Te Kaporeihana Āwhina Hunga Whara

# Brief Report

# Work-related risk factors for carpal tunnel syndrome

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**Important Note:**

- *The purpose of this brief report is to summarise the best evidence for the relationship between carpal tunnel syndrome and workplace physical factors. It has not been systematically developed according to a predefined methodology.*
- *It is not intended to replace clinical judgement, or be used as a clinical protocol.*
- *A reasonable attempt has been made to find and review papers relevant to the focus of this report, however it does not claim to be exhaustive*
- *The document has been prepared by the staff of the Research Unit, ACC. The content does not necessarily represent the official view of ACC or represent ACC policy*
- *This report is based upon information supplied up to February 2014.*

# Executive Summary

The purpose of this report is to provide a narrative for the findings of the Auckland University of Technology (AUT) review dated 2010 and update these finding with any relevant evidence published subsequently. The evidence described in this report is aimed to facilitate decision making by the ACC Work-Related Gradual Process Diseases and Infections team (WRGPDI) for work-related physical factors in relation to carpal tunnel syndrome (CTS).

A total of 14 studies from the AUT review are discussed in this report. Studies were first graded by two ACC reviewers using the Scottish Intercollegiate Guidelines Network criteria (SIGN, Appendix 3) in an attempt to ensure the best evidence available was presented. Risk factors were described in the literature as either single (force, repetition, posture, vibration and computer use) or combined (force and repetition; force and posture). In most studies, the diagnosis of CTS was based on a combination of physiological symptoms and symptoms or signs measured by questionnaires or clinical examinations, but the exact criteria used varied. The methodology of how risk factors were measured also differed. The variability in definitions, methodologies and participant occupations across studies produced variable results that were described as "inconsistent evidence" by the AUT review.

The main findings show that frequent and sustained flexion and extension of the wrist and vibration through hand-held tools are significantly associated with the occurrence of CTS. There was some evidence to support high force requirement, repetitive work and computer use as individual risk factors. However, overall the evidence is conflicting. There was also inconclusive evidence for an association of combined force and repetition with CTS, combination of high force and sustained postures with CTS, or high repetition and sustained postures with CTS. It is noteworthy that the variability across studies is a caveat within the evidence that should be taken into consideration when using this report to facilitate decision making processes on claims within ACC.

This report provides both quick reference material and more in-depth summaries for the reader. Quick reference material is provided in the form of summary tables (Table 4) that outline the main results for each physical risk factor. In the subsequent sections (single risk factors and combined risk factors) a more comprehensive outline of the evidence is provided, including specific study results in the form of odds ratios and related statistics (95% confidence intervals and statistical significance). This is followed by a short conclusion and discussion of the limitations within the evidence base. Descriptions of the individual papers used in this report are found in Appendix 2 and evidence tables in Appendix 4.

*Recommendations for the WRGDPI unit:*

Due to variations between studies and conflicting evidence within the best evidence identified in both this report and the AUT report, when considering an individual claim for CTS, other factors such as the Bradford-Hill criteria, the specifics of the case and expert opinion should be considered.

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## List of Abbreviations

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| AUT | Auckland University of Technology |
| CI | Confidence Interval |
| CTS | Carpal Tunnel Syndrome |
| GP | General Practitioner |
| MSD | Musculoskeletal Disorders |
| OR | Odds Ratio |
| SIGN | Scottish Intercollegiate Guidelines Network |
| WRGPDI | Work-Related Gradual Process Diseases and Infections team |

## Definition of CTS

Carpal tunnel syndrome (CTS) is defined in the ACC Distal and Upper Limb Guidelines (2009) as[1]:

*A symptomatic compression neuropathy of the median nerve at the level of the wrist, characterised by decreased function of the nerve at that level. This can result in variable symptoms such as numbness, tingling, hand and arm pain and muscle dysfunction.*

*There is currently no universally accepted cluster of symptoms, pattern of symptom presentation or diagnostic 'reference standard' for CTS. CTS may present with variable types and patterns of symptoms, and variable symptom severity (mild to severe) irrespective of whether it is short-lived or long-standing (well-established). Primary health care providers should initially form a clinical diagnosis on the basis of multiple sources of information, including case history, presence of risk factors (individual and environmental), symptom presentation, musculoskeletal changes and responses to clinical tests (neurological and provocation tests).*

CTS is the most frequent compression neuropathy with an estimated prevalence in the general population of 3.7 – 5.8%[1]. It may be up to three times more common in women than men, with the prevalence highest in the 40-55 year old age group. For further information regarding the diagnosis, management and prognosis of CTS, please refer to the ACC Distal and Upper Limb Guidelines (2009)[1].

## Methodology

The purpose of this report is to provide a narrative to the findings of the AUT review and summarise the best evidence for the relationship between CTS and workplace physical factors.

### *Outline of studies included in this report*

### Primary studies

In the current brief report, cross-sectional studies were excluded from analyses because of their high risk of bias. Five prospective cohort [2-6] and four case-control studies [7-10] met the inclusion criteria and are described briefly below.

### Secondary literature

Four systematic reviews and one meta-analysis were included in this report. One focused exclusively on the relationship between keyboard and mouse use and CTS [11], whereas the remaining four secondary studies examined a range of work-related physical factors[12-14]. The reviews varied in their inclusion and exclusion criteria but mostly included prospective cohort, case-control and cross-sectional studies that included between 28 to 44 participants. A short description of the methodologies and populations investigated for each study can be found in Appendix 2 at the end of this report. The evidence tables for the secondary and primary studies are presented in Appendix 4 at the end of this report.

### *Assessment of quality of studies included in report*

The studies were assessed for quality and assigned a level of evidence using the Scottish Intercollegiate Guidelines Network (SIGN) criteria (Appendix 3).

The relationship between CTS and occupational risk factors was most commonly reported as an odds ratio (OR). This provides the reader with a quantification of the likelihood that the outcome (in this case CTS) will occur if a particular risk factor (e.g. high forces) is present. The descriptors shown in Table 1 below provide a context of how strong and in which direction the OR (association) is: the higher the OR the higher the odds of CTS occurring if that particular risk factor is present [15]. A more in-depth description of ORs can be found in Appendix 1.

*Table 1 Odds Ratios and relevant descriptor outlining the strength of evidence*

| Odds Ratio | Descriptor |
|---|---|
| **<1.0** | Protective |
| **1.0 – 2.4** | Weak |
| **2.5 – 3.9** | Moderate |
| **>4.0** | Strong |

## Summary of Findings: Work-related risk factors for CTS

The physical work related risk factors for CTS were presented as either single or combined physical risk factors in the AUT review and in this report. Across single and combined risk factors there was variation between studies due to differences in methodologies and the definitions of risk factors.

The single risk factors summarised were force, repetition, posture, vibration and computer use. Mixed results were found both in the AUT review and in this report for the association of force or repetition with CTS, mainly due to variation across studies in methodology and how either force or repetition were defined. A meta-analysis that used conservative definitions of CTS found there was a strong association between force and CTS[12], whereas weak to strong associations were found for repetition and CTS depending on how repetition was measured[3, 5, 9-10, 12]. There was significant evidence that vibration was positively associated with CTS[4, 6, 8, 10] and some association was found between CTS and mouse use for over 20 hours a week but not with keyboard use[11].

The combined risk factors summarised were force and repetition and posture with either repetition or force. As with single risk factors, there was low consistency between studies for combined factors. For combined force and repetition, a range of weak to strong associations with CTS were found. When posture was combined with repetition, it appeared that sustained wrist flexion and extension was moderately associated with CTS, but there was insufficient data available to make any further conclusions.

***Table 2. Summary of Findings for physical risk factors associated with CTS***

| Risk Factor | Main Findings | Main issues with current evidence | Main occupations* or sectors assessed |
|---|---|---|---|
| ***Single Risk Factors*** | | | |
| **Force** | **Increased odds with:**<br>-High power grips (44.1N or 4.5kg) for more than 1% of the time<br>-Sustained forceful wrist motion<br>- Handling loads >1kg more than 10 times per hour<br>**Null or no association:**<br>- Pressing with the hand, hitting, pulling, pushing or holding position<br>-Pinch grips (of up to 8.9N for more than 5% of the time) | Variable in results, wide confidence intervals with some associations.<br>Description of work environments not well defined.<br>Heterogeneity between studies, however efforts to decrease heterogeneity increased the strength of association between Force and CTS.<br>High loss to follow-up. | Service industry (waiters, healthcare workers, drivers), housewives, clerks, factory workers, technicians, fishermen, poultry, fish and meat processors, dental workers, supermarket workers, butchers, assembly line workers, packers, garment workers, textile workers, forestry workers, musicians |
| **Repetition** | **Increased odds with:**<br>-Repetitively holding hand in position<br>-Lack of change in task or breaks for at least 15% of the daily work time<br>- Repetitive movement in similar jobs for over20 years<br>- Rapid “trigger” finger movements<br>**Null or no association:**<br>- tasks that included repetitive pressing with hands | Many studies combined measurement of repetition with postural movements making it difficult to assess if repetition as a single factor on its own increased odds of CTS.<br>Vague definitions of repetition affected qualities of some of the studies. | Service industry (waiters, healthcare workers, drivers), housewives, clerks, factory workers, technicians, fishermen, poultry, fish and meat processors, dental workers, supermarket workers, butchers, assembly line workers, packers, garment workers, textile workers, forestry workers, musicians |

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| **Posture** | **Increased odds with:**<br><br>-Frequent (>2/3 of the time) wrist flexion and extension<br><br>-Frequent sustained forceful motion<br><br>- Frequent bending and twisting of the hands or wrists for 3.5 – 6 hours a day<br><br>**Null or no association:**<br><br>- No association was found between specific upper limb postures and CTS | Increased odds with frequent and sustained wrist movements but not with sustained postures. | Service industry (waiters, healthcare workers, drivers), housewives, clerks, factory workers, technicians, fishermen, poultry, fish and meat processors, dental workers, supermarket workers, butchers, assembly line workers, packers, garment workers, textile workers, forestry workers, musicians |
| **Vibration** | **Increased odds with:**<br><br>-Using vibratory tools<br><br>-Using power tools or machinery for 6 – 11 hours a day, or for 1 to 20 years (two separate studies).<br><br>**Null or no association:**<br><br>- Null associations found between vibration and CTS in two prospective cohort studies | Heterogeneity between studies possibly due to: differences in how CTS defined, study design, country and how bias was detected.<br><br>Variability within studies increased with the number of years study conducted over. | Service industry (waiters, healthcare workers, drivers), housewives, clerks, factory workers, technicians, fishermen, poultry, fish and meat processors, dental workers, supermarket workers, butchers, assembly line workers, packers, garment workers, textile workers, forestry workers, musicians |
| **Computer use** | May be some association between mouse use of more than 20 hours a week and increased CTS but this evidence was low to moderate in quality<br><br>**Null or no association:**<br><br>- With keyboard use | Insufficient evidence that supports association of computer, keyboard or mouse use with CTS. | Computer users |

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| ***Combined Risk Factors*** | | | |
| **Force and repetition** | **Increased odds with:**<br><br>-Repetitive tightening with force in men only<br><br>**Null or no association:**<br><br>- Pressing with the hand, and holding hand in position | Conflicting evidence due to low consistency between studies. There was a weighting towards null association although other studies do report a weak to strong association.<br><br>Limitations in self-reported questionnaire used to collect information and there was a significant loss to follow-up in the studies (>50%). | Assembly line manufacturing, shoe and clothing manufacturing, food industry, packaging and supermarket cashiering |
| **Force and posture** | | Insufficient data available to determine if there is an association between these risk factors. Data based on cross-sectional studies alone. | |

**Occupations were not listed in all studies assessed for this report*

## Single risk factors

Evidence for single risk factors in association with CTS is discussed in this section. The single risk factors outlined are force, repetition, posture, vibration and computer use. Each section provides a brief description of findings from the AUT review followed by further evidence.

