (reference category); (ii) white-collar workers using computers; and (iii) blue-collar or manual workers. We determined factors associated with severe and non-severe MNLW.

Results. We investigated 92 patients with 119 severe MNLW and 352 with 589 non-severe MNLW. The risk of severe MNLW was similar for non-workers and blue-collar workers and was 2.5-fold higher than for workers using computers [adjusted odds ratio = 0.41; (95% CI)] after adjusting for age, gender and BMI.

Conclusion. Workers who use computers, who represent, in many countries, a large number of compensation claims, have a lower risk of severe MNLW as compared with blue-collar workers and also non-workers.

Key words: carpal tunnel syndrome, severe, hand workload, keyboard, white collar, blue collar, nerve conduction, median nerve lesion at the wrist, worker compensation.

Introduction

The effect of hand workload on the incidence of CTS is commonly accepted [1–10]. The use of a computer, mouse and keyboard (computer use) is commonly considered the cause of CTS and is accepted for worker’s compensation in many countries [11]. However, the real effect on the hand of jobs involving computer use and those involving powerful handgrip and vibrating tools is controversial. Some previous publications did not clearly specify the role of computer use but considered that work increased the incidence of CTS [7, 8], and one study found that computer use increased the incidence of CTS [1], whereas others found that computer use had no influence or had a protective effect on CTS occurrence [2–6, 9].

In France, in 2005, 68% of all workers’ compensation claims were for upper-limb cumulative trauma disorders, and CTS represented 39% of these disorders. Keyboard use may be described as highly repetitive work, but it does not resemble other types of repetitive activities such as the powerful handgrip necessary for automobile assembly, bricklaying, cabinetmaking and plumbing. With the current exponential increase in computer use at work (and at home), determining whether computer use is a real risk factor of CTS and, as a consequence, whether such workers should be systematically eligible for workers’ compensation, is important.

In fact, patients eligible for workers’ compensation are reputed to have increased loss of time from work, use of
surgery and physiotherapy, change in work status, time to return to work, and care costs and poorer results of medical and surgical care as compared with those not seeking compensation [12–15].

We conducted a prospective study comparing the frequency of severe and non-severe median nerve lesions at the wrist (MNLW) in a sample of patients with clinically and electrodiagnostically confirmed CTS. We determined the association of categories of hand workload at work and severity of MNLW in patients of working age from 20 to 59 years.

**Patients and methods**

**Patients**

We prospectively collected data for successive patients with classic or probable CTS referred to our two electro-diagnostic (EDX) laboratories, one in Paris and one in an industrial eastern suburb of Paris, from 2006 to 2007. We further collected all successive cases of patients with severe CTS until mid-2010 to increase the number of cases of severe CTS and obtain a ratio of 1 severe to 2 non-severe cases of CTS. All clinical and EDX examinations were performed by the same operator (S.P.) using the same protocol. All patients had unambiguous clinical symptoms and signs of CTS, with EDX-confirmed abnormal median nerve conduction at the wrist. Clinical CTS criteria were thenar muscle atrophy, permanent hypoesthesia or intermittent symptoms of burning, tingling and paresthesias in the radial three and a half digits or in the whole hand, especially at night or on awakening. The EDX criteria for MNLW were distal motor latency (DML) to the abductor pollicis brevis (APB) > 4 ms, orthodromic sensory conduction velocity (OSCV) of Digit 3 to the wrist < 45 m/s, or orthodromic median–ulnar latency difference > 0.40 ms for the fourth digit.

We excluded patients with polyneuropathic features, diabetes mellitus, severe chronic renal failure with dialysis, pregnancy, hypothyroidism, RA, wrist OA, previous wrist fracture, multiple diseases and permanent disability. All subjects gave their informed consent for use of their data for this study. The study was approved by the local committee on research ethics of Pitié-Salpêtrière Hospital.

For each patient, epidemiological evaluation included age, gender, BMI, incidence of bilateral MNLWs and occupational activity. The occupational activity was related exclusively to the intensity of hand workload on the job, not personal activities.

