Is carpal tunnel syndrome related to computer exposure at work? A review and meta-analysis

Zakia Mediouni, Alexis de Roquemaurel, Christian Dumontier, Bertrand Bécourt, Hélène Garrabé, Yves Roquelaure, Alexis Descatha

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A Review and Meta-Analysis

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Objective: A meta-analysis on epidemiological studies was undertaken to assess association between carpal tunnel syndrome (CTS) and computer work. **Methods:** Four databases (PubMed, Embase, Web of Science, and Base de Donnees de Sante Publique) were searched with cross-references from published reviews. We included recent studies, original epidemiological studies for which the association was assessed with blind reviewing with control group. Relevant associations were extracted, and a metarisk was calculated using the generic variance approach (meta–odds ratio [meta-OR]). **Results:** Six studies met the criteria for inclusion. Results are contradictory because of heterogeneous work exposure. The meta-OR for computer use was 1.67 (95% confidence interval [CI], 0.79 to 3.55). The meta-OR for keyboarding was 1.11 (95% CI, 0.62 to 1.98) and for mouse 1.94 (95% CI, 0.90 to 4.21). **Conclusion:** It was not possible to show an association between computer use and CTS, although some particular work circumstances may be associated with CTS.

Carpal tunnel syndrome (CTS) is a common and costly disease among working-aged adults and is the most common neuropathy of the upper limb.[1] Studies on CTS have reviewed the potential risk factors and confirmed its relationship with biomechanical exposure at work.[2–5]

Large disparities between popular belief and scientific evidence of CTS causation exist.[6] For the last two decades, marked with the expansion of computer use, it has been a matter of concern to find out whether computer use could be a risk factor for CTS, and if so, should the condition be recognized as an occupational disease. Computer work combines various tasks and duration of exposure, including keyboarding/typing and use of a computer mouse. Studies have been published in an attempt to provide this information, but their conclusions are conflicting.[4,7–9] Reviews have also been conducted, with contradictory findings regarding the duration of computer work as a risk factor and an increased risk was seldom observed.[8–10] No quantitative analysis has ever been performed. The purpose of this study was to undertake a systematic review and meta-analysis of the available epidemiological data regarding the association between computer work exposure and CTS.

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METHODS

Literature Research

Four databases (PubMed, Embase, Web of Science, and "Base de Données de Santé Publique," BDSP, ie, the French Public Health Database) were searched, using the key words: ("carpal tunnel syndrome" OR "median nerve") ("keyboard" OR "computer" OR "mouse" OR "visual display unit") ("occupational" OR "occupational disease" OR "work"). No language limitation was added. Only recent studies (1992 to June 2012) were included. Relevant articles originating from the reference list of full-text articles and reviews were included. Reviews on CTS occupational risk factors were included to check for extra references. The first selection of articles was performed by two independent readers (A.R. and A.D.) on the basis of the title and abstract to include (1) original epidemiological studies including a control group (case series not included); (2) CTS defined on clinical diagnosis confirmed by electrophysiological investigation or hand surgeons, with appropriate description or reference; and (3) the association between computer work and CTS that was assessed with blind reviewing (doubtful blinding excluded). The second stage included full-text articles on the basis of the same criteria. Studies meeting these criteria were included in the meta-analysis after a review by the independent readers (A.R. and A.D.).

Data Extraction and Analysis

Relevant data were extracted from the articles if the number of cases was more than 5. The core findings in each article were expressed by measures of association (odds ratio [OR]) with a corresponding 95% confidence interval (CI). Whenever possible, associations were directly extracted from the original article. In articles where this information was not presented, associations were calculated when sufficient raw data were provided. If more than one OR were presented in a particular study, only the most significant OR related to the adjusted model was included. Metarisks (meta-ORs) were calculated using the generic variance approach. The weight given to each study is the inverse of the variance of the estimated effect. Heterogeneity was tested with the Q statistic. From the Q statistic, we calculated a summary OR and 95% CI with the random-effect method. This approach provides more conservative estimates (wider CI) than a fixed-effect model, assuming that the differences between results are solely due to chance.