### *Force*

The AUT review concluded that there was conflicting evidence of an association between force and CTS. Positive associations were reported by three case-control[7, 9-10] and two prospective cohort studies[3, 6]. Null associations were associated with one case-control[8] and four prospective cohort studies[4-6, 16]. Between these studies there was a wide variability in the definition and measurement of 'force' as well as included participants and settings. The findings of these studies are discussed in more detail below.

A meta-analysis that examined the association of workplace exposure and CTS included an analysis for force[12]. Although this analysis did find a significant association between CTS and force (OR 2.18; 95% CI: 1.47-3.25; p<0.001), there was heterogeneity between the studies due to differences in how they graded force (quantitatively versus qualitatively). To decrease heterogeneity, associations were reassessed after abnormal nerve conduction findings were added to inclusion criteria with the presence of typical signs or symptoms of CTS. The findings from the more conservative definition showed force was strongly associated with CTS (OR 4.23; 95% CI: 1.53-11.68).

Evidence from primary studies shows a positive relationship between CTS and high hand force. A prospective cohort study of manufacturing and healthcare workers over one year reported that high power grips (44.1 N) for more than 1% of the time were significantly associated with CTS (p=0.035)[6]. However, this study was limited by a high loss-to-follow-up at one year (40%) and high power grip was not well defined. Another study found an increased odds ratio with frequent (greater than 2/3 of the time) and sustained forceful wrist motion (OR 2.6; 95% CI: 1.1-5.9)[7]. A further study found increased odds with high force activity with loads greater than 1 kg exerted more than 10 times per hour, however it should be noted that these results are highly variable (OR 9.01; 95% CI: 2.4 – 33.4; p< 0.001)[9]. These primary studies show that high hand force due to high power grip and high loads are associated with CTS. However, how force is defined is not always well explained and there is variability within studies.

Null associations between CTS and force are described in four prospective cohort studies. One study found no association with perceived high force level when workers were asked about CTS symptoms via a questionnaire[5]. Another study found that risk factors for CTS associated with force that included pressing with the hand or elbow, hitting, pulling, pushing and holding in position could also prevent CTS to an extent [3]. No association with CTS was reported for force applied through a pinch grip (8.9N for more than 5% of the time)[6]. Finally, further studies from the same group found a negative association between CTS and high force or heavy lifting; however, although these assessments were undertaken in a work environment, force was not well defined[4, 16]. Care needs to be taken when considering the reported null associations as this evidence includes studies with vague definitions of force, or associated with specific hand grips.

Evidence for associations between force and CTS as described by the AUT study is mixed due to variations and definition of force. A positive or null association of force and CTS is reported to be dependent on the type of hand grip used and how well force and CTS are defined. Primary studies that had better definitions of force and secondary studies that had decreased heterogeneity showed strong associations between force and CTS.

### *Repetition*

The AUT review concluded that there was conflicting evidence of an association between repetition and CTS. Both null and positive associations were found in four of the six case-control studies used in this analysis whereas only null associations were found in five prospective cohort studies. This suggests there was a lack of consistency in the relationship between repetition and CTS in the included studies, and that the association decreased or was not significant in the more rigorously designed prospective cohort studies.

A previously mentioned meta-analysis that examined the association of workplace exposure and CTS included an analysis for repetition(12). It reported a statistically significant increased odds of CTS with repetition (OR 2.26; 95% CI: 1.73 - 2.94; p<0.001)(12). However the authors reported there was variability in the way repetition was defined limiting the usefulness of this pooled analysis.

Further review of the primary studies shows positive associations over a wide range of definitions of repetition that include types of movement, cycles of the movement per minute, and duration (years) with CTS. A prospective cohort study reported repetitively holding the hand in position was moderately associated with an increase in CTS (OR 3.59; 95% CI: 1.06 – 12.1)(3). A case-control study suggested that a lack of change in task or breaks for at least 15% of the daily work time (OR 6.0; 95% CI: 1.8 – 20.2) and the length of the shortest elementary operation of less than 10 seconds (OR 8.4; 95% CI: 1.8 – 44.4) increased odds of CTS(9). A cycle time of less than 30 seconds was not associated with CTS. In the long-term, repetitive wrist movements in similar situations for 20 years or more increased odds of CTS (OR 4.6; 95% CI: 1.8 – 11.9)(10). Finally, repetitive movement through rapid trigger movements of the finger were associated with increased but variable odds of CTS (OR 3.8; 95% CI: 1.0 – 17; p=0.058)(5). Evidence from these studies shows repetition without breaks, with short cycle times and over long time periods (years) across different tasks can have moderate to strong positive associations with CTS.

A significant null association was found in one prospective cohort study (OR 0.56; p=0.46). These assessments were undertaken in a work environment; however, the definition of repetition was vague(16). In a previous prospective cohort study by the same group no significant association was found between repetition and CTS(4).

Further analysis of the primary studies supports the AUT review, as the variability in how repetition is defined could lead to conflicting evidence if attempts were made to pool data. Many studies combined the measurement of repetition with postural movements making it difficult to assess whether repetition as a single factor on its own was related to increased odds of CTS. Further analysis of primary and secondary research for this report shows there are weak to strong positive associations, especially with repetition without breaks, with short cycle times and over long time periods (years). Overall the variability between definitions has led to the conflicting evidence reported by the AUT review.

### *Posture*

The AUT review reported evidence of a positive association between posture of the hand/wrist and shoulder/elbow and CTS based primarily on three case-control studies and one prospective cohort study.

There was some association of increased odds with frequent and sustained wrist movements but not with sustained postures. Frequent (greater than 2/3 of the time) wrist flexion (OR 4.4; 95% CI: 1.8 – 10.7) and extension (OR 2.7; 95% CI: 1.1 – 6.5) were both associated with increased odds of CTS(7). In the same study it was reported that frequent and sustained forceful motion of the wrist increased odds of CTS (OR 2.6; 95% CI: 1.1 - 5.9). Other movements such as repetitive bending or twisting hands or wrists for around 3.5 – 6 hours per day also had increased odds of CTS (OR 2.65; 95% CI: 1.83 - 5.92)(8). Interestingly, at lesser (three hours or less per day) and greater (7 – 16 hours per day) durations, this association was not present. Overall no association with CTS was found in specific upper limb movement (i.e. elbow flexion, forearm pronation/supination), but association was found with frequent and sustained wrist flexion and/or extension(5, 9).

Overall, evidence suggests there is a moderate to strong association of frequent and sustained flexion and extension of the wrist with CTS, but no associations were found for upper limb postures.

### *Vibration*

The AUT review reported there was a consistent positive association between vibrations from hand-held tools and CTS. This is similar to findings from other systematic reviews(12, 14, 17).

Although most evidence positively associates vibration through hand-held tools with CTS, there are some null associations. One meta-analysis on CTS reported this could be due to heterogeneity found between the studies it investigated(12). It stated the heterogeneity was due to: the definition of CTS; study design; country and the risk of bias score used(12). A more conservative definition of CTS that included nerve conduction tests increased the association of CTS with vibratory hand tools across three studies (OR 5.40; 95% CI: 3.14 - 9.31; $p < 0.001$)(12).

Further primary studies are in agreement with the meta-analysis and AUT report. One prospective cohort study found a positive association between vibratory tools and CTS (OR 3.41; 95% CI: 1.09 – 10.72; $p = 0.04$)(4), whereas two other prospective cohort studies found no relationship(5, 16). Two case control studies found a positive association when power tools or machinery were used for 6 – 11 hours a day (OR 3.30; 95% CI: 1.11 to 9.80)(8), or used for one to twenty years (OR 2.7; 95 % CI: 1.1 – 6.7; $p = 0.04$). Both odds and significance increased for power tool or machinery use of over twenty years (OR 4.8; 95%CI: 1.5 – 15.6; p = 0.01)[10].

Evidence supports the AUT report in that although there are null associations between using vibratory hand tools and CTS, there is significant evidence that supports a positive association. Notable associations were found between vibratory hand tool use and CTS when used for long durations (6 – 11 hours) during the day[8] and over long periods (greater than one year) of time[10].

### *Computer use*

The AUT systematic review found conflicting evidence for an association between CTS and prolonged use of a computer, keyboard or mouse device. This was based on four cross-sectional and one prospective cohort study. This is consistent with the findings of a systematic review that examined eight studies and found insufficient evidence of a causal association between computer, keyboard or mouse use and CTS[11]. The authors of this study reported that the best quality evidence suggested there may be some association between mouse use of more than 20 hours per week and increased risk of CTS. However, most of this evidence was low to moderate in quality.

A prospective cohort study that investigated computer use reported an association with CTS when using a mouse more than 20 hours a week, but not with keyboard use[2]. After a one year follow-up the onset of new CTS-related symptoms was 5.5% amongst participants, but only 1.2% of these had median nerve symptoms. The authors concluded that computer use does not appear to pose a significant occupational risk for CTS.

Evidence supports the AUT report in that there is insufficient evidence to support the association of computer, keyboard or mouse use with CTS. Some association was found between CTS and mouse use for over 20 hours a week.

## Combined risk factors

Evidence for combined risk factors in association with CTS is discussed in this section. Combined risk factors outlined are force and repetition and posture combined with repetition or force. Each section provides a brief description of findings from the AUT review followed by further evidence.

### *Force and repetition*

The AUT review reported conflicting evidence for the association of force and repetition with CTS. They stated the consistency of these associations is weighted towards a null association based on five cross-sectional (ORs from 0.88 to 4.25) and one prospective cohort study (OR 1.0). For this report, positive associations were found across five cross-sectional studies over a wider range of odds (ORs from 1.8 to 15.5), indicating a weak to strong association of the combination of force and repetition with CTS.

A prospective cohort study examined the occupational factors related to increased incidence of CTS[3]. This study followed workers in five sectors involving repetitive work: assembly line manufacturing; shoe and clothing manufacturing; the food industry (mainly meat); packaging; and supermarket cashiering. Force and repetitive movement (described as 'repetitively tightening with force') was strongly associated with CTS in men only (OR 4.09; 95% CI: 1.43 – 11.7). These results should be interpreted with caution as there were noted limitations in the self-reported questionnaire used to collect information about physical work factors and there was a significant (greater than 50%) loss to follow-up potentially creating bias in the results[3].

Evidence for an association of combined force and repetition with CTS is conflicting as there is low consistency between studies that trend towards a null association.

### *Posture combined with repetition or force*

The AUT review concluded that there was insufficient data available to be able to determine if there is an association between CTS and tasks that involved the combination of high force and sustained postures, or high repetition and sustained postures. This was based on cross-sectional studies alone.

As discussed in the repetition section above, many of the studies included in the present report measured repetitive sustained postural movements or included occupational sectors because they involved a high degree of repetitive work. It is difficult to parse out the individual contributions of these factors, but it does appear that sustained wrist flexion/extension is associated with an increased odds of CTS.

## Limitations of the evidence base

The evidence base regarding the association between various occupational risk factors and the presence of CTS was overall of low to moderate quality. In the current report case-control and prospective cohort studies were focused on to provide the reader with the highest quality evidence. Unfortunately many of the prospective cohort studies were limited by a high drop-out rate, sometimes as much as 50% of the original sample, and additional limitations in the measurement of workplace factors, often collected by self-reported questionnaire.

