Systematic Review

Is Smoking Associated with Carpal Tunnel Syndrome?
A Meta-Analysis

Kaisa Lampainen 1,2,*1, Sina Hulkkonen 1, Jorma Ryhänen 1, Stefania Curti 3 and Rahman Shiri 4

Abstract: To date, the role of smoking in carpal tunnel syndrome (CTS) is unclear. The aim of this systematic review and meta-analysis was to assess the association between smoking and CTS. The literature searches were conducted in PubMed, Embase, and Scopus, from inception until October 2021. Three reviewers screened the titles, abstracts, and full-text articles and evaluated the methodological quality of the included studies. A random-effects meta-analysis was used, and heterogeneity across studies was examined using $I^2$ statistic. A total of 31 (13 cross-sectional, 10 case-control, and 8 cohort) studies were qualified for meta-analysis. In a meta-analysis of cohort studies, the risk of CTS did not differ between current and never smokers (pooled hazard ratio (HR) 1.09, 95% CI 0.84–1.43), current and past/never smokers (HR 1.07, 95% CI 0.94–1.23), and past and never smokers (HR 1.12, 95% CI 0.83–1.49). Furthermore, a meta-analysis of case control studies found no difference in the risk of CTS between current and never smokers (pooled odds ratio (OR) 0.92, 95% CI 0.56–1.53), current and past/never smokers (OR 1.10, 95% CI 0.51–2.36), and past and never smokers (OR 0.91, 95% CI 0.59–1.39). However, a meta-analysis of cross-sectional studies showed the associations of ever (OR 1.36, 95% CI 1.08–1.72) and current smoking (OR 1.52, 95% CI 1.11–2.09) with CTS. However, the association between ever smoking and CTS disappeared after limiting the meta-analysis to higher quality studies or after adjusting for publication bias. The association between current smoking and CTS also attenuated after limiting the meta-analysis to studies that confirmed CTS by a nerve conduction study or studies with low attrition bias. This meta-analysis does not support an association between smoking and CTS. The association between smoking and CTS observed in cross-sectional studies could be due to biases and/or confounding factors.

Keywords: median nerve; median neuropathy; systematic review; tobacco; lifestyle

1. Introduction

Compression of the median nerve at the carpal tunnel, known as carpal tunnel syndrome (CTS), is the most common entrapment neuropathy of the upper extremity [1–3]. The incidence of CTS varies between 88 and 105 cases per 100,000 person-years among men and between 193 and 232 cases per 100,000 person-years among women [4–6]. The etiology of CTS is multifactorial; often, both occupational and personal risk factors are involved. Its known risk factors include female gender, excess body mass, diabetes mellitus, rheumatoid arthritis, and thyroid disease [7–13]. Manual workers are at higher risk of CTS than non-manual workers [14]. Genetic factors might also play a role in CTS [15].

Smoking is a major health concern [16]. To date, the role of smoking in CTS remains unclear. Cigarette smoking is associated with reduced blood supply, oxidative stress, and systemic inflammation, which might impair the peripheral nerves and make them more vulnerable to compression neuropathies [17,18]. As found to be a neuroteratogen in
animal models, smoking may also increase the risk of median nerve damage through toxic effects [19]. Smoking was also associated with ulnar neuropathy at the elbow [20].

An earlier meta-analysis regarding the association between smoking and CTS, published in 2014 by Pourmemari and his colleagues, reported inconclusive results [21]. That meta-analysis found an association between current smoking and CTS in cross-sectional studies, but not in case control or cohort studies. Only three prospective cohort studies were included in that meta-analysis, and none of those was a high-quality cohort study [22–24]. Since the previous meta-analysis, multiple studies on the role of smoking in CTS have been published, including three large, population-based longitudinal studies [25–27].

The aim of this systematic review and meta-analysis was to determine whether smoking is associated with CTS.

2. Methods

We developed the protocol of this systematic review and meta-analysis according to the PRISMA guidelines [28]. We retained the studies included in the earlier meta-analysis by Pourmemari and colleagues [21] and performed literature searches from inception to October 2021. The study protocol is registered in PROSPERO (registration no. 347845).

2.1. Search Strategy

Literature searches were conducted in PubMed, Embase, and Scopus, from their inception until October 2021. We used a combination of MeSH terms (in PubMed), Emtree terms (in Embase), and text words (Table 1). The search strings for PubMed and Embase were similar to those used in the previous meta-analysis [21]. We also manually searched the reference lists of the included studies to locate the additional studies. We included all languages and excluded case reports, letters, editorials, guidelines, and reviews.

Table 1. PubMed, Embase, and Scopus searches, conducted on 2 October 2021.

| Search | Query | No of Items Found |
|--------|-------|-------------------|
| PubMed | (carpal tunnel[tiab] OR carpal tunnel syndrome[MeSH] OR median nerve[tiab] OR median neuropathy[tiab]) AND (smok * OR tobacco[tiab] OR cigar * OR life-style OR lifestyle) | 144 |
| Embase | (‘carpal tunnel syndrome’:ab,ti OR ‘median nerve compression’:ab,ti OR ‘median nerve’:ab,ti OR ‘carpal tunnel syndrome’/exp OR ‘median nerve compression’/exp OR ‘median nerve injury’/exp) AND (smok*:ab,ti OR cigar*:ab,ti OR smoking/exp OR ‘cigarette’/exp OR ‘cigar’/exp OR ‘tobacco’/exp OR tobacco:ab,ti OR life-style:ab,ti) | 278 |
| Scopus | (carpal tunnel OR median nerve OR median neuropathy) AND (smok * OR tobacco OR cigar * OR life-style OR lifestyle) | 311 |

2.2. Inclusion and Exclusion Criteria

Three reviewers (K.L, S.H., and R.S.) independently screened the titles and abstracts of the references retrieved. Both population- and hospital-based case-control, cross-sectional, and cohort studies that reported quantitative results for the association between smoking and CTS symptoms confirmed by nerve conduction studies or clinical signs were included in the meta-analysis. Studies conducted among volunteers and CTS patients without a control group were excluded. Moreover, studies defined CTS based on self-reports, studies defined CTS by symptoms only, or nerve conduction studies only were excluded. Lastly, studies conducted among pregnant women, patients undergoing dialysis, or among patients with toxic oil syndrome were excluded from the review. Disagreements between the reviewers were resolved through discussion.
2.2.1. Data Extraction

Characteristics of the included studies and quantitative data were extracted by two reviewers (S.H. and K.L.) and checked by a third reviewer (R.S.). The following characteristics of the included studies were extracted: study population, age and gender distribution, sample size, smoking, outcome assessment, summary results, and adjustment for confounding factors.

2.2.2. Quality Assessment

Three reviewers (K.L., S.H., and R.S.) independently appraised the risk of bias of included studies. For methodological quality assessment, we used a checklist adapted from the Effective Public Health Practice Project tool [28]. We rated the quality of each study, according to five sources of bias: selection, performance, detection, confounding factors, and attrition (Appendix A Table A1). Disagreements between reviewers were resolved through discussion.