Patients were classified into three categories:

(i) Non-workers: retirees, housewives, house husbands and people unemployed (for at least 6 months), with no hand workload related to a job, the reference category representing the ‘normal’ hand workload in a non-working life.

(ii) White-collar workers using computers (for at least 6 months): patients with jobs that did not involve a powerful handgrip or use of vibrating tools but may have involved repetitive movements related to computer use. These were lawyers, physicians, nurses, teachers, tradespeople, salespeople, managers, executives, secretaries and diverse workers who all required the daily use of a computer, mouse and keyboard for 1–8 h/day.

(iii) Blue-collar or manual workers (for at least 6 months): patients with jobs that required heavy physical hand workload, with powerful handgrip, use of vibrating tools and repetitive movements. These included industry employees, automobile or flight engineers, woodworkers, porters, storekeepers, bricklayers, cabinetmakers and plumbers; none of these jobs required use of a computer.

For each patient, the electrophysiological evaluation included bilateral nerve conduction study of the median and ulnar nerves, and needle examination of one muscle per myotome, from C6 to C8 (biceps brachii, triceps brachii, first dorsal interosseous muscles) in the more symptomatic upper limb and both APB. Skin temperature was measured and hands were warmed before testing if the skin temperature was < 32°C.

The motor conduction study involved the DML to APB, the distal compound muscle action potential (CMAP) amplitude and the motor conduction velocity in the forearm. The DML was measured at the onset of the negative deflection, and the CMAP amplitude was measured from baseline to the peak of the negative deflection. The median nerve was stimulated 1 cm above the distal wrist crease and at the elbow with the use of a bar electrode and recorded by use of a pair of disposable surface electrodes, with the active electrode on the belly of the APB and the reference on the MCP joint of the thumb. When no CMAP could be recorded with surface electrodes, we used the values 14.0 ms for DML and 0 mV for amplitude because 14.0 ms and 0.1 mV are the extreme values recorded with surface electrodes in some patients.

The OSCV from Digit 3 to the wrist was studied with bar electrodes for stimulation and recording. The stimulation was delivered at the base of Digit 3, and the sensory nerve action potential (SNAP) was recorded 1–2 cm above the distal wrist crease. Averaging 5–200 traces (long averaging) was necessary to obtain a SNAP with an amplitude as low as 0.2 μV. Latencies were measured at the onset of SNAP, and the amplitude was measured from peak to peak. When the amplitude of the SNAP was < 2 μV and desynchronized, the SNAP was recorded again, and the traces were superimposed to confirm that the waveform of both SNAPs was similar. When no SNAP could be recorded, the values of 12 m/s for OSCV and 0.0 μV for amplitude were used because 12 m/s and 0.2 μV are the extreme values recorded with surface electrodes in some patients.

**Definition of severe MNLW**

Patients were divided into two groups by EDX severity of MNLW [16, 17]. Severe MNLW was defined as a DML to APB > 6.0 ms; any patient with at least one severe MNLW was included in the severe group, and all other patients...
with a DML <6.0 ms on both wrists were included in the non-severe group.

**Statistical analyses**

Categorical data are reported as numbers and/or percentages and were compared by $\chi^2$ test. Quantitative data are reported as mean (S.D.) and compared by Student’s $t$-test. $P < 0.05$ was considered significant.

In comparing patients with severe and non-severe MNLW, we included patients of all ages. Then, to evaluate the impact of hand workload at work on MNLW severity, we excluded patients 560 years old. We chose this threshold because this is the legal retirement age in France. In analysing factors associated with MNLW severity, variables with $P < 0.20$ on univariate analysis were entered into a multivariate logistic regression model. Selection procedures involved different methods for sensitivity analyses: backward, stepwise and maximum $R^2$ improvement selection procedures. Statistical analyses involved use of SAS version 9.1 (SAS Institute, Cary, NC, USA).

**Results**

**Patients**

Of the 676 patients referred to our EDX laboratory between 2006 and 2010 with confirmed CTS, 229 had severe MNLW and 447 had non-severe MNLW: 444 were 20-59 years old (working age) and, of these, 92 had 119 severe MNLW and 352 had 589 non-severe MNLW. The characteristics of patients are provided in Table 1. We studied the effect of hand workload on the incidence of severe MNLW in the 444 patients of working age.