Findings for several physical risk factors were generated from a small number of studies. However where multiple studies were identified, there was a lack of consistency in the way occupational risk factors were defined and measured. It is important to acknowledge that the lack of association for some occupational risk factors may reflect limited availability of high quality studies rather than being evidence of no association. Unfortunately fewer case-control and prospective cohort studies of CTS have been undertaken compared to cross-sectional studies.

Given the relative lack of prospective cohort studies, when considering the causation of CTS for an individual claim wider considerations such as the Bradford-Hill criteria, the specifics of the case and expert opinion should be undertaken.

## Conclusions

The first objective of this report is to summarise the best evidence for the relationship between CTS and physical workplace factors. The number of available studies reporting on the association between occupational risk factors and CTS is reasonably large when cross-sectional studies are included, but the overall quality of evidence is moderate to low. Most of the studies included in previous reviews including the AUT report were cross-sectional in design, and possessed limitations that made them open to potential sources of bias as well as being unable to assess the likelihood of a causal relationship between a risk factor and CTS. In this report, cross-sectional studies were excluded from the review in order to focus on the highest quality primary studies, namely case-control and prospective cohort studies. It should be noted that flaws in the available best evidence and the wide variability in the definitions of work tasks and physical risk factors limited the ability to pool the findings of individual studies.

Notable findings were found with regards to force and CTS. A meta-analysis that used conservative criteria for defining CTS found a strong association between force and CTS. Primary studies found a range of weak to strong associations between repetition and CTS depending on how repetition was measured. There was significant evidence that vibration was positively associated with CTS and some association was found between CTS and mouse use for over 20 hours a week but not with keyboard use.

## Recommendations for the WRGDPI team when considering physical risk factors and CTS

Due to variation between studies and conflicting evidence within the best evidence identified in this report and the AUT report for CTS, when considering an individual claim, other factors such as the Bradford-Hill criteria, the specifics of the case and expert opinion should be considered.

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# Appendix 1.

## Background

ACC Research was commissioned by the Work-Related Gradual Process Diseases and Infections (WRGPDI) team to provide them with a brief report to support day-to-day decision-making as they carry out case assessments. The report uses an evidence-based approach to summarise the evidence regarding the relationship between specific occupational risk factors and carpal tunnel syndrome (CTS). The purpose of this report is to provide decision-making support to the WRGPDI team and, in particular, to summarise and explain the current evidence regarding CTS and occupational risk factors across multiple studies. Additional information is included in other resources used by the team, including a quick reference decision-support spreadsheet.

## AUT Investigation Analysis

In 2009, a group of researchers specialising in occupational health at Auckland University of Technology (AUT) was commissioned by ACC to complete a series of independent systematic reviews of the risk factors associated with 16 gradual process conditions, including CTS(13). The authors searched an extensive set of databases up to October 2010, and all relevant cross-sectional, case-control and cohort studies meeting inclusion criteria were appraised for quality. Studies which did not meet a pre-determined quality assessment score were excluded from further analysis. The remaining studies were summarised in evidence tables (Table 4 at the end of this document) and summary data was extracted. Due in part to the methodology utilised in these reviews and the presentation and length of the final reports, ACC Research was requested to complete a brief narrative report describing the findings of the primary studies included in the AUT report and any additional studies which had been published subsequently.

## Horizon Scanning for future upper limb disorder research

A large multi-centre prospective cohort study of distal upper-extremity musculoskeletal disorders, also known as the WISTAH hand study, started in 2012(18). The two main purposes of this study are to quantify the risks of upper limb disorders, including CTS, and to address weaknesses seen in prior research. Steps have been taken in this study to obtain high quality data: these include using prospective methods, data collection from diverse populations' nerve conduction studies in all subjects, baseline measurements and monthly follow-ups.

For this study over 1,000 workers from 17 different employment settings have been recruited. The settings include: (i) poultry processing, (ii) manufacturing and assembly of animal laboratory testing equipment, (iii) small engine manufacturing and assembly, (iv) small electric motor manufacturing and assembly, (v) commercial lighting assembly and warehousing, (vi) electrical generator manufacturing and assembly, (vii) metal automotive engine parts manufacturing (three facilities), (viii) plastic and rubber automotive engine parts manufacturing and assembly (ix) red meat processing, (x) apparel manufacturing, (xi) office work, (xii) cabinet manufacturing, (xiii) airbag manufacturing, (xiv) light valve assembly, and (xv) small metal parts fabrication. The aim of including this distribution was to include participants with low, medium and high physical demands at work.

One paper from this study has been published[19] . However the focus of this study is to determine how indicative two metrics (e.g. the Threshold Limit Value for Hand Activity Level) are as risk predictors for CTS[19] and thus it does not add to this brief report. No further information was available regarding future publications from this study.

## Measures

The relationship between CTS and occupational risk factors was most commonly reported as odds ratios (ORs). This is because of the nature of the research base (cross-sectional or case-control studies which are conducted at a point in time, rather than prospective studies conducted over a prolonged period). An odds ratio reports the likelihood of an outcome being present (e.g. tenosynovitis) when a particular exposure (e.g. forceful work) has been present, compared with the probability of the outcome being present when the exposure has not been present[20]. If the odds ratio is 1 then the outcome is equally as likely in the exposed group as the non-exposed group. If the odds ratio is greater than 1, then the outcome occurs more often in the exposed group. If it is less than 1, it occurs more often in the non-exposed group. The higher the odds ratio, the stronger the association is between the exposure and the outcome. The 95% confidence interval (95% CI) measures the precision of the odds ratio – wide confidence intervals indicate a low level of precision. It is important to note that odds ratios report probability based on association at a point in time. Using the odds ratio as a proxy for relative risk (RR) is based on an assumption that any such association arises because of a causal link, and this assumption cannot always be relied on.

The use and interpretation of odds ratios has been debated extensively in the literature, especially when compared with the use of relative risk[20]. It is emphasised in the literature that the odds ratio is not a representation of risk, but of probability or odds, and that this can make it more difficult to interpret[21]. The use of odds ratios has been criticised for exaggerating the strength of association between an exposure and an outcome when it is applied as a measure of risk. When an outcome is rare (initial risk <10% in both the exposed and non-exposed groups), for instance in the case of CTS where the prevalence in the normal population is estimated to be 1.3%, the odds ratio is said to be a valid approximation of the true relative risk and the strength of the association can be interpreted accordingly. However, as the prevalence of the outcome increases, the odds ratio moves further away from the true relative risk. Whereas the accepted relative risk cut-off for determining whether an outcome can be attributed to a particular exposure is >2.0[14], the cut-off for odds ratios is not clear and depends on the prevalence of the outcome.

## Appendix 2. Outline of methodology of included studies

**Andersen et al (2003):** A prospective cohort study that followed 6943 people recruited from the Danish Association of Technicians trade union for one year to examine the relationship between keyboard and mouse use and CTS. There was an 82% follow-up rate at one year. This study was part of the Neck Upper-extremity Disorders Among Technical Assistants Study (NU-DATA). A baseline questionnaire was used to identify CTS where participants were asked about tingling or numbness in the fingers at least once a week or daily within the last 3 months. This was followed up with a clinical interview and exam about tingling/numbness and pain in the median nerve. Keyboard and mouse use was self-reported (hours per week).

*Level of evidence: 2+*

**Fung et al (2007):** A case-control study that recruited 166 cases who had a diagnosis of CTS and 111 controls without a history of CTS from four orthopaedic departments in Hong Kong. Participants were interviewed by a single physician about wrist postures and motions, with a focus on the frequency of wrist flexion, frequency of wrist extension, and use of repetitive and sustained forceful motions.

*Level of evidence: 2-*

**Leclerc et al (2001):** A prospective-cohort study that reported on 1420 workers in five occupational sectors involving repetitive work, who completed a questionnaire regarding work activities and were examined by a physician based at their workplace. The sectors included assembly line manufacturing; shoe and clothing manufacturing; the food industry (mainly meat); packaging; and supermarket cashiering. A subsample of the original cohort was followed up 3 years later (n=598) based on the availability of the original workplace physician. Work factors were assessed by self-reported questionnaire and included: working with force, pressing with the hand or elbow, screwing or tightening with force, hitting, pulling, pushing and holding in position. Respondents were asked to indicate whether they did these repetitively, not repetitively or never. Three levels of CTS diagnosis were used: (i) Tinel's sign or Phalen's test where positive = proved diagnosis in the medical examination (ii) diagnosis based on nerve conduction velocity = proved diagnosis before the medical examination, and (iii) suspected diagnosis (not all the criteria met in the medical examination or diagnosis based on the description of symptoms that were no longer present at the time of the examination).

*Level of evidence: 2+*

**Nathan et al (2002; 2005):** Prospective cohort studies that reported 11 year and 17 year follow-up data from a cohort of 471 workers from four industrial sites (steel mill; meat/food packaging; electronics; plastics). At the 11 year follow-up (2002), 61% of the sample was available and at 17 years this had dropped to 35%, with most of the drop outs related to lay-offs in the workplaces. Identification of CTS was made using nerve conduction testing and the presence of hand/wrist symptoms specific to CTS. Work-related physical factors were measured by direct observation at baseline and stratified into 5 categories based on relative intensity of force, heavy lifting, repetition, presence of keyboard tasks and use of vibrational tools.

*Level of evidence: 2-*

**Nordstrom et al (1997):** A case-control study that compared work-related factors among 206 cases of CTS selected from a community sample using hospital and clinic data and 211 controls with no history of CTS. Cases were identified using ICD10 codes for CTS and controls were matched to cases based on five age strata. A telephone interview was utilised to collect information about the presence of risk factors in the previous 12 months, including 23 work factors (e.g. repetitive bending/twisting of wrists and hands, use of power tools/machinery, job satisfaction) and 17 non-work factors (e.g. BMI, history of musculoskeletal disorders, sports).

*Level of evidence: 2-*

**Roquelaure et al (1997):** A prospective cohort study that compared work-related factors in 65 cases and 65 controls matched for gender, age and workplace. Participants were recruited from three plants where television sets (plant A), shoes (plant B), and automobile brakes (plant C) were manufactured. Participants with a history of CTS or other MSDs were excluded as were those with malignancies, rheumatic diseases, thyroid deficiencies or diabetes. Case diagnosis was based on examination of the employees' medical files and the following criteria were employed: tingling, pain, or numbness in the median nerve distribution of the hand with nocturnal exacerbation (> 20 occurrences or lasting more than three weeks in the previous year); a positive Tinel's sign and a positive Phalen's test or hypoesthesia in the territory of the median nerve; and slowing of the sensory or motor conduction velocities (< 40 m/s) in the median nerve at the wrist level. Two assessors blind to CTS status examined the workstation occupied by the worker 6 months before CTS was diagnosed (cases) or at the end of 1992 (controls). Work factors included repetitive activity (<30 sec per cycle), high force activity (prehensive efforts of over 1kg), angular position of the elbow (flexion < 135 degrees), forearm (pronosupination), and wrist (flexion >45 degrees, neutral, extension > 45 degrees), the frequency of certain activities (pinching, gripping, screwing, pulling, pushing, lifting, turning).