2.2.3. Statistical Analysis

Odds ratio for cross-sectional and case-control studies and risk ratio for prospective cohort studies were estimated for those studies reporting descriptive results, such as the number of CTS cases in smokers and non-smokers or number of smokers in CTS cases and controls. The Woolf confidence interval was calculated for the estimated odds ratios [29]. Since the prevalence of CTS is less than 5%, we did not convert odds ratios to risk ratios for the meta-analysis of prospective cohort studies. With a prevalence of less than 5%, the odds ratio is identical to risk ratio. A random-effects meta-analysis was used to combine the estimates of studies, and the $I^2$ statistic was used to assess the presence of heterogeneity across the studies [30,31]. Subgroup analyses were conducted with regard to methodological quality of included studies. A funnel plot was used for exploring publication bias, and Egger’s regression test was used for examining funnel plot asymmetry. Due to small number of studies included in the meta-analyses, only presence or absence of bias in one quality domain was used for subgroup analysis. Furthermore, the trim and fill method was used to adjust for missing studies, due to publication bias [32,33]. Stata version 17 (StataCorp LP, College Station, TX, USA) was used for the meta-analyses.

3. Results

A total of 733 records were identified. After removing duplicates, 644 were screened. Of these, 591 were excluded based on titles and abstracts, and 53 full-text reports were assessed for eligibility. Of these, 22 reports were excluded with reasons (Figure 1). Finally, 31 studies, consisting of 13 cross-sectional studies [10,34–45], 10 case-control studies [11,46–54], and 8 cohort studies [22,24–27,55–57], were included in the meta-analysis. The characteristics and quality of the included studies are reported in Appendix A Tables A2–A4.

A meta-analysis of cross-sectional studies showed a higher prevalence of CTS among ever smokers, compared with never smokers (OR 1.36, 95% CI 1.08–1.72, Figure 2), as well as among current smokers, compared with past/never smokers (OR 1.52, 95% CI 1.11–2.09). Of note, a small ($n = 379$) cross-sectional study examined the association between number of packs per years smoked and CTS, but no association was found [44]. In the sensitivity analyses, the association between ever smoking and CTS disappeared after limiting the meta-analysis to higher quality studies or adjusting for publication bias (Table 2). The association between current smoking and CTS was not due to publication bias, selection bias, or confounding factors. The association did not remain statistically significant when the meta-analysis was limited to the studies with CTS confirmed by a nerve conduction study or to those studies with low attrition bias.
A meta-analysis of case control studies showed no associations of ever, past, and current smoking with CTS (Figure 3). The pooled OR was 0.92 (95% CI 0.56–1.53, three studies) for current smoking, compared with never smoking, 1.10 (95% CI 0.51–2.36, six studies) for current smoking, compared with past/never smoking, and 0.91 (95% CI 0.59–1.39, three studies) for past smoking, compared with never smoking.

A meta-analysis of prospective cohort studies showed that the incidence of CTS does not differ between current and never smokers (hazard ratio [HR] 1.09, 95% CI 0.84–1.43, two studies, Figure 4), current and past/never smokers (HR 1.07, 95% CI 0.94–1.23, five studies), and past and never smokers (HR 1.12, 95% CI 0.83–1.49, two studies). Only one cohort study compared ever smokers with never smokers (HR 1.48, CI 1.12–1.96). One prospective cohort study (n = 8703) explored the association of the number of pack-years smoked and hospitalization for CTS [58]. Among men, pack-years > 10 was associated with hospitalization for CTS but not pack-years ≤ 10, after adjustment for body mass index, socioeconomic status, and diabetes. Among women, both pack-years ≤ 10 and pack-years > 10 were associated with hospitalization for CTS.
studies), and past and never smokers (HR 1.12, 95% CI 0.83–1.49, two studies). Only one cohort study compared ever smokers with never smokers (HR 1.48, CI 1.12–1.96). One prospective cohort study (n = 8703) explored the association of the number of pack-years smoked and hospitalization for CTS [58]. Among men, pack-years > 10 was associated with hospitalization for CTS but not pack-years ≤ 10, after adjustment for body mass index, socioeconomic status, and diabetes. Among women, both pack-years ≤ 10 and pack-years > 10 were associated with hospitalization for CTS.

### Figure 2. Meta-analysis of cross-sectional studies on smoking and CTS.

| Study                  | Odds ratio (95% CI) | Weight (%) |
|------------------------|---------------------|------------|
| **Ever vs. never smoking** |                     |            |
| Ricco & Signorelli 2017 | 1.91 [1.11, 3.29]   | 6.70       |
| Hegmann 2016           | 1.24 [0.96, 1.60]   | 11.95      |
| Eleftheriou 2012       | 1.69 [1.03, 2.77]   | 7.47       |
| Shiri 2011             | 1.50 [1.11, 2.02]   | 11.05      |
| Frost 1998             | 0.65 [0.34, 1.24]   | 5.45       |
| Heterogeneity: $I^2 = 0.03$, $I^2 = 40.20\%$, $H^2 = 1.67$ | 1.36 [1.08, 1.72] |          |
| Test of $\delta = 0$: Q(4) = 8.15, p = 0.09 | | |

| **Past vs. never smoking** |                     |            |
| Jung 2016                | 0.69 [0.40, 1.18]   | 6.82       |
| Shiri 2011               | 1.20 [0.85, 1.70]   | 10.08      |
| Heterogeneity: $I^2 = 0.10$, $I^2 = 65.31\%$, $H^2 = 2.88$ | 0.95 [0.55, 1.62] | |
| Test of $\delta = 0$: Q(1) = 2.88, p = 0.09 | | |

| **Current vs. past/never smoking** |                     |            |
| Low 2021                  | 1.32 [1.07, 1.63]   | 12.85      |
| Pramchho 2020             | 1.45 [0.40, 5.25]   | 1.88       |
| Kiani 2014                | 0.39 [0.05, 3.02]   | 0.90       |
| Maghsoudipour 2008        | 4.68 [1.42, 15.47]  | 2.13       |
| Atroshi 2007              | 1.79 [1.10, 2.91]   | 7.60       |
| Heterogeneity: $I^2 = 0.03$, $I^2 = 23.62\%$, $H^2 = 1.31$ | 1.52 [1.11, 2.09] | |
| Test of $\delta = 0$: Q(4) = 6.69, p = 0.15 | | |

| **Current vs. never smoking** |                     |            |
| Jung 2016                  | 0.90 [0.50, 1.62]   | 6.10       |
| Shiri 2011                 | 2.10 [1.41, 3.12]   | 9.10       |
| Heterogeneity: $I^2 = 0.29$, $I^2 = 81.61\%$, $H^2 = 5.44$ | 1.42 [0.62, 3.24] | |
| Test of $\delta = 0$: Q(1) = 5.44, p = 0.02 | | |

| **Overall**                |                     |            |
| Heterogeneity: $I^2 = 0.06$, $I^2 = 86.61\%$, $H^2 = 2.30$ | 1.34 [1.11, 1.62] | |
| Test of $\delta = 0$: Q(13) = 28.09, p = 0.01 | | |
| Test of group differences: Qr(3) = 2.24, p = 0.52 | | |

Random-effects REML model
Figure 3. Meta-analysis of case-control studies on smoking and CTS.
### Figure 4. Meta-analysis of prospective cohort studies on smoking and CTS.