**Electrophysiological results**

The results of nerve conduction tests for the whole sample and patients age 20-59 years are in Table 2 and were similar because of the same selection criteria. For the severe group, the mean SNAP amplitude of Digit 3 was 1.4 mV, which was 2.9% of the normal amplitude (36 mV) for our laboratory [18], as compared with 17.5 mV for the non-severe group, which was 49% of the normal amplitude ($P < 0.0001$). Needle examination findings were abnormal for 95.5% of severe patients vs 18% of non-severe patients ($P < 0.0001$).

**Table 1** Characteristics of patients with severe and non-severe MNLW

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Severe MNLW</th>
<th>Non-severe MNLW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All cases $(n = 229)$</td>
<td>20-59 years $(n = 92)$</td>
</tr>
<tr>
<td>Number with CTS</td>
<td>314</td>
<td>119</td>
</tr>
<tr>
<td>Age, years</td>
<td>65.5 (5.1)</td>
<td>50.1 (7.2)</td>
</tr>
<tr>
<td>Sex, male</td>
<td>72 (31)</td>
<td>22 (24)</td>
</tr>
<tr>
<td>BMI, mean (s.d.)</td>
<td>28.2 (5.5)</td>
<td>29.4 (6.1)</td>
</tr>
<tr>
<td>Occupational activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-workers</td>
<td>147 (69)</td>
<td>23 (25)</td>
</tr>
<tr>
<td>White-collar workers</td>
<td>24 (11)</td>
<td>24 (26)</td>
</tr>
<tr>
<td>Blue-collar or manual</td>
<td>42 (20)</td>
<td>45 (49)</td>
</tr>
</tbody>
</table>

Data are expressed as $n$ (%).

**Table 2** Results of nerve conduction studies in patients age 20-59 years with severe and non-severe MNLW

<table>
<thead>
<tr>
<th>Nerve conduction variables</th>
<th>Severe MNLW</th>
<th>Non-severe MNLW</th>
<th>Univariate analyses $P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number with CTS</td>
<td>314</td>
<td>119</td>
<td>777</td>
</tr>
<tr>
<td>Motor conduction to APB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DML, ms</td>
<td>8.9 (3.0)</td>
<td>8.1 (2.6)</td>
<td>4.1 (0.7)</td>
</tr>
<tr>
<td>Amp$^a$, mV</td>
<td>4.1 (3.4)</td>
<td>5.8 (3.4)</td>
<td>10.3 (2.6)</td>
</tr>
<tr>
<td>Sensory conduction to Digit 3</td>
<td>19.4 (7.5)</td>
<td>20.7 (7.3)</td>
<td>39.8 (8.0)</td>
</tr>
<tr>
<td>Amp$^b$, $\mu$V</td>
<td>1.05 (1.3)</td>
<td>1.4 (1.5)</td>
<td>15.5 (10.4)</td>
</tr>
</tbody>
</table>

Data are expressed as mean (s.d.). $^a$Compound muscle action potential amplitude. $^b$SNAP amplitude. *Student’s $t$-test. $n$: number of patients or CTS cases.
TABLE 3 Factors associated with severity of MNLW for 444 patients age 20–59 years