When available, we stratified results on only mouse use or only keyboard use. We tested the publication bias due to study size by the Egger regression approach. Meta–odds ratios were run only on high-quality methodological studies, that is, longitudinal or population-based design and nerve conduction studies for sensitivity analyses. The meta-analysis was performed using STATA (version 10.0; Stata Corp, College Station, TX). The PRISMA checklist was used.[11]

RESULTS

In the four databases, we found 18 articles corresponding to our first stage (Fig. 1; disagreement between reviewers less than 10%). After full-text reading, 12 articles were excluded, because they did not fulfill the inclusion criteria (Supplemental Digital Content Appendix, available at http://links.lww.com/JOM/A140). Selected studies came from different continents and were published between 1993 and 2007. Most of them were cross-sectional, although there were two cohort studies.[12,13] Two studies had less than 5 cases, and one could not be included in the quantitative analysis.[14]

Table 1 presents the 6 articles selected in the review (all in English).[12–17] Exposure was assessed differently and mostly self-reported. Computer use was established with the help of a self-report questionnaire or a daily diary. The use of a keyboard and computer mouse was assessed using the number of hours per day or the average number of hours per day. One of the studies used goniometric assessment of wrist movements and angular velocity.[15] Electrophysiological investigations were used as references in most studies.[12,14–16]

Figure 2 illustrated the meta-OR for computer use found at 1.67 (95% CI, 0.79 to 3.55), with a significant heterogeneity ($Q = 16.506$; $P = 0.002$), and without significant publication bias (the Egger test; $P > 0.05$). The statistical heterogeneity came mostly from two studies with a high methodological quality, which provide conflicting results: one large longitudinal study clearly demonstrated the ill effects of computer use and showed a dose–effect relationship (no nerve conduction available however),[13] whereas one population-based study using nerve conduction studies (cross-sectional) found a protective effect.[16]

On the basis of three studies,[13,15,17] the meta-OR for keyboard use or typing was 1.11 (95% CI, 0.62 to 1.98) and for mouse use 1.94 (95% CI, 0.90 to 4.21). None of the selected studies had a longitudinal design and a diagnosis based on nerve conduction studies. Sensitivity analyses focusing on nerve conduction and population-based studies included very few studies without significant effect of computer work exposure: meta-OR, 1.32 (95% CI, 0.47 to 3.69) and 1.17 (95% CI, 0.25 to 3.35), respectively.

DISCUSSION

This first quantitative meta-analysis attempted to pool the results of 20 years of studies. It confirmed the lack of evidence for an association between computer work and CTS and showed a small risk excess and a not significant meta-OR. The results included were heterogeneous and sometimes contradictory because of different designs of the study, evaluation of exposure, and definition of CTS.

Limitations of this meta-analysis should be discussed. The methodology used to select articles and to extract data may be a source of limitation. Blind reviewing helped reduce this effect. The few extra articles found in the reference list of the published reviews advocated for a limited selection effect. Sources of difficulty lay in the heterogeneous character of the results, variability of CTS definition, and evaluation of computer work exposure. Actually, the reliability and validity of the reference for CTS are sometimes questionable, be it expertise or nerve conduction, and their condition of realization.[18–20] The choice of the result for the quantitative analysis is questionable, assuming that other extract results might change the meta-OR. Nevertheless, we did not found significant association by taking only the most significant OR related to the adjusted model (except in Andersen et al[13] study where we chose the >20 hours per week threshold, to use the same threshold for mouse and keyboard use). The lack of longitudinal population-based studies using electrophysiological assessment and the small number of selected