| Study                        | Hazard ratio (95% CI) | Weight (%) |
|------------------------------|-----------------------|------------|
| **Ever vs. never smoking**   |                       |            |
| Hulkkonen 2020               | 1.48 [1.12, 1.96]     | 15.09      |
| Heterogeneity: $I^2 = 0.00$, $Q(0) = -0.00$, $p = .00$ | 1.48 [1.12, 1.96]    |            |
| **Past vs. never smoking**   |                       |            |
| Pourmemari 2018              | 1.20 [0.78, 1.85]     | 6.89       |
| Harris-Adamson 2013          | 1.05 [0.71, 1.56]     | 8.18       |
| Heterogeneity: $I^2 = 0.00$, $Q(1) = 0.20$, $p = 0.85$ | 1.12 [0.83, 1.49]    |            |
| **Current vs. past/never smoking** |                 |            |
| Rydberg 2020                 | 1.06 [0.92, 1.23]     | 40.33      |
| Gell 2005                    | 0.88 [0.38, 2.06]     | 1.87       |
| Werner 2005                  | 1.08 [0.71, 1.65]     | 7.22       |
| Nathan 2002                  | 2.42 [1.06, 5.52]     | 1.99       |
| Roquelaure 2001              | 0.50 [0.11, 2.35]     | 0.57       |
| Heterogeneity: $I^2 = 0.00$, $Q(4) = 4.92$, $p = 0.30$ | 1.07 [0.94, 1.23]    |            |
| **Current vs. never smoking**|                       |            |
| Pourmemari 2018              | 1.10 [0.71, 1.71]     | 6.57       |
| Harris-Adamson 2013          | 1.09 [0.78, 1.52]     | 11.28      |
| Heterogeneity: $I^2 = 0.00$, $Q(1) = 0.00$, $p = 0.97$ | 1.09 [0.84, 1.43]    |            |
| **Overall**                  |                       |            |
| Heterogeneity: $I^2 = 0.00$, $Q(9) = 9.31$, $p = 0.41$ | 1.14 [1.01, 1.28]   |            |
| Test of group differences: $Q(3) = 4.19$, $p = 0.24$ |                |            |

Random-effects REML model

Figure 4. Meta-analysis of prospective cohort studies on smoking and CTS.
Table 2. Sensitivity analyses of cross-sectional studies on the associations of ever and current smoking with CTS, according to methodological quality of included studies and adjustment for publication bias.

| Risk of Bias               | Ever Smoking | Current Smoking |
|----------------------------|--------------|-----------------|
|                            | No. of Studies | OR  | 95% CI | I² (%) | No. of Studies | OR  | 95% CI | I² (%) |
| Overall                    | 5             | 1.36 | 1.08–1.72 | 40      | 7             | 1.54 | 1.13–2.09 | 49     |
| Adjustment for publication bias | 6             | 1.28 | 0.99–1.65 | 7       | 1.54 | 1.13–2.09 | 49     |
| Selection bias             |               |     |         |         |               |     |         |         |
| Low                        | 1             | 1.50 | 1.11–2.02 | -       | 2             | 1.97 | 1.45–2.68 | 0      |
| Moderate                   | 3             | 1.16 | 0.73–1.85 | 69      | 4             | 1.39 | 0.87–2.21 | 50     |
| High                       | 1             | 1.91 | 1.11–3.29 | -       | 1             | 0.39 | 0.05–3.02 | -      |
| Confounding                |               |     |         |         |               |     |         |         |
| Low                        | 2             | 1.04 | 0.46–2.34 | 81      | 2             | 2.55 | 1.30–5.00 | 36     |
| Moderate                   | 2             | 1.34 | 1.03–1.75 | 16      | 3             | 1.40 | 1.13–1.75 | 6      |
| High                       | 1             | 1.91 | 1.11–3.29 | -       | 2             | 0.84 | 0.48–1.49 | 0      |
| Detection bias             |               |     |         |         |               |     |         |         |
| Low                        | 3             | 1.19 | 0.69–2.04 | 74      | 4             | 1.63 | 0.89–3.00 | 58     |
| Moderate                   | 2             | 1.55 | 1.20–2.00 | 0       | 3             | 1.52 | 0.97–2.36 | 62     |
| Attrition bias             |               |     |         |         |               |     |         |         |
| Low                        | 3             | 1.31 | C        | 75      | 5             | 1.48 | 0.82–2.65 | 52     |
| Moderate                   | 2             | 1.34 | 1.11–1.63 | 0       | 2             | 1.61 | 1.03–2.53 | 76     |

4. Discussion

In this meta-analysis, we found no association between smoking and CTS in case control or cohort studies. Only a meta-analysis of cross-sectional studies showed an association between smoking and CTS. The results of the current meta-analysis are consistent with those of a previous systematic review and meta-analysis of studies published up to 2014 [21]. Limiting the meta-analysis of cross-sectional studies to higher quality research did not support an association between smoking and CTS.

The lack of uniformity in using a comparison group for current smoking across the included studies reduced the statistical power of this meta-analysis. A meta-analysis of cross-sectional studies did not show a significant difference in the prevalence of CTS between current and never smokers, but showed a significant difference between current and past/never smokers. Furthermore, most of the studies included in the current meta-analysis did not assess the association between the number of cigarettes smoked per day and CTS.

Recent studies have identified the relationship between workload factors and CTS [26,59,60]. Occupational biomechanical factors, such as forceful handgrip, repetitive wrist extension and flexion, extreme wrist postures, and use of vibratory tools, play a role in the causation of CTS [26,59–61]. In this meta-analysis, we found an association between smoking and CTS in cross-sectional studies; however, some of these studies did not adjust their estimates for work-related factors. It would be worth noting that blue-collar workers are more likely to smoke [62]. It is possible that the association between smoking and CTS in cross-sectional studies is confounded by work-related factors. In the sensitivity analysis of cross-sectional studies, the association between smoking and CTS was attenuated after limiting the meta-analysis to higher quality studies. It is likely that the association between CTS and smoking observed in cross-sectional studies is not a true association. It may be due to biases and/or confounding factors.

With respect to the meta-analysis of case control studies, we found no association of ever, past, or current smoking with CTS. It is possible that hospital-based controls have influenced the outcomes, as most of the included studies in this meta-analysis used hospital-based controls [11,47–49,51,52]. Only one case control study used both population- and hospital-based control groups [54]. In particular, there was a higher proportion of current smokers among hospital controls (29%) than population-based controls (19%).
Hospital-based controls are likely to have other latent or undiagnosed diseases. Many studies have shown that the prevalence of CTS is significantly higher, for example, among patients with postmastectomy lymphedema or chronic hemodialysis than among the general population [63–66]. Using hospital patients as a control group may underestimate the true association between smoking and CTS.

The studies included in the current meta-analysis had some limitations. Smoking was assessed subjectively, rather than objectively, which makes it prone to recall bias. Study participants may underreport their tobacco consumption [67]. Another possible explanation for underreporting is that smoking tends to be a habitual and almost unconscious habit [68]. Some of the included studies did not control their estimates for the known risk factors of CTS. The observed association in cross-sectional studies can partly be due to confounding factors. Furthermore, most of the included studies did not collect data on the number of cigarettes smoked per day, number of years spent smoking, and duration of smoking cessation. Thus, we were not able to explore a dose-response relationship between smoking and CTS.