*Level of evidence: 2+*

**Roquelaure et al (2001):** A prospective cohort study that reported on 199 workers in a footwear factory who were followed-up after 1 year (81% follow-up rate). The main jobs performed were sewing preparation, including cutting, sewing, mechanised and manual assembly, finishing and packing. The diagnosis of CTS required: i) the presence of paraesthesia, pain or numbness affecting at least part of the median nerve distribution of the hand(s) occurring for at least one week or, if intermittent, occurring at least 10 times during the previous 12-month period; ii) the presence of objective findings in affected hand(s) or wrist(s), including Tinel's sign or positive Phalen's test or diminished or absent sensation to pin prick in the median nerve distribution; and iii) the absence of any sign of other causes of hand numbness or paraesthesia such as cervical radiculopathy, thoracic outlet syndrome and pronator teres syndrome. Workplace assessments were conducted by direct observation and questioning by two trained interviewers using a checklist. The presence of repetitive, forceful activities and mechanical or postural stress were assessed.

*Level of evidence: 2+*

**Silverstein et al (2010):** A prospective cohort study that followed 733 workers in 12 occupational sectors involving manufacturing or healthcare work for one year (58% follow-up rate). CTS was defined by: i) experience of pain, numbness, tingling, or burning in ≥1 of the first three digits in the past 12 months occurring more than 3 times or lasting more than one week; and ii) abnormal nerve conduction test results. Videotaped job tasks assessed by ergonomists were used to quantify exposure to forceful exertions, postures and repetitive movements.

*Level of evidence: 2+*

**Wieslander et al (1989):** A case-control study which compared work-related factors among 38 men who were operated on for CTS, 76 controls who were operated on for other conditions e.g. gall bladder but had no history of CTS, and 76 population-based controls Each participant was interviewed by phone with a focus on occupational exposures to vibrating hand-held tools, performance of repetitive wrist movements at work, and work involving heavy load on the wrist. Degree of exposure was evaluated both with regard to the total number of work years and the average number of exposed hours a week.

*Level of evidence: 2-*

## Appendix 3.

***Table 3 Scottish Intercollegiate Guidelines for Levels of Evidence***

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| **1++** | High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias |
| **1+** | Well-conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias |
| **1-** | Meta-analyses, systematic reviews, or RCTs with a high risk of bias |
| **2++** | High quality systematic reviews of case control or cohort or studies<br>High quality case control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal |
| **2+** | Well-conducted case control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal |
| **2-** | Case control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal |
| **3** | Non-analytic studies, e.g. case reports, case series |
| **4** | Expert opinion |

## Appendix 4. Evidence Tables:

***Table 4. Evidence tables summarising secondary literature which evaluates the association between physical work characteristics and CTS***

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Barcenilla et al (2012)***<br><br>**Research Question:**<br><br>To examine the relationship between workplace exposure and CTS<br><br>**Methodology Described:**<br><br>Meta-analysis<br><br>**Types of study included:**<br><br>Prospective cohort, case-control, cross-sectional<br><br>**Literature Search:**<br><br>Medline, CINAHL, | **Included Studies:**<br><br>N=37 studies<br><br>28 cross-sectional<br><br>5 case-control<br><br>4 cohort<br><br>Used two previous meta-analyses - Abbas (1998) and Palmer (2007) – to provide the initial pool of primary studies, and updated the search to December 2009<br><br>**Inclusion criteria:**<br><br>(i) concerned CTS in occupational population<br>(ii) peer reviewed and published in English,<br>(iii) included a control group<br>(iv) quantitative description of the measures of effect e.g. odds ratio, or relative risk<br>(v) cases met NIOSH criteria | Summary effects (OR with 95% CI) of specific exposure<br><br>risks were calculated based on random-effects models for:<br><br>o hand force<br>o repetition<br>o a combination of force and repetition<br>o vibration and wrist posture<br><br>Heterogeneity was quantified using the Chi-squared and I statistics.<br><br>In most studies, the diagnosis of CTS was based on a combination of abnormal nerve conduction findings and a combination of symptoms or signs<br><br>NIOSH criteria:<br><br>o one or more symptoms indicative of CTS, e.g. | **Outcome Measures:**<br><br>Summary odds ratios with 95% CI reported for four physical exposures (hand force; repetition; force + repetition; vibration and wrist exposure)<br><br>Heterogeneity reported for each exposure<br><br>**Results:**<br><br>NIOSH case definition:<br><br>Hand Force: n=13 studies. OR 2.18 (95% CI 1.47 – 3.25, p<0.001).<br><br>Repetition: n=25 studies. OR 2.30 (95% CI 1.75, 3.01; P<0.001).<br><br>Force + repetition: n = 9 studies; OR 2.03 (95% CI 1.43, 2.89; P<0.001)<br><br>Vibratory tools: n=12 studies; OR 2.73 (95% CI 1.90, 3.92; P<0.001)<br><br>Abnormal wrist posture: n=7 studies. OR 2.69 (95% CI 1.32, 5.49; P = 0.007)<br><br>**Heterogeneity:**<br><br>Except for force in combination with repetition, significant |

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| PubMed<br><br>**Date of search:**<br><br>Jan 1980 – December 2009<br><br>**How funded:**<br><br>Not stated<br><br>No conflicts of interest declared | for definition<br><br>Final decision on inclusion of papers and quality assessment of included studies completed by two authors. Cochrane methodology used and each study rated low, moderate, or high risk of bias | paraesthesia, pain or numbness; and<br>o clinical signs that included a positive Tinel's sign or Phalen's sign or nerve conduction findings indicative of nerve dysfunction across the carpal tunnel<br><br>Conservative case definition:<br><br>o at least abnormal nerve conduction findings plus<br>o The presence of either typical symptoms or signs of CTS. | heterogeneity in results was seen among studies for force, repetition, vibration and wrist posture.<br><br>**Conservative case definition:**<br><br>Using conservative case definition resolved heterogeneity for repetition and use of vibratory tools and produced the following findings:<br><br>Repetition: n=11 studies. OR 2.26 (95% CI 1.73, 2.94; P<0.001)<br><br>Force + repetition: n=5 studies. OR 1.85 (95% CI 0.99 – 3.45, p<0.054)<br><br>Vibration: n=3 studies. OR 5.40 (95% CI 3.14, 9.31, P<0.001) |
| | | | **Biases/Weaknesses:**<br><br>• Few prospective cohort studies, so causality could not be established<br>• Retrospective collection and self-reported measures of exposures common<br>• Low incidence of CTS lead to lack of power in prospective cohort studies – possibly unable to detect significant associations, and wide confidence intervals<br>• Heterogeneity in assessment of exposures, many assessed using questionnaires<br>• ORs tended to decrease for prospective cohort studies, indicating less of an effect of exposure in these higher quality studies<br><br>**Conclusion:**<br><br>• Activities that increase CTS risk include excess use of vibratory tools, highly repetitive wrist or hand work, |

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| | | | high hand force, and the combination for forceful and repetitive hand or wrist work<br>• No single occupational activity or duration or dose response could be identified from these studies |
| | | | **Level of evidence: 2++**<br>• Selection criteria clearly stated<br>• Two authors completed quality assessment – clearly reported<br>• **Objective synthesis – significant heterogeneity between studies limited some findings** |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Boocock et al (2010)***<br>**Research Question:**<br>To examine the evidence for an association between carpal tunnel syndrome and work tasks/activities<br>**Methodology Described:**<br>Systematic review<br>**Types of study included:**<br>Prospective cohort, case-control, cross-sectional<br>**Literature Search:** | **Included Studies:**<br>N= studies<br>8 case-control<br>8 prospective cohort<br>**Inclusion criteria:**<br>(i) peer reviewed and published in English, (ii) studies of physical or psychosocial load at work, (iii) self-reported and job title acceptable as measures of work tasks, (iv) non-epidemiologic and lab studies excluded, (v) had to | | **Outcome Measures:**<br>**Evidence of causation using 2 of the Bradford-Hill criteria:**<br>• Strength of association - based on odds ratios<br>• Consistency of association – based on a pattern-of-evidence assessment of positive, negative and null associations<br>**Results:**<br>- Repetition: 15 studies (9 cross-sectional; 6 case-control) with positive associations. 8 studies with null associations (including 5 prospective cohort studies). Overall evidence considered "conflicting". Increased risk of CTS reported for repetitive wrist movements (wrist flexion, extension and twisting) for more than 50% of cycle time or a cycle time less than 30 seconds; and performing the same wrist action >2 times/minute, ≥4 hour/day, ≥⅔ of |

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| 17 electronic databases including PubMed, EMBASE (Ovid), ISI Web of Science, Index NZ, and OSH References Collection Search (giving access to the following six databases OSHLINE, NIOSHTIC, NIOSHTIC-2, HSELINE, CISILO and Canadian).<br><br>**Date of search:**<br><br>1980 - October 2010<br><br>**How funded:**<br><br>Developed as part of a review for Accident Compensation Corporation of NZ | pass initial quality assessment by one of two authors | | time. One study found that repeated shoulder rotation with an elevated arm >1 time/minute increases the risk of CTS. Repeated or rapid finger movements were found to be poorly associated with CTS.<br><br>- Posture: 11 studies (7 cross-sectional; 3 case-controls; 1 prospective cohort) reported positive associations. 4 studies (2 cross-sectional; 1 case-control; 1 prospective cohort) reported null associations. Overall evidence rated as suggesting a positive association between posture and CTS. Increased risk of CTS reported for wrist/hand posture that is flexed, extended, bent or twisted or held in precision grip for ≥2 hours/ day or >1-7 hours per week. Positive associations reported for shoulder/elbow posture suggest that working overhead increases the risk of CTS.<br><br>- Force: 11 studies (6 cross-sectional; 3 case-controls; 2 prospective cohorts) reported positive associations. 7 studies (2 cross-sectional; 1 case-control; 4 prospective cohorts) reported null associations. Overall the evidence was considered "conflicting". Increased risk of CTS was reported with forceful exertion and heavy load on wrist >3kg or >⅔ of time.<br><br>- Heavy physical work: 1 cross-sectional study reported a positive association and 4 studies (2 cross-sectional; 2 prospective cohort) reported null associations. Overall the evidence suggested no evidence of an association between heavy physical work and CTS.<br><br>- Vibration: 15 studies (12 cross-sectional; 2 case-controls; 1 prospective cohort) reported positive associations. 2 prospective cohort studies reported null associations. Overall evidence was in favour of a positive association. |

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| | | | Increased risk of CTS was reported with daily cumulative vibration >10 years from holding a hand tool.<br>- Computer use: 5 studies (4 cross-sectional; 1 prospective cohort) reported positive associations. 5 studies (1 cross-sectional; 2 case-controls; 2 prospective cohorts) reported null associations. Overall the evidence was considered "conflicting". Increased risk of CTS was reported with use of a mouse device for >20 hours/week with the same hand and use of the keyboard for >28 hours/week.<br>**Combined physical factors**<br>***Force and repetition:***<br>- 5 cross-sectional studies reported positive associations. 2 cross-sectional and 1 prospective cohort study reported null associations. Overall the evidence was weighted towards a null association.<br>***Repetition and posture:***<br>- 2 cross-sectional studies reported positive associations. Evidence was considered "insufficient" to determine a relationship.<br>***Force and posture:***<br>- 2 cross-sectional studies reported positive associations. Evidence was considered "insufficient" to determine a relationship.<br>***Force, repetition and duration***<br>- 2 cross-sectional studies reported positive associations. Evidence was considered "insufficient" to determine a relationship. |