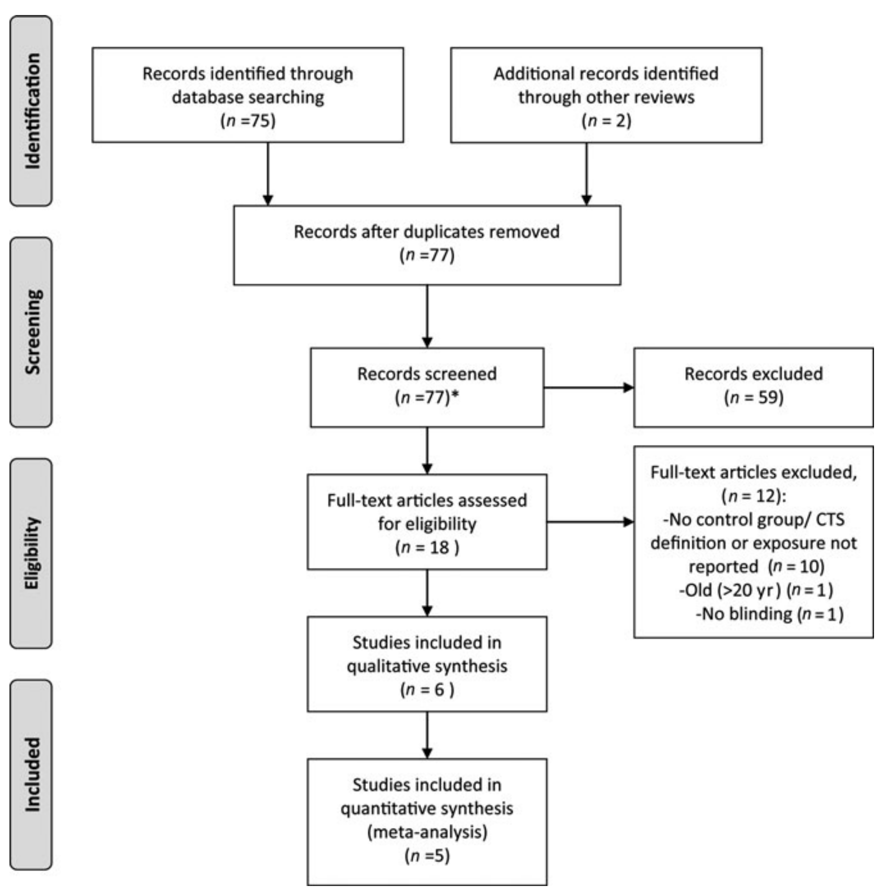

FIGURE 1. PRISMA style flow diagram.[11] CTS, carpal tunnel syndrome. *See Appendix (http://links.lww.com/JOM/A140).

TABLE 1. Articles Selected in the Final Round

Name	Country	Type of Study	Outcome	Exposure	Study Population: Exposure	Number of CTS Cases	Criteria for OR	OR	95% CI	Major Strength(s)	Major Limitation(s)
Albers et al[14]	USA	CS	PE + NCS	Study of the workstation	19	2				Exposure assessment	CS/number of cases of CTS (NCS)
Stevens et al[15]	USA	CS	PE + NCS	SQ	257 employees in a clinic with computer use?	9	Typewriter (use vs no use)	0.9	0.40–2.03	Participation	CS/exposure assessment confounders
							Mouse use (frequently vs no use)	3.35*	0.76–15.76		
Thomsen et al[12]	USA	Cohort (1.5 yrs of follow-up)	PE + NCS	Ergonomic exposure (walk through, interview of key personnel, goniometric assessment	731 participants, 3 companies (bank and postal centers mail delivery offices)	2				Longitudinal study with clear exposure	2 incident cases
		CS	Similar	Similar	Similar	10	Repetitive work for >10 hr/wk	1.84	1.06–3.19	Precise exposure	CS
							Forceful work >10 hr/wk	1.41	0.86–2.30		
Andersen et al[13]	Denmark	Cohort (1 yr)	PE	SQ	5658 participants	166	>20 hr of mouse use	2.6*	1.2–5.5	Longitudinal/ dose–effect relationship/ number of subjects	CTS definition
							> 20 hr of keyboard use	1.4	0.5–4.3		
Atroshi et al[18]	Sweden	CS (population based)	PE + NCS	SQ	2465 randomly selected working-aged people from a representative region of Sweden	67	Computer use >1 hr (univariate)	0.52	0.23–1.2	Population based, confounders/ inclusion of subjects	CS/self-reported exposure/computer use (keyboarding mostly)
							Computer use >4 hr (univariate)	0.55	0.26–1.2		
							Computer use >1 hr (multivariate)	0.55*	0.32–0.96		
Hou et al[17]	Taiwan	CS	PE	SQ	340 men from an information and communication company	13	Keyboard >4 hr/d	1.35	0.36–5.05	Keyboard and mouse use exposure evaluation	CS/self-reported exposure and number of subject with confirmed CTS
							Mouse use >4 hr/d	0.85	0.27–2.65		
							Seniority >5 yrs (vs 3 yrs) multivariate	2.7*	0.6–12.4		
			PE + NCS	SQ	82 participants	3					

CI, confidence interval; CS, cross-sectional; CTS, carpal tunnel syndrome; PE, physical examination; NCS, nerve conduction study; SQ, self-administered questionnaire.
*Includes in the quantitative analyses.