5. Conclusions

In this meta-analysis, we found no association between smoking and CTS in the meta-analyses of case control and cohort studies. Smoking was associated with CTS only in a meta-analysis of cross-sectional studies. However, limiting the meta-analysis to higher quality cross-sectional studies did not support an association between smoking and CTS. It is likely that the association between smoking and CTS observed in cross-sectional studies is not a true association.

Author Contributions: Conceptualization, K.L., S.H., R.S., J.R. and S.C.; methodology, R.S.; formal analysis, R.S.; investigation, K.L., S.H. and R.S.; data curation, K.L., S.H. and R.S.; writing—original draft preparation, K.L. and R.S.; writing—review and editing, K.L., S.H., J.R., R.S. and S.C. All authors have read and agreed to the published version of the manuscript.

Funding: K.L. received funding from EPSHP, Southern Bothnia Healthcare District (grant No.: 2022).

Institutional Review Board Statement: Not applicable for secondary research.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Appendix A

Table A1. Quality assessment.

| Type of Domain | Criteria Definition | Classification (Potential for Bias) |
|----------------|---------------------|-------------------------------------|
| Selection bias | Sampling method of the study population, representativeness, response rate, difference between responders and non-responders, investigation, and control of variables, in case of difference between responders and non-responders | Weak: Target population defined as representative of the general population or subgroup of the general population (specific age group, women, men, specific geographic area, and specific occupational group), and response rate is above 80%. Moderate: Target population defined as somewhat representative of the general population, a restricted subgroup of the general population, response rate 60–79%. Strong: Target population defined as “self-referred”/volunteers, response rate less than 60%. |
| Type of Domain | Criteria Definition | Classification (Potential for Bias) |
|---------------|---------------------|-------------------------------------|
| Performance bias | Valid and reliable assessment of exposure Assessors blinded for outcome status | Weak: Smoking status was defined as never, past, and current smokers. Information on the number of cigarettes smoked per day or number of pack-years smoked. The assessors of smoking status blinded towards the outcome. Moderate: Smoking status was defined as never, past, and current smokers. No information on the number of cigarettes smoked/day or number of pack-years smoked. Strong: A dichotomous question was used, and never-smokers or current smokers were not recognized from past smokers, assessors not blinded to outcome status. |
| Detection bias | Clear definition of outcome Standard method for outcome assessment Assessor of outcome blinded to exposure status | Weak: The outcome was defined by clinical diagnosis and nerve conduction studies. Moderate: The outcome was defined by clinical diagnosis only. Strong: Self-reported outcome, assessors not blinded to exposure status. |
| Confounding | Matching Stratification Statistical analysis | Weak: Considered confounders and controlled for 80–100% of confounders. Moderate: Considered confounders and controlled for 60–79%. Strong: Considered confounders and controlled for less than 60%. |
| Attrition bias | Withdrawal and drop-out rates Size of missing data | Weak: Follow up participation rate of more than 80% or missing data of less than 20%. Moderate: Follow up participation rate of 60–79% or missing data of 20–40%. Strong: Follow up participation rate of less than 60% or missing data of more than 40%. |
### Table A2. Cross-sectional studies included in review.

| Author, Year, and Country | Study Population | Age | Gender | Sample Size (in Analysis) | Smoking | Outcome | Risk of Bias | Results | Adjustment for Other Covariates |
|---------------------------|------------------|-----|--------|---------------------------|---------|---------|-------------|---------|--------------------------------|
| Low 2021, USA [40]        | Part of the National Ambulatory Medical Care Survey between 2006 and 2015. A random sample of visits to non-federally employed, office-based physicians, community health centers, and advanced practice providers. | 22.9% aged 18–29 years, 33.8% aged 30–39 years, and 43.5% aged 60 years or older | Both, 50.4% were females | 322,092 (191,397 females and 130,695 males) | Current smokers vs. never, past, or unknown smokers | CTS identified based on ICD codes | Moderate | Strong | Moderate | Moderate | Moderate | Moderate | OR 1.32 (CI 1.07–1.63) | Age, sex, obesity, diabetes, dyslipidemia, and chronic kidney disease |
| Hashimoto 2020, Japan [44] | A random sample of public servants from town of Obuse | Mean age 69.4 (age range 50–89) | Both, 50% were females | 379 | Pack-years (= 100 packs/year * number of years smoked) | Symptoms and nerve conduction study. Subjects with history of CTS diagnosis or surgery were also defined as prevalent cases | Strong | Moderate | Moderate | Strong | Weak | OR 1.0 (95% CI 1.0–1.0) | Unadjusted |
| Pranchoo 2020, Thailand [41] | Rubber tappers who were household members of the Pawong Rubber Fund Cooperative in Pawong subdistrict, Mueang district | Mean age 49.8 ± 9.0 for CTS cases and 49.1 ± 11.7 for non-CTS participants | Both, 47.6% were females | 534 | Smoking (no/yes) | CTS diagnosis based on symptoms + clinical examination | Moderate | Strong | Moderate | Strong | Weak | OR 0.8 (95% CI 0.5–1.3) | Unadjusted |
| El-Helaly 2017, Egypt [10] | Medical technicians of the King Fahd Hospital clinical laboratory | Mean age 37.2 ± 9.5 | Both, 67.4% were females | 279 | Current smoking (no/yes) | Diagnosis of CTS was based on Kamath and Stothard clinical questionnaire and nerve conduction study | Moderate | Strong | Weak | Moderate | Weak | 11.1% of 27 participants with CTS and 7.8% of 252 participants without CTS were current smokers. Estimated OR 1.49 (95% CI 0.40–5.24) | Unadjusted. Pregnant, those with diabetes, hypothyroidism, rheumatoid arthritis or with a history of hand trauma were excluded |
| Ricco & Signorelli 2017, Italy [14] | Consecutive patients referred to a single occupational health service from 31 meat processing plants | Mean age 37.0 ± 10.6 | Both, 48.5% were females | 434 | Current or past smokers vs. never-smokers | Diagnosis of CTS was based on symptoms, clinical signs, and ultrasonography and/or nerve conduction study | Strong | Strong | Weak | Weak | Weak | OR 1.169 (95% CI 1.07–1.29) | Unadjusted |
| Hagmann 2016, USA [13] | Employees of manufacturing and food processing, and office workers were recruited from 35 facilities, involving 25 diverse industries, located in the states of Illinois, Utah, Washington, and Wisconsin | Mean age 45.1 ± 9.8 years among CTS cases and 40.3 ± 11.5 years among those without CTS | Both, 50.6% were females | 1824 | Ever-smokers vs. never-smokers | CTS diagnosis was based on symptoms and nerve conduction study | Moderate | Strong | Weak | Moderate | Moderate | OR 1.24 (95% CI 0.96–1.60) | Sex, body mass index and job strain index |
| Jung 2016, Korea [10] | Healthy orchardists living in Gyeongsangnam-do who participated in the health promotion program | Mean age 58.9 ± 7.9 | Both, 53.8% were females | 377 | Never, past, and current smokers | Diagnosis of CTS was based on symptoms, clinical signs, and nerve conduction study | Moderate | Weak | Moderate | Weak | Strong | Unadjusted. Prevalence of past smoking was 44.1% in participants with CTS and 50.9% in those without CTS. Prevalence of current smoking was 59.0% in participants with CTS and 49.1% in those without CTS. Estimated OR 0.69 (CI 0.40–1.17) for past smoking and 0.90 (CI 0.50–1.63) for current smoking | Unadjusted |
Table A2. Cont.