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| | | | **Overall findings**<br><br>Consensus regarding key risk factors and levels of exposure for those studies reporting positive associations suggest that repetitive bending and twisting of the hands as well as wrist bending (flexion, extension and deviation) combined with lifting act to increase the risk of CTS. |
| | | | **Biases/Weaknesses:**<br><br>• Exclusion of studies using quality score prior to synthesis – reasons for exclusion not reported, specific quality assessment of included studies not reported<br>• Only used two of the Bradford Hill criteria to assess strength and consistency of association – unable to assess causal relationship<br><br>**Conclusion:**<br><br>• Synthesis was weak and did not clearly present the highest quality evidence for each factor<br>• Brief narrative summary |
| | | | **Level of evidence: 2++**<br><br>• Search and identification of papers thorough<br>• Final inclusion based on quality score which is not usual practice in systematic reviewing<br>• Use of scoring system to assess consistency of findings seems arbitrary and is based on study design alone |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Palmer (2007)***<br><br>**Research Question:**<br><br>To examine the relationship between occupational risk factors and CTS<br><br>**Methodology Described:**<br><br>Systematic review<br><br>**Types of study included:**<br><br>Prospective cohort, case-control, cross-sectional<br><br>**Literature Search:**<br><br>Medline, Embase (OVID)<br><br>**Date of search:**<br><br>Jan 1980 – December 2004 | **Included Studies:**<br><br>N=38 studies<br><br>28 cross-sectional<br><br>5 case-control<br><br>4 cohort<br><br>Used two previous reports – NIOSH (1997) and Kourinka and Fourcier (1995)– to provide the initial pool of primary studies, and updated the search to December 2004<br><br>Inclusion criteria not specified<br><br>(i) peer reviewed and published in English,<br>(ii) included a control group<br><br>Final decision on inclusion of papers completed by two authors. No quality assessment completed. | In most studies, the diagnosis of CTS was based on a combination of physiological and symptoms or signs but the exact criteria used varied. | **Outcome Measures:**<br><br>Relative risk, odds ratios calculated where prevalence was stated<br><br>Results summarised for relationship between CTS and job title and CTS and individual occupational risk factors<br><br>Results:<br><br>Repetitive flexion/extension of wrist: 4 studies found that repeated flexion and extension of the wrist (defined in various ways) more than doubled the risk of physician-confirmed CTS.<br><br>Use of vibratory tools: 7 studies reported that regular and prolonged use of hand-held vibratory tools increases the risk of CTS >2-fold.<br><br>Keyboard and mouse use: some evidence that high mouse use >20 hours per week is associated with increased risk of CTS (Andersen 2003)<br><br>**Biases/Weaknesses:**<br><br>• Limited number of studies located and included e.g. two studies of occupational activities and LE<br>• Lack of homogeneity in the studies especially in measurement of exposure to risk factors, not possible to pool odds ratios<br>• Methodological quality of some included studies was not high. Lack of prospective cohort studies. |

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| **How funded:**<br><br>Industrial Industries Advisory Council, UK<br><br>No conflicts of interest declared | | | **Conclusion:**<br><br>• Regular and prolonged use of hand-held vibratory tools increases the risk of CTS > 2-fold. Evidence on lesser durations and exposures was limited.<br>• Prolonged and highly repetitive flexion/extension of the wrist increases risk of CTS especially when combined with a forceful grip<br>• Little evidence of an association between CTS and computer/keyboard work |
| | | | **Level of evidence: 2++**<br><br>• Selection criteria clearly stated<br>• Two authors completed quality assessment<br>• Objective synthesis limited by a lack of well-conducted studies for some conditions |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Thomsen et al (2008)***<br><br>**BMC Musculoskeletal Disorders, 9:134**<br><br>**Research Question:**<br><br>To examine the evidence for an association between computer use and CTS<br><br>**Methodology Described:** | Included Studies:<br><br>N=8 studies (4 prospective, 1 case-referent, 3 cross-sectional)<br><br>Inclusion criteria:<br><br>(i) peer reviewed and published in English (reports, | Exposure:<br><br>1) Computer work (keyboard or mouse) or typing<br><br>Outcome definition:<br><br>1) Symptoms (questionnaire or interview or both) of CTS plus NCT or;<br>2) Symptoms alone but | **Outcome Measures:**<br><br>Evidence of causation based on classification system used by Danish Society of Occupational and Environmental Medicine.<br><br>Association between risk factor and outcome assessed as:<br><br>Strong evidence of a causal association (chance, bias or confounding could be reasonably ruled out). Positive relationship observed in several studies.<br><br>Moderate evidence (bias and confounding are not a likely explanation of associations) |

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| Systematic review<br><br>**Types of study included:**<br><br>Longitudinal, Prospective cohort, case-referent, cross-sectional<br><br>**Literature Search:**<br><br>PubMed, EMBASE (Ovid), ISI Web of Science, Arbline).<br><br>**Date of search:**<br><br>August 2008<br><br>**How funded**<br><br>Developed as part of a review for Danish National Board of Industrial<br><br>Injuries to decide whether MSD sustained by computer workers should be added to the government compensation register | abstracts and proceedings were not included),<br>(ii) reporting on original data<br>Excluded:<br>(iii) Studies which ascertained CTS with questionnaire only/NCT only/Tinel's or Phalen's test only<br>(iv) Studies using workers compensation data<br>Quality assessment of included studies completed by two authors but no particular scale used | confirmed by qualitative interview | Limited evidence (positive relationship observed but bias and confounding are not an unlikely explanation of associations)<br><br>Insufficient evidence of a causal association – quality, consistency or power of studies insufficient to permit a conclusion<br><br>**Evidence suggesting lack of a causal association**<br><br>**Results:**<br><br>- Atroshi et al: significant protective effect of keyboard work; prevalence of CTS increased with decreasing hours/day computer work<br>- NUDATA study (Andersen et al): OR 2.4 (95% CI 1.2 – 4.5) with 5-9 hours/week mouse use; OR 3.6 (95% CI 1.8 – 7.1) with 20-24 hours/week mouse use. Two case definitions – the second yielded only marginal positive relationship between mouse use and CTS<br>- Gerr et al: prevalence of CTS too low to allow for analyses<br>- Danish PRIM study (Thomsen et al): measured mainly effect of data entry. Prevalence of CTS low. Risk of CTS increased for every 10 hours of repetitive work after adjusting for forceful work and personal characteristics<br>- Nathan et al (2002)– prospective cohort study, population followed for 11 years, , no effect of keyboard or repetitive work<br>- Stevens et al compared groups with CTS vs non-CTS. No differences between groups in hours/day of keyboard use or years of keyboard use. Possible differences in 'frequent' mouse use<br>- De Krom et al – case-referent study, n=158 CTS cases compared with n=473 non-CTS controls. No difference in |

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| | | | hours per week of typing.<br>- Ali et al - cross-sectional study: significant effect of years and hours/day of computer work. Poor quality study. |
| | | | **Biases/Weaknesses:**<br>• Outcome definition and case definition varied between studies<br>• Overall quality of studies was moderate, with limitations in all included studies<br>• Four prospective studies, one well-performed study found some positive associations (Andersen et al,2003)<br><br>**Conclusion:**<br>• insufficient evidence for a causal relationship between CTS and computer work per se, keyboard and mouse time<br>• authors concluded that CTS as a result of computer use cannot be recognised as an occupational condition<br>• Atroshi; Andersen and Thomsen were the best quality studies: these suggested there may be some evidence that mouse use of more than 20 hours/week may increase CTS risk; Atroshi et al showed a protective effect of keyboard work<br>• none of the evidence was considered moderate or strong |
| | | | **Level of evidence: 2++**<br>• Selection criteria clearly stated<br>• Possible publication bias and limited databases searched<br>• Quality assessment but not based on standardised scale<br>• Objective synthesis limited by a lack of well-conducted studies for some conditions |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Van Rijn et al (2009)***<br><br>**Research Question:**<br><br>To examine the relationship between physical occupation risk factors and CTS<br><br>**Methodology Described:**<br><br>Systematic review<br><br>**Types of study included:**<br><br>Prospective cohort, case-control, cross-sectional<br><br>**Literature Search:**<br><br>Medline, EMBASE(Ovid), Cochrane Register of Controlled Trials<br><br>**Date of search:** | **Included Studies:**<br><br>N=44 studies<br><br>30 cross-sectional<br><br>9 case-control<br><br>5 cohort<br><br>N=22 reported on relationship between CTS and occupations<br><br>N=23 reported on relationship between specific work factors and CTS<br><br>**Inclusion criteria:**<br><br>(i) concerned CTS in occupational population<br>(ii) peer reviewed and published in English, French, German or Dutch (reports, abstracts and proceedings were not included),<br>(iii) quantitative description of the measures of exposure<br>(iv) association between | **Work-related physical exposures:**<br><br>o Force<br>o Hand-arm vibration<br>o Repetitiveness<br>o Combined exposure measure<br>o Awkward postures | **Outcome Measures:**<br><br>Odds ratios, risk ratios presented from each study<br><br>Statistical associations:<br><br>Positive – higher values of risk factor associated with higher occurrence of condition<br><br>Negative – higher values of risk factor associated with lower occurrence of condition<br><br>Null – risk estimate not significantly different from 1 (evaluated as no evidence of effect or insufficient evidence<br><br>Four exposure risk factors reported: force, repetition, vibration, posture<br><br>**Results:**<br><br>- Occupations: meat and fish processing, forestry work with chainsaws, electronic assembly work<br>- Force: n=3 studies. Roquelaure – handling loads >1kg at least 10 times per hour. Lam et al – moderate and heavy manual work. Abbas et al – precision grip. Four studies reported null associations<br>- Repetition: n=5 studies. Roquelaure et al; Chiang et al – work cycles <10 seconds. Contradictory results for work cycles <30 seconds. Five studies reported null associations.<br>- Hand-arm vibration: n=-3 studies. Using vibrating tools, |

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| September 2007<br><br>**How funded:**<br><br>Worksafe, British Columbia<br><br>No conflicts of interest declared | risk factor and condition expressed quantitatively<br><br>Quality assessment of included studies completed by two authors – each criterion scored positive, negative, unclear | | power tools or machinery (6-11 hours per day). Two studies reported positive associations which did not reach significance.<br><br>- Posture: n=6 studies. De Krom et al, Blanc et al, Nordstrom et al - wrist flexion/extension 1-20 hours/week association with increased risk of CTS. Two studies (Roquelaure et al; Ali et al) reported null associations<br>- Computer use: 2 studies reported positive associations, 5 studies null associations<br>- Combined exposure: n=3 cross-sectional studies |
| | | | **Biases/Weaknesses:**<br><br>• Few prospective cohort studies, so causality could not be established<br>• Self-reported measures of exposures common<br>• Low incidence of CTS lead to lack of power in prospective cohort studies – possibly unable to detect significant associations, and wide confidence intervals<br>• Heterogeneity in assessment of exposures, many assessed using questionnaires<br><br>**Conclusion:**<br><br>• Hand-arm vibration, prolonged repetitious flexion/extension of the wrist identified as risk factors but unable to provide guidance as to harmful levels of exposure<br>• Contradictory findings for computer use and CTS<br>• Repetitiveness at work (cycle time < 10 secs or >50% of a cycle time performing the same movements) |

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| | | | **Level of evidence: 2++**<br><br>• Selection criteria clearly stated<br>• Two authors completed quality assessment – clearly reported<br>• Small number of studies identified (n=23) compared with other reviews e.g. Barcenilla et al (n=37 studies) – suggests possible limitations in the search strategy or databases used<br>• Objective synthesis limited by a lack of well-conducted studies for some conditions |

***Table 5. Evidence tables summarising primary literature which evaluates the association between physical work characteristics and CTS***