<table>
<thead>
<tr>
<th></th>
<th>Severe MNLW (n = 92)</th>
<th>Non-severe MNLW (n = 352)</th>
<th>Univariate analyses, P-value</th>
<th>Multivariate analyses***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (s.d.), years</td>
<td>50.1 (7.2)</td>
<td>48.8 (8.2)</td>
<td>0.16* NS</td>
<td></td>
</tr>
<tr>
<td>Sex, male, n (%)</td>
<td>22 (24)</td>
<td>64 (18.2)</td>
<td>0.20** NS</td>
<td></td>
</tr>
<tr>
<td>BMI, mean (s.d.)</td>
<td>29.4 (6.1)</td>
<td>26.7 (4.9)</td>
<td>0.0004* 1.09 (1.04, 1.14)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Bilateral MNLW, %</td>
<td>90 (98)</td>
<td>264 (75)</td>
<td>&lt;0.0001** Not included</td>
<td></td>
</tr>
<tr>
<td>Occupational activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-workers, n (%)</td>
<td>23 (25)</td>
<td>58 (16.4)</td>
<td>0.0009**</td>
<td></td>
</tr>
<tr>
<td>White-collar workers using computers, n (%)</td>
<td>24 (26)</td>
<td>170 (48.3)</td>
<td>0.41 (0.20, 0.83) 0.002</td>
<td></td>
</tr>
<tr>
<td>Blue-collar or manual workers, n (%)</td>
<td>45 (49)</td>
<td>124 (35.2)</td>
<td>0.95 (0.49, 1.83) 0.18</td>
<td></td>
</tr>
</tbody>
</table>

Bilateral MNLW was not included in the multivariate model because a patient was considered to have severe MNLW with MNLW being severe at least on one side. *Student’s t-test. **χ² test. ***Multivariate analyses were adjusted for age and occupational activity. NS: not significant, P > 0.05.

Effect of age, gender and BMI on MNLW severity

Age and gender did not affect the severity of MNLW in the working-age population (Table 3). Multivariate analyses retained BMI, bilateral MNLW and occupational activity as independent risk factors of MNLW severity. The risk of severe MNLW was increased with increasing BMI (adjusted odds ratio (aOR) = 1.088 per one BMI point (95% CI 1.039, 1.14), P < 0.0004; aOR for quartiles 1–4 = 2.42 (1.25, 4.67), P < 0.02). The risk of severe MNLW was increased with bilateral MNLW, but this variable was not included in the multivariate model because patients were considered in the severe group with severe MNLW at least on one side.

Effect of hand workload at work on MNLW severity

Analysis of hand workload at work on MNLW severity in the working-age population (Table 3) included 288 females and 64 males in the non-severe MNLW group and 70 females and 22 males in the severe MNLW group. Blue-collar or manual workers and non-workers did not differ in risk of severe MNLW [aOR = 0.95; 95% CI (0.49, 1.83); P = 0.18]. This risk was lower for white-collar workers using computers than for non-workers [aOR = 0.41; 95% CI (0.20, 0.83); P = 0.002] and blue-collar workers [aOR = 0.43 (95% CI 0.21, 0.71); P = 0.0016].

Discussion

With the current exponential increase in computer use at work (and at home), determining whether computer use is a real risk factor of CTS and, as a consequence, whether such workers should be systematically eligible for workers’ compensation seems important. We evaluated the effect of hand workload, especially computer use, on the incidence of severe MNLW in patients with idiopathic CTS. We chose to study the severe forms of CTS because, as in all fields of medicine, study of the most severe forms is the first to uncover the pathological and pathogenic keys. Surprisingly, we found that the risk of severe MNLW was similar for non-worker patients and blue-collar and manual workers, but was 2.5-fold higher than for white-collar workers using computers.

Epidemiological studies [2–9, 11] considering the impact of hand workload on the occurrence of CTS are usually based on comparing the CTS incidence in different groups of workers with different levels of hand workload or on comparing the CTS incidence between working and non-working patients in large populations. Studies of computer workers are few, and in two recent reviews, the authors concluded that ‘all studies had one or more limitations, including imprecise exposure and outcome assessment, low statistical power or potentially serious biases’ [9], and other authors concluded ‘contradictory findings … for associations between computer work and CTS’ [10]. Naturally, the present study also has some limitations, and a more detailed study of duration of computer use or a larger number of subclasses of white- and blue-collar workers would have provided more precise data. But considering that we needed 4 years to collect a sufficient number of cases of severe CTS for our analysis of three categories of workers, many years would be needed for analysis of more subcategories. However, studying only three categories of workers is nearer to the current evaluation by general physicians or specialists (rheumatologists, neurologists or hand surgeons) who are responsible for CTS care and most of the compensation claims.