| Author, Year, and Country | Study Population | Age | Gender | Sample Size (in Analysis) | Smoking | Outcome | Risk of Bias | Results | Adjustment for Other Covariates |
|---------------------------|------------------|-----|--------|---------------------------|---------|---------|-------------|---------|--------------------------------|
| Kiani 2014, Iran [42]     | Convenience sample of patients with diabetes | Mean age 54.0 ± 13.2 for females and 51.6 ± 16.5 for males | Both, 69% were females | 432 | Current smoking (n=years) | Symptoms and clinical examination | Strong | Strong | Moderate | Strong | Weak | 2.7% of patients with CTS (N = 37) and 6.6% of those without CTS (N = 309) were current smokers. Estimated OR 0.39 (95% CI 0.05–2.99) | Unadjusted |
| Eleftheriou 2012, Greece [36] | Occupational population (data entry and processing unit) | 45.2 ± 9.46 | Both, 55.6% females | 461 | Ever smokers vs. never smokers | Case definition A: history of CTS diagnosed by physician, including surgery due to CTS. Definition B: definition A + suggestive CTS at clinical examination | Moderate | Strong | Moderate | Moderate | Weak | OR of case definition A for ever smoking 1.99 (1.01–2.54). OR of case definition B for ever smoking 1.69 (1.03–2.76) | Age, sex, keyboard use, and physical activity |
| Shiri 2011, Finland [37] | General population | 30 years or older, mean age 52 years | Both, 48% males | 6254 | Home interview: (1) current smokers (2) past smokers (3) occasional smokers (4) never smokers. | Clinical diagnosis. Probable, possible CTS, surgery due to CTS | Weak | Weak | Moderate | Weak | Moderate | OR of possible/probable CTS for current smoking 2.1 (1.4–3.1), for past smoking 1.2 (0.8–1.6) and for ever smoking 1.50 (1.1–2.0). OR of surgery due to CTS for current smoking 1.5 (0.7–3.2) | Age, sex, education, somatization, hand grip with high forces, and work using vibrating tools |
| Maghsoudipour 2008, Iran [43] | Occupational population (auto factories) | Mean age in CTS group 29.85 years, mean age in healthy group 27.95 years | Both, 23% were females | 395 | Cigarette smokers vs. nonsmokers | Symptoms + clinical diagnosis + nerve conduction study | Moderate | Strong | Weak | Weak | Weak | OR 4.68 (95% CI 1.08–11.80) for current smoking | Age, gender, marital status, body mass index, education, job duration, workplace risk factors (force exertion > 1 kg, rapid hand movement, break time > 75 min, wrist bending/twisting, job rotation, using vibrating tools |
| Atroshi 2007, Sweden [10] | General population | 25–65 | Both, 53.8% females | 2003 (925 males and 1078 females) | Current smokers versus non-smokers | Symptoms + clinical diagnosis + nerve conduction study | Weak | Strong | Weak | Moderate | Weak | OR 1.79 (95% CI 1.10–2.90) | Sex, age ≥ 40 years, overweight and keyboard use ≥ 15 h/day |
| Frost 1998, Denmark [10] | Occupational population (slaughterhouse workers and chemical factory workers) | Mean age 40.5 years | Both, 64.7% were males | 1341 (906 males and 375 females) | Ever smokers | Symptoms, clinical diagnosis, nerve conduction study or previous surgery due to CTS | Moderate | Strong | Weak | Weak | Weak | OR for ever smoking 0.65 (95% CI 0.34–1.24) | Age (stratified), gender, occupational risk factor, wrist trauma, body mass index, and medical condition |
Table A3. Case-control studies included in the review.

| Author, Year and Country | Study Population | Age | Sex | Sample Size | Smoking | Outcome | Risk of Bias | Results | Adjustment for Other Covariates |\hline
| Ulbrichtova 2020, Slovakia [46] | Cases were consecutive electrophysiologically confirmed CTS patients and controls were a randomly selected patients without any known systemic disease or symptoms of CTS who were treated at the Clinic of Occupational Medicine and Toxicology | Age range 27-63 for cases and 21-63 for controls, mean age 52.5 ± 5.9 for cases and 48.1 ± 9 for controls | Both, 55.8% of cases and 54% of controls were females | 162 cases and 300 controls | Never/past/current. | Symptoms and nerve conduction study | Weak | Moderate | Weak | Moderate | Weak |\hline
| Bhanderi 2017, India [47] | CTS cases were patients managed at K M Patel School of Physiotherapy, Gugarat. Controls were patients attending the same institute, patients attending other outpatient departments or relatives of patients | Mean age 47.6 ± 10.96 years (range, 18–80) for cases and 47.5 ± 10.89 (range, 20–65) for controls | Both, 78.8% were females | 137 cases and 274 controls | Never, past, and current smokers | Symptoms, clinical, and nerve conduction study | Moderate | Moderate | Weak | Moderate | Weak |\hline
| Guan 2018, China [48] | Cases were outpatient and surgical CTS cases free of other diseases recruited from a single medical center and controls were outpatients | Age range 41–70 | Both, 82.5% of cases and 82.5% of controls were females | 1512 cases and 4536 controls | Current smokers vs. nonsmokers | Symptoms, clinical, and nerve conduction study | Moderate | Strong | Weak | Strong | Weak |\hline
| Coggon 2013, UK [49] | Cases were CTS patients and controls were patients attended the accident and emergency department | Age range 20–64 | Both, 68% were females | 1230 (457 cases and 773 controls) | Never, past, and current smokers | Symptoms + nerve conduction study | High | Moderate | Low | Low | Low |\hline
| Mattoli 2009, Italy [50] | Cases: random sample of local hospitals. Controls: random sample of national health service registries | Age range 16–65 years | Both, 54% were females | 191 cases and 286 controls, | Never-smokers, past smokers, current smokers, and pack-years | Surgery due to CTS (symptoms, clinical diagnosis, and nerve conduction study) | Weak | Weak | Weak | Moderate | Weak |\hline
| Fung 2007, Hong Kong [51] | Outpatient CTS patients and patient controls were recruited from three centers | Age range 16-60, mean age 46.3 ± 9.1 | Both, 84.3% were females | 166 cases and 111 controls | Current smokers vs. non-smokers | Symptoms + clinical assessment and nerve conduction study for atypical cases (51% of cases) | Moderate | Strong | Weak | Moderate | Weak |\hline

**Risk of Bias**

- **Selection**
  - Weak
  - Moderate
  - Strong

- **Performance**
  - Weak
  - Moderate
  - Strong

- **Detection**
  - Weak
  - Moderate
  - Strong

- **Confounding**
  - Moderate
  - Weak

- **Attrition**
  - Weak
  - Moderate
  - Strong

**Results**

- OR 1.51 (95% CI 0.94–2.42)
  - It seems the OR is for ever vs. never smoking

**Adjustment for Other Covariates**

- Age, sex, body mass index, alcohol drinking, diabetes, and hypertension.
### Table A3. Cont.