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Andersen et al (2003)***<br><br>**Research Question:**<br><br>To examine the relationship between computer keyboard and mouse use and CTS<br><br>**Methodology Described:**<br><br>Prospective cohort<br><br>**How funded:**<br><br>Danish Medical Research Council; Danish Min of Employment; National Work Authority<br><br>No conflicts of interest declared | N=6943 people recruited from the Danish Association of Technicians (a trade union, n=9480)<br><br>Participation rate 73%<br><br>82% follow-up at 1 year<br><br>Part of the Neck Upper-extremity Disorders Among Technical Assistants Study (NU-DATA)<br><br>From two employment groups: technical assistants (draughtsmen) and machine technicians who carried out mainly technical drawing, administrative, graphical, and other office-based tasks | 1 year follow-up prospective cohort study<br><br>**Identification of CTS**<br><br>Baseline questionnaire:<br>- tingling or numbness in the fingers at least once a week or daily within the last 3 months (no, seldom, at least once a month, at least once a week, at least once a day)<br>- followed up with a clinical interview and exam about tingling/numbness and pain in the median nerve<br><br>Work-related factors:<br>- self-reported time spent using mouse (hours per week)<br>- self-reported time spent | **Outcome Measures:**<br><br>Mean mouse use and keyboard use in hours/week<br><br>Relative risk, odds ratios calculated where prevalence was stated, 95% CIs<br><br>**Results:**<br><br>Mean mouse use:<br><br>Women = 14.7 hours/week<br>Men = 12.5 hours/week<br><br>Mean keyboard use:<br><br>Women = 9.3 hours/week<br>Men = 8.0 hours/week<br><br>Prevalence of CTS symptoms at baseline:<br><br>4.8% tingling/numbness in the median nerve<br>1.4% symptoms at night<br><br>Incidence of new cases at 1 year follow-up:<br><br>1.2% tingling/numbness in median nerve<br><br>Mouse use: Tingling/numbness in the median nerve OR 2.2 – 3.5 with >2.5 hours per week mouse use. Using this less rigorous |

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| | | using keyboard (hours per week) | definition of CTS there was an apparent exposure-response relationship<br><br>Addition of median nerve symptoms at night reduced the odds ratios for all mouse use except ≥ 30 hours per week mouse use (OR 4.1, 95% CI 1.0 – 16). Other ORs not significant<br><br>Keyboard use: no significant findings |
| | | | **Biases/Weaknesses:**<br><br>• diagnostic criteria for CTS based on questionnaire and clinical interview – other clinical assessments e.g. Phalen's test not used and not confirmed by nerve conduction studies<br>• could not rule out tingling/numbness due to conditions other than nerve entrapment<br>• self-reported hours of mouse and keyboard use, may be prone to bias<br>• authors reported potential information bias because of reporting of the study in the media<br><br>**Conclusion:**<br><br>• Little evidence of an association between CTS and keyboard work<br>• Some evidence that ≥ 30 hours mouse use is associated with an increase in odds of CTS (OR 4.1)<br>• Authors conclusion "computer use does not pose a severe occupational hazard for developing CTS symptoms |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Fung et al (2007)***<br><br>Hand Surgery, Vol. 12, No. 1, 13–18.<br><br>**Research Question:**<br><br>Relationship between wrist posture and motion risk factors and CTS<br><br>**Methodology Described:**<br><br>Case-control<br><br>**How funded:**<br><br>Hong Kong Orthopaedic Association<br><br>No conflicts of interest declared | N=166 cases and 111 controls<br><br>Cases recruited from one of 4 hospitals in Hong Kong – patients in orthopaedic dept. with idiopathic CTS. Not specified if cases were consecutive patients or selection process.<br><br>Diagnosis was based on symptoms (the presence of paraesthesia over the radial side of the palm, with positive Tinel sign and/or Phalen's test, sometimes with thenar atrophy) by orthopaedic surgeons, supplemented by electrophysiological study if the presentation was atypical.<br><br>Controls also orthopaedic patients at the same hospitals with no history of CTS<br><br>Cases and controls excluded if they had any condition associated with secondary CTS<br><br>Participation rate 90% of cases | **10 interviewers**<br><br>Each participant interviewed with a focus on wrist postures and motions:<br><br>- frequency of wrist flexion,<br>- frequency of wrist extension,<br>- use of repetitive and sustained forceful motions<br><br>**Response categories:**<br><br>Never<br><br>Seldom <1/3 of the time<br><br>Sometimes 1/3 – 2/3 of time<br><br>Frequently >2/3 of time | **Outcome Measures:**<br><br>Logistic regression analyses, ORs and p-values reported<br><br>Results:<br><br>Most participants were working in the service industry – taxi drivers, waiters, drivers, health care workers<br><br>Odds ratios adjusted for age, sex, BMI, stress and smoking.<br><br>**Flexion of the wrist**<br><br>Referent = never:<br><br>Seldom OR 3.2 (95% CI 1.3–7.8)<br>Sometimes OR 2.1 (95% CI 0.90–5.0)<br>Frequently OR = 4.4 (95% CI: 1.8–10.7)<br><br>**Extension of the wrist**<br><br>Referent = never:<br><br>Seldom OR 0.74 (95% CI 0.3–1.8)<br>Sometimes OR 0.75 (95% CI 0.3–1.8)<br>Frequently OR = 2.7 (95% CI 1.1–6.5)<br><br>**Straight wrist**<br><br>Referent = never:<br><br>Seldom OR 2.6 (95% CI 0.8–8.4)<br>Sometimes OR 1.4 (95% CI 0.7 - 2.9) |

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| | | | Frequently OR = 1.0 (95% CI: 0.5–2.1)<br><br>**<u>Sustained forceful motion of the e wrist</u>**<br><br>Referent = never:<br><br>Seldom OR 2.3 (95% CI 0.9- 5.9)<br>Sometimes OR 1.9 (95% CI 0.8 – 4.6)<br>Frequently OR = 2.6 (95% CI: 1.1-5.9)<br><br>**<u>Repetition</u>**<br><br>Referent = never:<br><br>Seldom OR 1.1 (95% CI 0.4–3.2)<br>Sometimes OR 0.7 (95% CI 0.2 - 1.9)<br>Frequently OR = 0.9 (95% CI: 0.4–2.4) |
| | | | **Biases/Weaknesses:**<br><br>• potential recall bias and information bias during interview-based data collection<br>• no blinding of research interviewers<br>• 'sustained forceful motions' not defined in more detail<br><br>**Conclusion:**<br><br>• frequent extension, flexion and sustained forceful motions of the wrist increase the risk of developing CTS |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Leclerc et al (2001)***<br><br>Scandinavian Journal of Work, Environment and Health, 27, 268-278<br><br>**Research Question:**<br><br>To investigate the relationship between CTS and workplace ergonomic tasks<br><br>**Methodology Described:**<br><br>Prospective cohort<br><br>**How funded:**<br><br>INSERM (National Institute on Health and Medical Research), France | N= of 598 workers in five occupational sectors involving repetitive work. Participants were part of an original cohort of 1420 workers.<br><br>Participants followed up after 3 years – baseline data gathered 1993 – 4; follow-up data 1996-7.<br><br>Sectors included assembly line manufacturing, shoe and clothing manufacturing; food industry (mainly meat); packaging; and supermarket cashiering.<br><br>Inclusion criteria was being exposed to repetitive work as indicated by their job sector<br><br>**Drop outs and incomplete data**<br><br>39 occupational physicians associated with each included workplace completed physical assessments with the original 1420 workers. Of those, 18 (46%) were able to complete follow-up assessments 3 years later, yielding a follow-up of 598 workers (42% of original cohort).<br><br>Loss to follow-up associated with age >50 years or <30 years and activity sector (supermarket | Self-reported questionnaire regarding work activities:<br><br>• Working with force, pressing with the hand or elbow, screwing or tightening with force, hitting, pulling, pushing and holding in position.<br><br>Respondents were asked to indicate whether they did these repetitively, not repetitively or never.<br><br>**Case definition:**<br><br>Examined by a physician based at their workplace.<br><br>Three levels of diagnosis possible:<br><br>(i) Tinel's sign or Phalen's test positive = proved diagnosis in the medical examination<br><br>(ii) Definition based on nerve conduction velocity = proved diagnosis before the medical examination, and<br><br>(iii) Suspected diagnosis (not all the criteria met in the medical examination or diagnosis based on the description of symptoms that were no longer present at | **Outcome Measures:**<br><br>Incidence of CTS in the 3 year follow-up period for participants without the disorder at baseline.<br><br>Odds ratios for CTS adjusted for age and gender<br><br>Regression analyses used to create model of risk factors<br><br>Measured personal and occupational (years on the job; job sector) risk factors and biomechanical and postural constraints (turn and screw, tighten with force, work with force (other than tighten), press with the hand, press with the elbow, hit, pull, push, hold in position; use of vibrating tools)<br><br>Findings:<br><br>N= 34 proved cases of CTS in the 3 year follow-up period (incidence = 7.3%)<br><br>N=57 proved or suspected cases (incidence = 12.2%)<br><br>**Biomechanical and postural constraints**<br><br>Men:<br><br>Repetitively tighten with force OR 4.09 (95% CI 1.43 – 11.7)<br>Repetitively hold in position OR 3.59 (95% CI 1.06 – 12.1)<br>Repetitively press with the hand OR 0.28 (95% CI 0.009 – 0.82)<br><br>All others not significant<br><br>**Women:**<br><br>No postural factors significantly associated with CTS<br><br>Analyses using a stricter definition of only proved diagnoses did |

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| | cashiers). Prevalence of proved or suspected CTS was higher (21.9%) in those included in the full study compared with those who were lost to follow-up (14.5%) | the time of the examination). | not change the magnitude of ORs<br><br>**Biases/Weaknesses**<br>• self-reported questionnaire used to collect physical work factors – potential for reporting bias, authors felt there may have been some limitations to the questionnaire<br>• Significant (>50%) loss to follow-up from initial cohort – reasons for loss-to-follow-up e.g. development of upper limb disorder, not reported<br>• Analyses based on suspected cases as well as proved cases – when run with proved cases only, no change in magnitude of ORs<br><br>**Conclusion:**<br>• In men, CTS is related to repetitively tightening with force and repetitively holding in position. Repetitively pressing with the hand is a protective factor against CTS |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Nathan et al (2002)***<br><br>Journal of Hand Surgery,<br><br>**Research Question:** | N=471 workers without CTS at 4 industrial sites screened at baseline<br><br>Followed since 1984<br><br>11 year follow-up data presented in this paper<br><br>N= 289 followed up in 1995 (61%) | **Identification of CTS:**<br>(i) at least 1 of 3 criteria for abnormal median nerve conduction established during electrophysiological testing and<br>(ii) reports of 2 or more hand/wrist symptoms | **Outcome Measures:**<br><br>Odds ratios, 95% CIs, p-values<br>Logistic regression analysis<br>Incidence of CTS over 11 year period<br><br>**Results:**<br><br>***Incidence of CTS:*** |