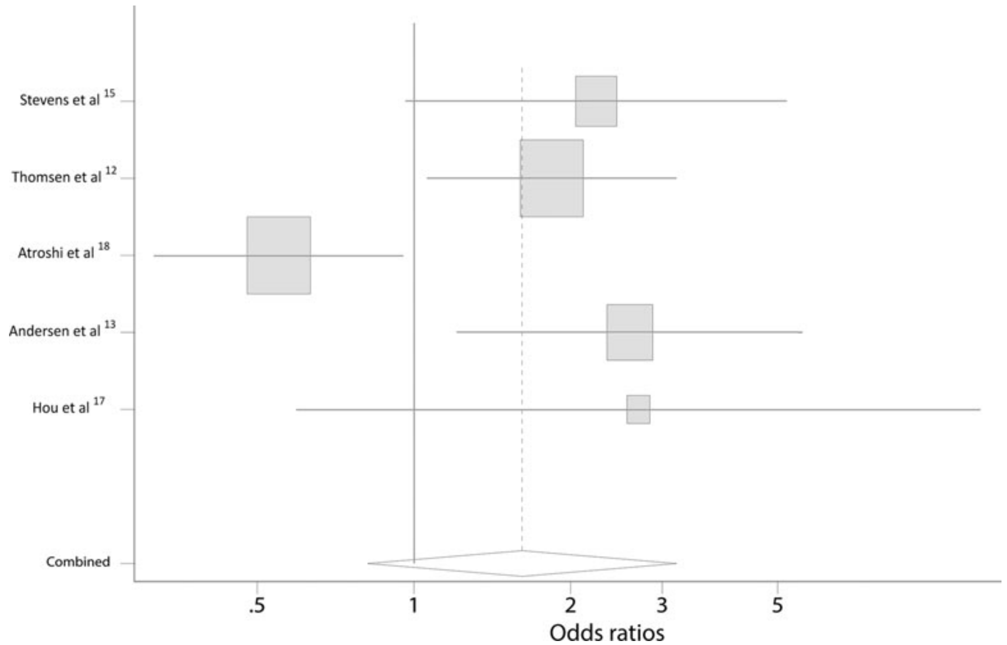

FIGURE 2. Forest plot. The black square and horizontal line correspond to the studies' odds ratios and 95% confidence intervals. The area of the black squares reflects the weight each study contributes to the meta-analysis. The diamond represents the meta–odds ratio with its 95% confidence interval.

studies could suggest an impossibility of conclusion. Nevertheless, restricted to either one (population-based or nerve conduction) in the sensitivity analyses, results remained unchanged.

Previous reviews highlighted that evidence is insufficient to conclude that computer work (mouse and keyboard) causes CTS.[4,7–9] The authors discussed that only one large epidemiological study (Andersen et al[13]) found a positive association and highlighted the conclusion of Andersen et al that "computer use does not pose a severe occupational hazard for developing symptoms of CTS."[5,9] The review by Van Rijn et al[4] included several studies that did not fulfill our criteria (control group,[21] clear definition of exposure,[22] or blinding[23]) and found similar contradictory findings.[4] Some longitudinal studies showed that few CTS incident cases have been found, although pain is frequent among computer users.[9,12,24]

Different interpretations exist to explain these apparent contradictions: a possible misclassification,[25] the inclusion of manual workers in the control group of some population-based studies (which could explain a protective effect), the lack of a clear definition of what computer work is, and finally heterogeneous exposure situations. Using assessment of fingers, wrists, and forearm positions, it has been suggested that keyboard use and typing differs from mouse use. It has been found that mean carpal tunnel pressure levels were between 28 and 33 mm Hg when study participants were doing dragging or clicking mouse. Lower values were found when the hand was static on the mouse.[26] The same team found that typing elevated carpal tunnel pressure in comparison with a similar but static position (the hand held static in the same posture).[27] The variability of work situations and tasks assigned to employees in different companies and countries increases complexity. The exposure of a computer professional in Asia is very different from that of a graphic artist in America or an office clerk in a European country. Evaluation of computer work exposure is complex: different combined and repetitive tasks and wrist movements are involved,[28] and organizational factors like the number of working hours per day come into account. This is shown, for example, by Ali et al,[23] who found that computer use is associated with more symptoms (although not blinded) with an OR at 4.4 (95% CI, 1.3 to 14.9) when working more than 12 hours a day. Furthermore, awkward and bad ergonomic conditions may be associated with an increased CTS risk, requiring intervention on working condition but not sufficient to claim occupational compensation for computer use. It is possible that prolonged mouse use combined with ergonomic errors is associated with a CTS risk and does not exclude the potential role of keyboarding or typing in the occurrence of CTS.

CONCLUSION

This meta-analysis and previous reviews come to similar conclusion: it has not been possible to show an association between computer use and CTS. Specific work circumstances involving the use of a computer mouse may be associated with CTS. To be able to give a quantitative assessment of the relationship between CTS and computer work (OR slightly higher than 1 but not statistically significant) might be helpful for occupational physicians. When assessing a case of CTS, occupational practitioners should discuss how to improve in working conditions with ergonomists. Long-term longitudinal population-based studies and using standardized work exposure and nerve conduction studies assessment would be of great interest.

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