| Author, Year and Country | Study Population | Age | Sex | Sample Size (in Analysis) | Smoking | Outcome | Risk of Bias | Results | Adjustment for Other Covariates |
|--------------------------|------------------|-----|-----|---------------------------|---------|---------|-------------|---------|--------------------------------|
| Geoghegan 2004, UK [11]  | General practice population, the West Midlands section of The UK General Practice Research Database | 16–96, Mean age 46 | Both, 72% were females | 16855 (3201 cases and 13654 controls) | Current smokers vs. non-smokers | Registry data: diagnosis of CTS, surgery due to CTS | Risk of Bias | Results | Adjustments |
|                          |                  |     |     |                           |         |         | Selection   | Performance | Detection | Confounding | Attrition | Other Covariates |
|                          |                  |     |     |                           |         |         | Weak        | Strong     | Moderate   | Moderate    | Strong    | Age, sex, general practice, date of diagnosis, and mean annual consultation rates |
| Karpitskaya 2002, USA [52] | Patient population, Patients who underwent CTR, control group formed of patient seen for general reconstructive surgery or those with acute hand diagnoses | Mean age 50 ± 15 for cases, 47 ± 14 for controls | Both, 59.6% were females | 514 cases and 100 hospital controls | Never, past, and current smoking, and pack-years, estimates reported for current smokers vs. non-smokers | Surgery, due to CTS based on hospital records | Risk of Bias | Results | Adjustments |
|                          |                  |     |     |                           |         |         | Moderate    | Weak      | Weak       | Strong      | Weak      | 26.3% of cases and 33% of controls were smokers; OR 0.72 (95% CI 0.45–1.25) for current smoking |
| Ferry 2000, UK [53]      | General practice population, The Royal College of General Practitioners’ Oral Contraception Study attendees | Mean age 41.9 for both groups | Female | 1264 cases and 1264 controls | Smokers vs. non-smokers | General practitioner diagnosed CTS | Risk of Bias | Results | Adjustments |
|                          |                  |     |     |                           |         |         | Weak        | Strong     | Moderate   | Moderate    | Weak     | Age |
| Wieslander 1989, Sweden [54] | Patients undergoing CTR as cases and other surgical patients as control group 1 and population sample as control group 2 | Age range 20-66 | Males | 177 (54 cases and 143 controls), two hospital controls and two population controls for each case | Current smokers vs. non-smokers | Surgery due to CTS (clinical diagnosis + nerve conduction study) | Risk of Bias | Results | Adjustments |
|                          |                  |     |     |                           |         |         | Moderate    | Strong     | Moderate   | Moderate    | Weak |

### Table A4. Cohort studies included in the review.

| Author, Year and Country | Study Population | Age | Gender | Sample Size (in Analysis) | Smoking | Outcome | Risk of Bias | Results | Adjustment for Other Covariates |
|--------------------------|------------------|-----|--------|---------------------------|---------|---------|-------------|---------|--------------------------------|
| Rydberg 2020, Sweden [73] | A population-based study of the Malmö Diet and Cancer Study, median follow-up 21.4 years | 46–75 mean 57 ± 7.6 | Both, 60% were females | 30,323 | Current smoking, yes/no | Information on diagnosis of CTS was obtained from register data, surgical codes were not available, only ICD codes for clinical, and hospital-based CTS were available | Risk of Bias | Results | Adjustments |
|                          |                  |     |        |                           |         |         | Selection   | Performance | Detection | Confounding | Attrition | Other Covariates |
|                          |                  |     |        |                           |         |         | Weak        | Strong     | Moderate   | Moderate    | Weak    | Age, sex, alcohol consumption, body mass index, hypertension, and the use of antihypertensive treatment |
| Hulkkonen 2020, Finland [56] | The Northern Finland Birth Cohort 1966 participants, mean follow-up time 18.3 years | 31 years | Both, 46.5% were females | 6326 (3260 males, 3066 females) | Past or current smokers vs. never smokers | Diagnosis of CTS was based on register data on out- and inpatient specialist care | Risk of Bias | Results | Adjustments |
|                          |                  |     |        |                           |         |         | Moderate    | Strong     | Moderate   | Weak       | Weak    | HR 1.49 (1.12–1.96) for both sexes combined and 1.66 (1.39–2.02) for females. The HR was not significant for males |
| Hulkkonen 2019, Finland [58] | The Northern Finland Birth Cohort 1966 participants, mean follow-up time 18.3 years | 31 years | Both, 52.2% were females | 8703 (4156 males, 4547 females) | Number of pack-years | Diagnosis of CTS was based on register data on out- and inpatient specialist care | Risk of Bias | Results | Adjustments |
|                          |                  |     |        |                           |         |         | Weak        | Moderate   | Moderate   | Moderate    | Weak    | HR was 1.94 (95% CI 1.02–1.71) for pack-years ≤10 and 1.89 (95% CI 1.14–3.12) for pack-years >30 for males. It was 1.54 (1.11–2.15) for pack-years ≤10 and 1.90 (95% CI 1.20–3.01) for pack-years >30 for females. Body mass index, socioeconomic status, and diabetes |
|                          |                  |     |        |                           |         |         |            |           |            |            |            |
### Table A4. Cont.