When EDX was required, the cut-off values to assess CTS varied among studies [9]. Our study involved all patients presenting clinical CTS symptoms and requiring electrodiagnosis. This choice avoids previous biases and is strengthened by the use of severe MNLW as the major indicator. We compared patients with severe MNLW and patients with non-severe MNLW. Cases of severe MNLW are the easiest to diagnose and they match historical cases described by Marie and Foix [19] or Phalen and...
Kendrick [20], with a high frequency of thenar wasting and persistent sensory disturbance in the radial three and a half digits. In our experience, as in other studies [16, 17, 21], patients with severe MNLW represent ≤10% of all CTS patients. EDX is the current gold standard for CTS diagnosis and evaluation of its severity (axonal loss and active denervation). We used the DML and the 6-ms cut-off value to define severe MNLW according with the current practice in the literature [16, 17, 21]. The importance of axonal loss in severe MNLW (mean 97.1%), which was highlighted by the sensory nerve conduction study, confirmed the accuracy of the DML cut-off we chose.

The relation between occupational activity and severity of MNLW is complex. As our definition of hand workload was exclusively related to the job (personal activities such as hobbies, home duties, gardening and sports were excluded), we did not find increased risk for blue-collar workers and decreased risk for white-collar workers as compared with non-workers (reference category). The absence of a difference in risk between non-workers and blue-collar workers does not mean that hand workload has no relation to the incidence and severity of CTS, which would be somewhat unusual and at odds with the literature data. According to some authors, who suggested that the occupation represents only a small part of the hand activity in the whole lifetime and ‘acts as the last straw in CTS causation’ [22], one can presume that personal activities, when they are performed daily by non-workers, might increase the risk of severe MNLW similar to the occupational activity of blue-collar workers. Thus, the decreased risk we observed for workers using computers, and equivalent risk for manual workers and non-workers, might be accounted for either by a direct beneficial effect of keyboard use or by a rest effect, whereby hours spent at a computer-based job prevent the individual from performing more strenuous manual tasks with the hands. These more strenuous, personal manual tasks, when they are performed daily, as by non-workers, might explain the increased risk of severe MNLW similar to the occupational activity of blue-collar workers.

Our findings are crucial information; in France, workers using computers represent a large number of worker’s compensation claims for CTS. These data also agree with the results of some studies of computer and/or keyboard use at work [3]. As ‘worker’s compensation patients tended to be younger, have a shorter duration of symptoms before surgery, report lower post-operative activity levels, have more subsequent surgeries, and have mediocre results as compared with non-worker’s compensation patients’ [13-15], these results are important and might lead to revisiting the eligibility criteria for CTS worker’s compensation for workers using computers, who still represent a large number of workers with compensation claims in many countries.

We investigated the role of diverse risk factors such as age, bilaterality of MNLW, BMI and male gender that may influence the severity of MNLW to eliminate their confusing effect on the occurrence of severe MNLW in the different categories of workers and non-workers. The impact of these factors on the MNLW severity we report is in accordance with previous findings. The role of age, certainly one of the most important risk factors of severe MNLW [5, 22-24], was negated by our selecting patients of working age and not elderly patients, who were mostly non-working patients with a high rate of severe MNLW (Table 1). Finally, we did not study other factors such as tobacco, caffeine and alcohol use, which are well-known independent risk factors of CTS but would not have changed the results of the present study [5].

**Conclusion**

In patients of working age (60 years old), the risk of severe MNLW was the same for blue-collar and non-workers, while it was significantly reduced for white-collar workers using computers. These results suggest that for workers using computers, computer use could have a direct beneficial effect or a resting effect, whereby the hours spent at a computer-based job prevent such workers from performing the more strenuous manual tasks performed by blue-collar workers and non-workers. Most occupational physicians are now aware of the decreased risk of CTS for workers using computers, but general physicians and specialists who care for CTS patients may not be aware of the recent changes in eligibility criteria for CTS worker’s compensation.

**Rheumatology key messages**

- Risk of severe MNLW is the same for non-workers and manual workers, but 2.5-fold lower for computer workers.
- Bilaterality of MNLW and BMI are independent risk factors of severity of MNLW.

**Disclosure statement:** The authors have declared no conflicts of interest.

**References**


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