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| To examine the relationship between workplace factors and CTS<br><br>**Methodology Described:**<br><br>Prospective cohort<br><br>**How funded:**<br><br>Portland Hand Surgery and Rehabilitation Center.<br><br>No conflicts of interest declared | Dropout rate related to lay-offs at the workplaces<br><br>N=24 missing data<br><br>Final analysis n=256 (111 women, 145 men)<br><br>From 4 industrial sites (steel mill; meat/food packaging; electronics; plastics)<br><br>Participants lost to follow-up study were younger (32.3 vs 35.4 y, p < .01) and more slender (mean body mass index of 24.0 vs 25.6, p< .01) than individuals who continued in this longitudinal study, a finding consistent with the greater job mobility of younger workers. Otherwise the personal and job characteristics of these 2 groups were not found to be significantly different. | specific to CTS or 1 symptom specific to CTS and 2 hand/wrist symptoms indirectly related to CTS<br>(iii) individuals who reported having carpal tunnel release surgery in their dominant hand since the last follow-up visit were also categorized as carpal tunnel cases independent of nerve studies or symptoms<br><br>**Work-related factors:**<br><br>- occupational hand use collected by direct observation at baseline and stratified into 5 categories based on relative intensity of force, heavy lifting, repetition and presence of keyboard tasks<br>- subsequent data collection added vibrational tools and was collected using 5-point Likert scales<br>- Scoring from 1 – not at all to 5 - consistent<br><br>Non-occupational information | 34 incident cases<br><br>*Univariate analysis*<br><br>Repetition OR 1.05 (95% CI 0.8 – 1.4, p=0.73)<br>Force OR 1.00 (95% CI 0.75 – 1.34, p=0.97)<br>Heavy Lifting OR 0.99 ( 95% CI 0.76 – 1.29, p=0.94)<br>Keyboard Use OR 0.95 (95% CI 0.74 – 1.23, p=0.71)<br>Vibration OR 2.28 (955 CI 0.84 – 6.29, p=0.10)<br>Factors with p < 0.10 were included in the multivariate analysis<br><br>*Multivariate analysis*<br><br>Vibration OR 3.41 (95% CI 1.09 – 10.72, p = 0.04)<br><br>No other significant associations with workplace factors<br><br>**Biases/Weaknesses:**<br><br>Dropout rate high<br><br>Definitions of force, heavy lifting, repetition unclear<br><br>Small sample and small number of incident cases (n=34) leading to a lack of precision in analyses<br><br>**Conclusion:**<br><br>• Over the 11 year follow-up period, workplace factors were generally weak predictors of CTS<br>• The performance of vibration – based work activities was associated with an increased odds of CTS<br>• "These overall findings are at variance with a number of prior epidemiologic studies that have found significant relations between an array of job conditions such as force, posture, and repetitions and CTS." |

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| | | collected about exercise, medical health, smoking, BMI | |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Nathan et al (2005)***<br><br>Journal of Hand Surgery, 30B, 6, 593 – 598.<br><br>**Research Question:**<br><br>To examine the relationship between workplace factors and CTS – 17 year follow-up<br><br>**Methodology Described:**<br><br>Prospective cohort<br><br>**How funded:**<br><br>Portland Hand Surgery and Rehabilitation Center. | N=471 workers without CTS at 4 industrial sites screened at baseline<br><br>Followed since 1984<br><br>N= 289 followed up in 1995 (61%)<br><br>Dropout rate related to lay-offs at the workplaces and workplace mobility<br><br>N=161 followed up 2001 – 2002<br><br>From 4 industrial sites (steel mill; meat/food packaging; electronics; plastics)<br><br>Returnees (n = 166) to non-returnees from the 1984 baseline examination (n = 304): no differences in age (35.4 years of age vs. 33.8 years of age) or gender (59% male vs. 52% | **Identification of CTS**<br><br>(iv) at least 1 of 3 criteria for abnormal median nerve conduction established during electrophysiological testing and<br>(v) reports of 2 or more hand/wrist symptoms specific to CTS or 1 symptom specific to CTS and 2 hand/wrist symptoms indirectly related to CTS<br>(vi) individuals who reported having carpal tunnel release surgery in their dominant hand since the last follow-up visit were also categorized as carpal tunnel cases independent of nerve studies or symptoms<br><br>**Work-related factors:**<br><br>- occupational hand use | **Outcome Measures:**<br><br>Odds ratios, 95% CIs, p-values<br><br>Logistic regression analysis<br><br>Incidence of CTS over 17 year period<br><br>Two types of analyses with regards to workplace factors<br><br>(1) relationship between presence of factors in 1984 to development of CTS in 2001-2<br>(2) relationship between presence of factors in 1984/1989/1994 – 5 to the development of CTS in 2001/2<br><br>**Results:**<br><br>*Incidence of CTS:*<br><br>34 incident cases<br><br>***Analysis 1: association between workplace factors in 1984 and CTS in 2001/2***<br><br>Repetition OR 0.56, p=0.12<br>Force OR 2.68, p=0.18<br>Heavy Lifting OR 0.36 p=0.11 |

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| No conflicts of interest declared | male).<br><br>No differences between returnees and non-returnees in dominant-hand numbness, nocturnal awakening, pain, or clumsiness.<br><br>Returnees also tended to have been slightly heavier than non-returnees in1984. | collected by direct observation at baseline and stratified into 5 categories based on relative intensity of force, heavy lifting, repetition and presence of keyboard tasks<br>- subsequent data collection added vibrational tools and was collected using 5-point Likert scales<br>- Scoring from 1 – not at all to 5 - consistent<br><br>Non-occupational information collected about exercise, medical health, smoking, BMI | Keyboard Use OR 0.81 p=0.39)<br>Vibration OR 2.15, p=0.33<br><br>*Factors with p < 0.20 were included in the multivariate analysis*<br><br>*Multivariate analysis*<br><br>Repetition OR 0.50, p = 0.046<br>Heavy lifting OR 0.39, p = .07<br>Force OR 3.50, p = 0.064<br><br>*Analysis 2: association between workplace factors in 1984/1989/1994-5 and CTS in 2001/2*<br><br>Repetition OR 0.87, p=0.84<br>Force OR 0.88, p=0.88<br>Heavy Lifting OR 2.11 p=0.23<br>Keyboard Use OR 1.31 p=0.63<br>Vibration OR 0.68, p=0.77<br><br>No workplace factors included in multivariate model |
| | | | **Biases/Weaknesses:**<br><br>Dropout rate high<br><br>Definitions of force, heavy lifting, repetition unclear<br><br>Small sample and small number of incident cases (n=34) leading to a lack of precision in analyses<br><br>**Conclusion:**<br><br>• Over the 17 year follow-up period, there was little relationship between workplace factors and weak CTS |

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| | | | • Biggest predictors were gender and BMI<br>• The performance of vibration – based work activities was associated with an increased odds of CTS |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Nordstrom (1997)***<br><br>Occupational and Environmental Medicine;54:734-740<br><br>**Research Question:**<br><br>To identify individual, psychosocial and physical risk factors for CTS<br><br>**Methodology Described:**<br><br>Case-control<br><br>**How funded:**<br><br>National Institute for Occupational Safety and Health grant<br><br>No conflicts of interest declared | N=206 cases and 211 controls aged 18 – 69 years<br><br>Recruitment May 1994 - October 1995<br><br>Cases obtained from a population of 55,000 using the local hospital and clinic database (estimated to cover 92% of the outpatient and 94% of hospital visits)<br><br>Cases identified using ICD10 codes for CTS; CTS release surgery, decompression of median nerve at carpal tunnel; arthroscopy wrist with release of carpal ligament; peripheral neuropathy.<br><br>Controls selected from the general population with no history of CTS – match to cases based on 5 age strata<br><br>Participation rate 83% of cases and 82% of controls<br><br>Prevalent cases diagnosed 1979 | 30 minute telephone interview to identify risk factors:<br><br>- 40 risk factors included in interview<br><br>- 23 work and 17 non-work<br><br>- included job stress and job control scales and physical work factors<br><br>- hours of exposure estimated<br><br>- non work factors included BMI; history of MSD; play sport; home typewriter; family history of CTS<br><br>Occupational risk factors in 12 months prior to diagnosis (cases) or interview (controls) | **Outcome Measures:**<br><br>Logistic regression analyses, ORs and p-values reported<br><br>**Results:**<br><br><u>Not significant:</u><br><br>Lift objects >2 pounds, use electronic scanner, use computer keyboard, use computer pointer device, use typewriter, work on assembly line, twist forearm, pinch grip<br><br><u>Power tools or machinery (mean h/day):</u><br><br>0 OR 1.00<br><1 OR 0.53 (95% CI 0.17 to 1.64)<br>1-2 OR 1.43 (95% CI 0.52 to 3.90)<br>2.5-5.5 OR 1.58 (95% CI 0.63 to 4.00)<br>6-11 OR 3.30 (95% CI 1.11 to 9.80)<br><br>Overall not significant (p=0.11)<br><br>Significant dose-response effect (p=0.01)<br><br><u>Repetitively bending or twisting hands or wrists (mean h/day)</u><br><br>0 OR 1.00 control<br><2 OR 2.42 (95% CI 0.88 to 6.62)<br>2-3 OR 1.27 (95% CI 0.50 to 3.26)<br>3.5-6 OR 2.65 (95% CI 1.83 to 5.92)<br>7-16 OR 2.11 (95% CI 0.98 to 4.52) |

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| | – April 1994 excluded | | Overall not significant (p=0.07)<br><br>Significant dose-response effect (p=0.03)<br><br><u>Cumulative hours in primary job since January 1993</u><br><br>0-2954 OR 1.00 control<br>3048-4857 OR 1.54 (95% CI 0.74 to 3.20)<br>4880-5383 OR 0.29 (95% CI 0.12 to 0.72)<br>5464-6507 OR 0.43 (95% CI 0.18 to 1.05)<br>6647-15510 OR 0.29 (95% CI 0.10 to 0.78)<br><br>Significant p< 0.001 |
| | | | **Biases/Weaknesses:**<br><br>• potential recall bias and information bias during interview-based data collection<br>**Conclusion:**<br><br>• Use of vibrating tools e.g. saw or drill, showed an inconsistent pattern of association with CTS – may be a threshold of use before it has an effect. In current study 6-11 hours per day was associated with increased risk of CTS (OR 3.3, 95% CI 1.11 – 9.80)<br>• High repetition of hand/wrist bending or twisting was a greater factor than high force<br>• No association between CTS and keyboard use |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Roquelaure et al*** | N= 199 workers in a footwear factory<br><br>Participants followed up after 1 year – | **Self-assessed questionnaire** | **Outcome Measures:**<br><br>Incidence of CTS in the 1 year follow-up period for |

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| ***(2001)***<br><br>International Journal of Occupational Medicine and Environmental Health, 14, 357-367<br><br>**Research Question:**<br><br>To investigate the relationship between CTS and workplace ergonomic tasks<br><br>**Methodology Described:**<br><br>Prospective cohort<br><br>**How funded:**<br><br>INSERM (National Institute on Health and Medical Research), France | baseline data gathered 1996; follow-up data 1997.<br><br>Main jobs performed were sewing preparation, including cutting (24%), sewing (25%), mechanized (18%) and manual assembly (15%), finishing and packing (18%)<br><br>**Drop outs and incomplete data**<br><br>20% of workers in the factory were randomly selected to take part. 79% participation rate.<br><br>162/199 (81%) followed up at 1 year<br><br>**Case definition:**<br><br>Examined by a physician based at their workplace.<br><br>The diagnosis of CTS required:<br><br>1) the presence of paraesthesia, pain or numbness affecting at least part of the median nerve distribution of the hand(s) occurring for at least one week or, if intermittent, occurring at least 10 times during the previous 12-month period;<br><br>2) the presence of objective findings in affected hand(s) or wrist(s), including Tinel's sign or positive Phalen's test or diminished or absent sensation to pin prick in the | Ergonomic factors:<br>• force level, repetition level, motion velocity, work postures, local mechanical stress, visual demand, ability to take breaks, job rotation<br>• 6-point scale ranging from very low to very high for each factor.<br><br>**Work post assessment:**<br><br>• direct observation and questioning by two trained interviewers using a checklist<br>• repetitiveness (work cycle <30 sec or >1/2 cycle spent repeating the same motions)<br>• force (carrying an object weighing >4.5 kg, holding an object weighing >2.7 or 1 kg per hand) more than a third of the working cycle<br>• mechanical contact stress and posture (pinch grip, wrist flexion, extension and ulnar deviation) more than a third of the working cycle | participants without the disorder at baseline.<br><br>Prevalence at baseline and 1 year follow-up<br><br>Odds ratios for CTS adjusted for age and gender and occurrence of another WMSD in 1996<br><br>Regression analyses used to create model of risk factors<br><br>**Findings:**<br><br>Prevalence at baseline = 33 cases (16.6%)<br><br>Prevalence at 1 year follow-up = 34 cases ()<br><br>Incidence of new cases = 19 cases = 11.7%<br><br>Workplace factors:<br><br>No association with any particular job e.g. sewing, manual assembly<br><br>Regression analysis indicated rapid trigger movements of the finger were associated with increased risk of CTS; OR 3.8 (95% CI 1.0 – 17.2, p=0.058).<br><br>No other significant physical risk factors<br><br>**Biases/Weaknesses**<br><br>small sample size and therefore small number of cases, limiting precision of findings and statistical power<br><br>**Conclusion** |