| Author, Year and Country | Study Population | Age | Gender | Sample Size (in Analysis) | Smoking | Outcome | Risk of Bias | Selection | Performance | Detection | Confounding | Attrition | Adjustment for Other Covariates |
|--------------------------|------------------|-----|--------|----------------------------|---------|---------|-------------|-----------|-------------|-----------|-------------|-----------|--------------------------------|
| Pourmemari 2018, Finland [27] | Population-based study linked to the Hospital Discharge Register for specialist medical care, 15-year follow-up | 52 ± 14 years | Both, 54% were females | 6177 | Never (occasional/ past/current smoking) | Register data on carpal tunnel release | Weak | Moderate | Weak | Moderate | Weak | HR: 1.2 (1.05–2.9) for male current smokers, 1.0 (0.6–1.7) for female current smokers and 1.1 (0.5–2.2) for both sexes combined. Current smokers: HR: 1.1 (0.5–2.2) for male past smokers, 1.3 (0.7–2.3) for female past smokers and 1.2 (0.8–1.9) for both sexes combined. Past smokers. |
| Harris-Adamson 2013, USA [55] | Full-time workers in industries primarily engaged in manufacturing, production, service, and construction | 31% were <30 years, 24% were 30–39 years, 26% were 40–49 years and 19% were 50 years or older | Both, 67% were females | 3514 | Never, past, current | CTS diagnosis based on symptoms and nerve conduction study | Weak | Moderate | Weak | Strong | Weak | IRR: 1.09 (0.78–1.51) for current smokers and 1.05 (0.70–1.54) for past smokers. |
| Gell 2005, USA [22] | Workers from four industrial and three clerical workplaces, 5.4 years follow-up | 19–69 | Both, 71% females | 432 | Smokers vs. non-smokers | Symptoms, clinical diagnosis and nerve conduction study or self-reported surgery due to CTS, since the time of the initial screening | Moderate | Strong | Weak | Strong | Strong | OR: 0.88 (0.37–2.03) for smoking. |
| Werner 2005, USA [56] | Workers from an automobile assembly plant, 1-year follow-up | Mean age 49.8 for participants with CTS and 47.5 for those without CTS | Both, 25.5% were females | 189 | Currently smoking (no/yes) | Symptoms + nerve conduction study or self-reported physician diagnosed CTS, since the time of the initial screening | Strong | Weak | Strong | Weak | Strong | 56% of 20 participants with CTS and 53% of 169 participants without CTS during the follow-up were smokers at baseline, estimated risk ratio 1.08 (95% CI: 0.71–1.60). |
| Nathan 2002, USA [57] | Four industrial sites (a steel mill, meat/food packaging, electronics, and plastics), 15-year follow-up | Mean age 34.86 ± 9.96 | Both, 56.6% were males | 256 (145 males and 111 females) | Smokers vs. non-smokers, a retrospective data | Symptoms + nerve conduction study or surgery due to CTS since the last follow-up visit | Moderate | Strong | Weak | Weak | Strong | Smokers vs. non-smokers, OR = 2.42 (1.06–5.51). |
| Nathan 2005, USA [23] | 17-year follow-up | 60% males | 148 | Sum of the ratings of current smoking in 1984, 1989, and 1994 to 1995, where smoking equalled 1 and non-smoking equalled 0 | As above | Current smoking vs. non-smoking, OR = 2.22 (0.66–7.49). Confidence interval not reported. | Gender, age, body mass index, obesity, heavy lifting, keyboard use, vibration, and force |
| Roquelaure 2001, France [24] | Occupational population, five footwear factories | Mean age 40.7 ± 7.7 | Both, 61% were females | 134 | Current smokers vs. non-smokers | Clinical diagnosis | Moderate | Strong | Moderate | Strong | Moderate | OR for current smoking 0.3 (0.1–2.2). |
28. Armijo-Olivo, S.; Stiles, C.R.; Hagen, N.A.; Biondo, P.D.; Cummings, G.G. Assessment of Study Quality for Systematic Reviews: A Comparison of the Cochrane Collaboration Risk of Bias Tool and the Effective Public Health Practice Project Quality Assessment Tool: Methodological Research. J. Eval. Clin. Pract. 2012, 18, 12–18. [CrossRef]
29. WOOLF, B. On Estimating the Relation between Blood Group and Disease. Ann. Hum. Genet. 1955, 19, 251–253. [CrossRef]
30. Cumpton, M.; Li, T.; Page, M.J.; Chandler, J.; Welch, V.A.; Higgins, J.P.; Thomas, J. Updated Guidance for Trusted Systematic Reviews: A New Edition of the Cochrane Handbook for Systematic Reviews of Interventions. Cochrane Database Syst. Rev. 2019, 10, ED000142. [CrossRef]
31. Higgins, J.P.T.; Thompson, S.G. Quantifying Heterogeneity in a Meta-Analysis. Stat. Med. 2002, 21, 1539–1558. [CrossRef]
32. Rothstein Hannah, S.A.B.M. Publication Bias in Meta-Analysis: Prevention, Assessment and Adjustments; Wiley: New York, NY, USA, 2005.
33. Duval, S.; Tweedie, R. Trim and Fill: A Simple Funnel-Plot-Based Method of Testing and Adjusting for Publication Bias in Meta-Analysis. Biometrics 2000, 56, 455–463. [CrossRef] [PubMed]
34. Ricco, M.; Signorelli, C. Personal and Occupational Risk Factors for Carpal Tunnel Syndrome in Meat Processing Industry Workers in Northern Italy. Med. Pr. 2017, 68, 199–209. [CrossRef]
35. Hegmann, K.T.; Thiese, M.S.; Kapellusch, J.; Merryweather, A.S.; Bao, S.; Silverstein, B.; Wood, E.M.; Kendall, R.; Wertsch, J.; Foster, J.; et al. Association Between Cardiovascular Risk Factors and Carpal Tunnel Syndrome in Pooled Occupational Cohorts. J. Occup. Environ. Med. 2016, 58, 87–95. [CrossRef] [PubMed]
36. Eleftheriou, A.; Rachiotis, G.; Varitimidis, S.E.; Koutis, C.; Malizos, K.N.; Hadjichristodoulou, C. Cumulative Keyboard Strokes: A Possible Risk Factor for Carpal Tunnel Syndrome. J. Occup. J. Med. Toxicol. 2012, 7, 16. [CrossRef] [PubMed]
37. Shiri, R.; Heliovaara, M.; Moilanen, L.; Viikari, J.; Liira, H.; Viikari-Juntura, E. Associations of Cardiovascular Risk Factors, Carotid Intima-Media Thickness and Manifest Atherosclerotic Vascular Disease with Carpal Tunnel Syndrome. BMC Musculoskelet. Disord. 2011, 12, 80. [CrossRef] [PubMed]
38. Frost, P.; Andersen, J.H.; Nielsen, V.K. Occurrence of Carpal Tunnel Syndrome among Slaughterhouse Workers. Scand. J. Work. Environ. Health 1998, 24, 285–292. [CrossRef] [PubMed]
39. Jung, H.Y.; Kong, M.S.; Lee, S.H.; Lee, C.H.; Oh, M.K.; Lee, E.S.; Shin, H.; Yoon, C.H. Prevalence and Related Characteristics of Carpal Tunnel Syndrome Among Orchardists in the Gyeongsangnam-Do Region. Ann. Rehabil. Med. 2016, 40, 902–914. [CrossRef]
40. Low, J.; Kong, A.; Castro, G.; Rodriguez de la Vega, P.; Lozano, J.; Varella, M. Association Between Diabetes Mellitus and Carpal Tunnel Syndrome: Results From the United States National Ambulatory Medical Care Survey. Cureus 2021, 13, e13844. [CrossRef]
41. Pramchoo, W.; Geater, A.F.; Tangtrakulwanich, B. Physical Ergonomic Risk Factors of Carpal Tunnel Syndrome among Rubber Tappers. Arch. Environ. Occup. Health 2020, 75, 1–9. [CrossRef] [PubMed]
42. Kiani, J.; Goharifar, H.; Moghimbeigi, A.; Azizkhanl, H. Prevalence and Risk Factors of Five Most Common Upper Extremity Disorders in Diabetics. J. Res. Health. Sci. 2014, 14, 92–95. [PubMed]
43. Maghsoudipour, M.; Moghim, S.; Dehghaan, F.; Rahimpanah, A. Association of Occupational and Non-Occupational Risk Factors with the Prevalence of Work Related Carpal Tunnel Syndrome. J. Occup. Rehabil. 2008, 18, 152–156. [CrossRef] [PubMed]
44. Hashimoto, S.; Ikegami, S.; Nishimura, H.; Uchiyama, S.; Takahashi, J.; Kato, H. Prevalence and Risk Factors of Carpal Tunnel Syndrome in Japanese Aged 50 to 89 Years. J. Hand Surg. Asian Pac. Vol. 2020, 25, 320–327. [CrossRef] [PubMed]
45. El-Helaly, M.; Balkhy, H.H.; Vallenius, L. Carpal Tunnel Syndrome among Laboratory Technicians in Relation to Personal and Ergonomic Factors at Work. J. Occup. Health 2017, 59, 513–520. [CrossRef]
46. Ulbrichtová, R.; Jakušová, V.; Osina, O.; Zibolenová, J.; Kuka, S.; Huděcková, H. Association of the Role of Personal Variables and Nonoccupational Risk Factors for Work-related Carpal Tunnel Syndrome. Cent. Eur. J. Public Health 2020, 28, 274–278. [CrossRef]
47. Bhandari, D.; Mishra, D.; Parikh, S.; Sharma, D. Computer Use and Carpal Tunnel Syndrome: A Case-Control Study. Indian J. Occup. Environ. Med. 2017, 21, 109–114. [CrossRef]
48. Guan, W.; Lao, J.; Gu, Y.; Zhao, X.; Rui, J.; Gao, K. Case-Control Study on Individual Risk Factors of Carpal Tunnel Syndrome. Exp. Ther. Med. 2018, 15, 2761–2766. [CrossRef]
49. Coggon, D.; Ntani, G.; Harris, E.C.; Linaker, C.; van der Star, R.; Cooper, C.; Palmer, K.T. Differences in Risk Factors for Neurophysiologically Confirmed Carpal Tunnel Syndrome and Illness with Similar Symptoms but Normal Median Nerve Function: A Case-Control Study. BMC Musculoskeletal. Disord. 2013, 14, 240. [CrossRef]
50. Mattioli, S.; Baldasseroni, A.; Bovenzi, M.; Curtis, S.; Cooke, R.M.T.; Campo, G.; Barbieri, P.G.; Gherzi, R.; Broccoli, M.; Cancellieri, M.P.; et al. Risk Factors for Operated Carpal Tunnel Syndrome: A Multicenter Population-Based Case-Control Study. BMC Public Health 2009, 9, 343. [CrossRef]
51. Fung, B.K.; Chan, K.Y.; Lam, L.Y.; Cheung, S.Y.; Choy, N.K.; Chu, K.W.; Chung, L.Y.; Liu, W.W.; Tai, K.C.; Yung, S.Y.; et al. Study of Wrist Posture, Loading and Repetitive Motion as Risk Factors for Developing Carpal Tunnel Syndrome. Hand Surg. 2007, 12, 13–18. [CrossRef]
52. Karpińska, Y.; Novak, C.B.; Mackinnon, S.E. Prevalence of Smoking, Obesity, Diabetes Mellitus, and Thyroid Disease in Patients with Carpal Tunnel Syndrome. Ann. Plast. Surg. 2002, 48, 269–273. [CrossRef] [PubMed]
53. Ferry, S.; Hannaford, P.; Warskij, M.; Lewis, M.; Croft, P. Carpal Tunnel Syndrome: A Nested Case-Control Study of Risk Factors in Women. Am. J. Epidemiol. 2000, 151, 566–574. [CrossRef] [PubMed]
54. Wieslander, G.; Norback, D.; Gothe, C.J.; Juhlin, L. Carpal Tunnel Syndrome (CTS) and Exposure to Vibration, Repetitive Wrist Movements, and Heavy Manual Work: A Case-Referent Study. Br. J. Ind. Med. 1989, 46, 43–47. [CrossRef] [PubMed]
55. Harris-Adamson, C.; Eisen, E.A.; Dale, A.M.; Evanoff, B.; Hegmann, K.T.; Thiese, M.S.; Kapellusch, J.M.; Garg, A.; Burt, S.; Bao, S.; et al. Personal and Workplace Psychosocial Risk Factors for Carpal Tunnel Syndrome: A Pooled Study Cohort. *Occup. Environ. Med.* 2013, 70, 529–537. [CrossRef]