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| | median nerve distribution; and<br><br>3) The absence of any sign of other causes of hand numbness or paraesthesia such as cervical radiculopathy, thoracic outlet syndrome and pronator teres syndrome. | | • Rapid trigger movements of the finger were associated with increased risk of CTS: OR 3.8 (95% CI 1.0 – 17.2) |

| Reference and Methodology | Participants | Intervention | Outcomes |
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| ***Roquelaure et al (1997)***<br><br>Scand J Work Environ Health;23(5):364-369<br><br>**Research Question:**<br><br>Occupational risk factors for CTS<br><br>**Methodology Described:**<br><br>Case-control<br><br>**How funded:**<br><br>French Ministry of Research and | N=65 cases and 65 controls matched for gender, age and plant<br><br>Data collection 1993 – 4<br><br>Participants recruited from 3 plants where television sets (plant A), shoes (plant B), and automobile brakes (plant C) were manufactured.<br><br>Aged 18 – 59 years<br><br>Participants with history of CTS or other MSD excluded. Participants with malignancies, rheumatic diseases, thyroid deficiencies or diabetes excluded<br><br>Controls: | Case diagnosis:<br><br>Diagnosis was based on examination of medical files completed by the occupational physician at each plant:<br><br>(i) tingling, pain, or numbness in the median nerve distribution of the hand with nocturnal exacerbation with more than 20 occurrences or lasting more than 3 weeks in the previous year;<br>(ii) a positive Tinel's sign and a positive Phalen's test or hypoesthesia in the territory of the median nerve;<br>(iii) slowing of the sensory or motor conduction velocities (< 40 m/s) in the median nerve at the wrist level; and<br>(iv) Surgical release of the transverse carpal ligament. | **Outcome Measures:**<br><br>Multiple regression analyses, ORs and p-values reported<br><br>**Results:**<br><br>Exertion of effort - determined by the weight of the tools or the parts handled - of 1 kg<br><br>Exertion of effort - determined by the weight of the tools or the parts handled - of 1 kg<br><br>OR 9.01 (95% CI 2.4 – 33.4, p< 0.001)<br><br>Two risk factors were related to motion repetitiveness.<br><br>Length of the shortest elementary operation of < 10 s<br><br>OR 8 4 (95% CI 1.8 – 44.4, p= 0.008) |

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| Technology<br><br>No conflicts of interest declared | - Free of CTS and musculoskeletal disorders of the upper limb from 1984 to 1992. No nerve conduction studies were performed. | <u>Occupational risk factors:</u><br><br>Two assessors blind to CTS status examined the workstation occupied by the worker 6 months before CTS diagnosed (cases) or at the end of 1992 (controls)<br>- length of employment<br>- duration of previous manual work<br>- repetitive activity (<30 sec per cycle)<br>- high force activity (prehensive efforts of over 1kg)<br>- repetition and postural movements<br>- angular position of the elbow (flexion < 135°), forearm (pronosupination),<br>- and wrist (flexion >45°, neutral, extension > 45°),<br>- the frequency of certain activities (pinching, gripping, screwing, pulling, pushing, lifting, turning),<br>- motion performed by the hand (precise, forceful)<br>- Hand-exerted forces were determined by the weight of the tools and the parts handled.<br>- Force was considered "high" when the load was greater than 1 kg with a frequency of exertion in excess of 10 times per hour. | Lack of change in task or breaks for at least 15% of the daily work time, excluding breaks for meals<br><br>OR 6.0 (95%CI 1.8 – 20.2)<br><br>Cycle time of<30 s was not associated with CTS (P = 0.36).<br><br>No other posture of the wrist, elbow, or the trunk or other specific motion of the hand was associated with CTS.<br><br>**Biases/Weaknesses:**<br>• Small sample and low prevalence of CTS may have contributed to the wide confidence intervals seen for some analyses<br>• Independent assessment of workstation a positive<br>• Assessors blind to CTS status - positive<br><br>Conclusion:<br>• Cases were generally severe CTS cases, most had undergone surgery<br>• Their work called for precise motion and pinching – force of 1kg or more could be considered high with such movements<br>• Risk factors had a cumulative effect |

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| ***Silverstein et al (2010)***<br><br>Scand J Work Environ Health;36(5):384–393<br><br>**Research Question:**<br><br>To investigate the incidence, prevalence and persistence over 1 year of CTS. To investigate the relationship between CTS and workplace ergonomic tasks<br><br>**Methodology Described:**<br><br>Prospective cohort<br><br>**How funded:**<br><br>National Institute for | N= of 733 workers in 12 occupational sectors involving manufacturing or healthcare work e.g. electronics, cabinetry. Final included baseline = 691 participants.<br><br>N= 418 workers followed up at 1 year (58.1% of original sample)<br><br>Median age = 40.1 years<br><br>Median time on job = 2.4 years<br><br>Initial participation rate 64.5% of eligible (mostly due to not being able to participate because of their job schedule)<br><br>Facilities with ≥20 employees in ≥3 of 6 hand force (high/low) by repetition (high/medium/low) categories were eligible for inclusion | <u>Assessment of physical risk factors</u><br><br>Assessments conducted by ergonomists blind to health status of participants. Videotaped job tasks used to quantify exposure to forceful exertions, postures and repetitive movement:<br><br>- high forces perceived to be ≥8.9 N of pinch or object weight (corresponding to 2 lb or 0.9 kg), or 44.1 N of power grip, object weight, or push/pull force (corresponding to 10 lb or 4.5 kg)<br>- - use of vibrating tools (yes/no)<br><br><u>Case definition:</u><br><br>Trained interviewers asked about initial MSD symptoms<br><br>To be classified as a case:<br><br>(i) experience pain, numbness, tingling, or burning in ≥1 of the first 3 digits (equivalent to Katz criteria for possible CTS) in the past 12 | **Outcome Measures:**<br><br>Frequency and duration of high force pinch grip, power grip, and push/pull force which was translated into percentage of time in the job spent on forceful exertions.<br><br>Incidence of CTS in the 1 year follow-up period for participants without the disorder at baseline.<br><br>Percentages with each risk factor present at baseline<br><br>**Findings:**<br><br><u>Baseline</u><br><br>N= 118 CTS cases = 10.9% prevalence dominant hand; 6.2% non-dominant hand<br><br><u>Follow-up</u><br><br>N= 83 CTS cases = 11.5% prevalence dominant hand; 8.4% non-dominant hand<br><br>1 year incidence (28 CTS cases) = 7.5% dominant |

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| Occupational Safety and Health grant (OH007316) and the Washington State Department of Labour and Industries. | Drop outs and incomplete data<br><br>Mostly due to being laid off (23.7%) or had employment terminated (26.3%) during the economic recession.<br><br>5.3% of the participants had left the company and 9.5% were no longer interested in participating. | months occurring >3 times or lasting >1 week, with no acute traumatic onset; and (ii) meet nerve conduction study criteria for abnormal nerve conduction test, which included either delayed median motor latency, delayed sensory distal latency, or median-sensory latency difference | hand and 6.4% non-dominant hand<br><br>Physical risk factors<br><br>Relationships between risk factors and CTS at 1 year follow-up (n=418)<br><br>Vibration OR 2.2 (95% CI 1.07 - 4.63, p=0.032)<br><br>High power grip >1% of the time (p = 0.035)<br><br>**Biases/Weaknesses:**<br><br>• 42% drop out rate and initial participation rate 65% of eligibles<br>• Independent assessment of workstation a positive<br><br>**Conclusion:**<br><br>• Vibration and high power grip related to CTS amongst CTS cases at baseline |

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| ***Wieslander et al (1989)***<br><br>British Journal of Industrial Medicine | N= 38 men operated on for CTS between 1974 and 1980, + 76 referents drawn from surgical database + 76 referents drawn from a population registry. | 1 interviewer (a physician)<br><br>Each participant interviewed by phone with a focus on type of work and occupational exposure:<br><br>- vibrating handheld tools,<br>- performance of | **Outcome Measures:**<br><br>Odds ratios, 95% CIs, p-values<br><br>Odds ratios were not adjusted for confounders – cases differed in rates of diabetes, thyroid and rheumatoid diseases. Cases and controls did not differ in obesity or smoking |

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| 1989;46:43-47<br><br>**Research Question:**<br><br>Relationship between CTS and occupational exposures<br><br>**Methodology Described:**<br><br>Case-control<br><br>**How funded:**<br><br>Not stated<br><br>No conflicts of interest declared | Age 20 -66 years<br><br>89% and 94% participation rate for cases and controls respectively<br><br>CTS were diagnosed clinically by a hand surgeon, and the diagnosis was confirmed electroneurographically by measurement of the conduction velocities in the median nerve at the wrist level.<br><br>Hospital Controls were operated on for gall bladder or varicose veins. All controls were matched for sex (only men were included), age (± 3 years), and the hospital referents also for year of operation (±3 years). | repetitive wrist movements' at work, and<br>- work involving heavy load on the wrist<br><br>Degree of exposure was evaluated both with regard to the total number of work years and the average number of exposed hours a week. | **Results:**<br><br><u>Use of vibrating tools:</u><br><br>Overall OR = 3.3 (95% CI 1.6 – 6.8, p = 0.002)<br><1 year OR 1.0<br>1-20 years OR 2.7 (95 % CI 1.1 – 6.7, p=0.04)<br>20+ years OR 4.8 (95%CI 1.5 – 15.6, p = 0.01)<br><br><u>Repetitive movement of wrist:</u><br><br>Overall OR = 2.7 (95% CI 1.3 – 5.4, p=0.006)<br><1 year OR 1.0<br>1-20 years OR 1.5 (95 % CI 0.5 – 4.4, NS)<br>20+ years OR 4.6 (95%CI 1.8 – 11.9, p = 0.002)<br><u>Work causing great load on wrist:</u><br><br>Overall OR = 1.8 (95% CI 0.96 – 3.5, NS)<br><1 year OR 1.0<br>1-20 years OR 1.7 (95 % CI 0.7 – 3.9, NS)<br>20+ years OR 2.1 (95%CI 0.8 – 5.5, NS) |
| | | | **Biases/Weaknesses:**<br><br>• potential recall bias and information bias during interview-based data collection<br>• blinding of research interviewer not recorded<br>• selection bias for cases and referents<br>• small number of cases<br><br>**Conclusion:**<br><br>• use of vibrating tools and repetitive wrist movements are associated with an increased odds of CTS |