56. Werner, R.A.; Franzblau, A.; Gell, N.; Hartigan, A.G.; Ebersole, M.; Armstrong, T.J. Incidence of Carpal Tunnel Syndrome among Automobile Assembly Workers and Assessment of Risk Factors. *J. Occup. Environ. Med.* 2005, 47, 1044–1050. [CrossRef]

57. Nathan, P.A.; Meadows, K.D.; Istvan, J.A. Predictors of Carpal Tunnel Syndrome: An 11-Year Study of Industrial Workers. *J. Hand Surg.* 2002, 27, 644–651. [CrossRef]

58. Huulkonen, S.; Auvinen, J.; Miettunen, J.; Karppinen, J.; Ryhänen, J. Smoking as Risk Factor for Carpal Tunnel Syndrome: A Birth Cohort Study. *Muscle Nerve* 2019, 60, 299–304. [CrossRef]

59. Kozak, A.; Schedlbauer, G.; Wirth, T.; Euler, U.; Westermann, C.; Nienhaus, A. Association between Work-Related Biomechanical Risk Factors and the Occurrence of Carpal Tunnel Syndrome: An Overview of Systematic Reviews and a Meta-Analysis of Current Research. *BMC Musculoskelet. Disord.* 2015, 16, 231. [CrossRef]

60. Violante, F.S.; Farioli, A.; Graziosi, F.; Marinelli, F.; Curti, S.; Armstrong, T.J.; Mattioli, S.; Bonfiglioli, R. Carpal Tunnel Syndrome and Manual Work: The OCTOPUS Cohort, Results of a Ten-Year Longitudinal Study. *Scand. J. Work Environ. Health* 2016, 42, 280–290. [CrossRef]

61. Mölstam, K.; Englund, M.; Atroshi, I. Association of Clinically Relevant Carpal Tunnel Syndrome with Type of Work and Level of Education: A General-Population Study. *Sci. Rep.* 2021, 11, 19850. [CrossRef]

62. Palmer, K.T.; Syddall, H.; Cooper, C.; Coggon, D. Smoking and Musculoskeletal Disorders: Findings from a British National Survey. *Ann. Rheum. Dis.* 2003, 62, 33–36. [CrossRef]

63. Kuharić, M.; Zibar, L. Screening for Carpal Tunnel Syndrome in Patients on Chronic Hemodialysis. *Acta Med. Acad.* 2019, 48, 167–176. [CrossRef] [PubMed]

64. Ganel, A.; Engel, J.; Sela, M.; Brooks, M. Nerve Entrapments Associated with Postmastectomy Lymphedema. *Cancer* 1979, 44, 2254–2259. [CrossRef]

65. Vecht, C.J. Arm Pain in the Patient with Breast Cancer. *J. Pain Symptom Manag.* 1990, 5, 109–117. [CrossRef]

66. Bozentka, D.; Beredjiklian, P.; Chan, P.; Schmidt, S. Hand Related Disorders Following Axillary Dissection for Breast Cancer. *Univ. PA Orthop.* 2001, 14, 35–37.

67. Brigham, J.; Lessov-Schlaggar, C.N.; Javitz, H.S.; Krasnow, R.E.; Tildesley, E.; Andrews, J.; Hops, H.; Cornelius, M.D.; Day, N.L.; McElroy, M.; et al. Validity of Recall of Tobacco Use in Two Prospective Cohorts. *Am. J. Epidemiol.* 2010, 172, 828. [CrossRef]

68. Means, B.; Habina, K.; Swan, G. Cognitive Research on Response Error in Survey Questions on Smoking. National Center for Health Statistics. *Vital Health Stat.* 1992, 6, 22–31.