sciendo

DOI: 10.2478/rjom-2023-0007

Original papers

Evaluation of occupational and non-occupational risk factors associated with carpal tunnel syndrome-related symptoms in office workers

Cristina-Manuela Mocanu[1,2], Diana-Teodora Axente[2]

[1] Clinical Ophthalmology Emergency Hospital, Bucharest, Romania
[2] University of Medicine and Pharmacy Carol Davila, Bucharest

Corresponding author
Cristina-Manuela Mocanu
mocanu.c_manuela@yahoo.com

Abstract

Background: While the main occupational and non-occupational risk factors associated with carpal tunnel syndrome are known, we still need to understand which of these factors has a stronger correlation with carpal tunnel-related symptoms in office workers and to improve future work-space recommendations accordingly.
Objective: This study aimed to investigate the relationship between occupational and non-occupational risk factors and carpal tunnel syndrome-related symptoms among office workers who use a computer in their day-to-day activities.
Methods: The data used in this study were collected from May to September 2022 through an online questionnaire from one respondent to another through different forms of social media, using the snowball method. The recorded data were further analysed using an SPSS program. In this way, we analysed quantitative variables by calculating the means, the medians, the standard deviation and the normal distribution and qualitative variables by reporting them as absolute values and percentages of the total. We compared different subgroups of samples using the chi-square test and the binary regression method. A p-value of less than 0.05 was the threshold of statistical significance.
Results: This study evaluated 130 office workers and identified and analysed the complex relationships between occupational and non-occupational risk factors of CTS and CTS symptoms grouped as pain, sensory function impairment and motor function impairment. Through data analysis and further logistic regression analysis, we concluded that while sensory function impairment is mostly associated with occupational factors such as computer typing with one hand, pain and motor function impairment are associated with both non-occupational, well-known risk factors (female sex, high BMI) and number of hours on the computer outside of work, and occupational risk factors like using both a mouse and an external keyboard, having a chair with adequate arm support and typing with one hand.
Conclusion: Both occupational and non-occupational risk factors contribute to the development of CTS-related symptoms. Our dataset highlights the complex relationship between CTS occupational and non-occupational risk factors in office workers, thus providing insights for future workplace recommendations and preventive strategies.

Keywords: *carpal tunnel syndrome; office workers; ergonomics; musculoskeletal system.*

Introduction

Carpal tunnel syndrome (CTS) is a mononeuropathy caused by the compression of the median nerve in the carpal tunnel by the transverse carpal ligament. In most cases, CTS is idiopathic. However, certain risk factors such as gender (women have a higher risk of developing CTS, with a peak at ages 45-54 years, in the first year of menopause, or the third trimester of pregnancy), comorbidities: acromegaly, rheumatoid arthritis, amyloidosis, obesity, hypothyroidism, diabetes, and muscle strain (computer typing, writing, playing on the piano) [1, 2, 3] are well documented. Only a low percentage of the total number of CTS cases are associated with endocrine pathologies.

The clinical presentation of CTS includes pain in the distribution territory of the median nerve, which starts at the wrist level and may irradiate throughout the forearm. The pain is increased by hand flexion and prehension movements and is often associated with dysaesthesia of the lateral three and ½ fingers. The patient examination includes provocation tests, namely the Tinel Test and the Phanlen Test, and paraclinical investigations (electromyography highlights the neural injury) [1,2].

In workers, CTS is often a consequence of a repetitive strain injury characterised by pain that appears in the workspace, often associated with a change of work activity and a shortage of personnel. In its late phases, the pain is diffuse and not limited to work-related activities [2]. Other occupational risk factors associated with the presence of CTS in workers include vibrations, average hand force > 4kg and repetitive work (< 10s cycle time or >50% cycle time performing the same movement) [3].

Treatment options for CTS include nocturnal splinting (also used as a diagnostic test, nocturnal splinting relieves the symptoms of CTS by keeping the hand in neutral position during the night and, if worn for several weeks in early stages, it may lead to total recovery), non-steroidal anti-inflammatory drugs (NSAIDs), intraarticular glucocorticoid injections (efficacy rate of 70%) or surgical treatment (recommended for the severe cases) [1,2,3]. A retrospective comparative study from 2022 [6] showed the importance of the routine use of clinic-based occupational and physical therapy in the postoperative period.

Another pillar for managing CTS in the workspace is the return to work after surgery, as there is still no consensus on the optimal duration of sickness leave post-surgical intervention, nor on the process of gradual reinsertion to the workforce and the treatment of work-related pain and discomfort which would increase work-related satisfaction and performance [3, 7-12].

Methods

This study aimed to investigate the relationship between occupational and non-occupational risk factors and subclinical carpal tunnel syndrome among office workers who use a computer in their day-to-day activities.

The identification of the occupational risk factors associated with CTS took into consideration the following aspects: the type of computer used (whether it was a laptop or a desktop computer with an external keyboard); the utilisation of an external keyboard in case of laptop usage; the type of work-chair used and whether it was adjustable and had adequate arm support and whether or not computer-typing was done only using one hand, using one hand predominantly and the other sparsely or using both hands for an equal amount of time. When recording the total number of computer usage hours per day, we differentiated between work-related computer use (mentioning the number of hours spent typing) and non-work-related computer use (non-occupational risk factor). We considered the number of hours spent typing as very rare if it was less than 30 minutes per day, rare if it was less than 1 hour per day, frequent if it was between 2 and 4 hours each day and almost total if it was more than 4 hours per day. We also recorded the number of years the respondents had this program. Using this data and the estimated average of 252 work days per year, we calculated the total number of work hours the worker had during his/her lifetime [14]. Another essential element we evaluated was the position of the different segments of the upper member during work: we assessed the angle between the arm and forearm when the forearm is supported by the work surface (angle greater than 90 degrees, angle of approximately 90 degrees, angle smaller than 90 degrees) and the angle between hand and forearm (angle of 0 degrees, hand flexion of 15 degrees, hand extension of 15 degrees), presented in the figure included in the questionnaire.

The identification of the non-occupational risk factors associated took into consideration the following aspects: the total number of computer usage hours per day outside of work hours and demographic data such as age, sex, level of education, height, weight and whether or not patients were smokers (for patients that were smokers, we also recorded the number of years for which they have been smokers

and the number of smoked cigarettes smoked per day on the average). Using the height and weight, we calculated the BMI as (weight (kg)/height (cm)2. We grouped the patients into the following categories: underweight (BMI<18.5 kg/m2), normal weight (BMI between 18.5 kg/m2 and 24.9 kg/m2), overweight (BMI between 25 kg/m2 and 29.9 kg/m2) and obese (BMI>30 kg/m2). We determined the pack-year as the average number of smoked cigarettes per day divided by 20 and multiplied by the number of years of smoking [14].

We also recorded whether or not the respondents had one or more of the pathologies that are often associated with CTS, meaning a history of diabetes, hypothyroidism, shoulder, arm or hand trauma such as fractures or sprains, hypertension, cervical spondylosis, lumbar spondylosis, rheumatoid arthritis. Our respondents also had the option to specify whether or not they had a previous diagnosis of musculoskeletal disorder not otherwise specified [14].

We calculated the carpal syndrome risk using the Boston scale. A Boston score higher than 2.47 is a high-risk factor for developing carpal tunnel syndrome and is widely used for early diagnosis (with a sensibility of 95% and a specificity of 95%) [13, 14]. Further, we divided the questions of the Boston scale into 3 groups based on the symptoms assessed: pain (question 1,2,3,4,5), sensory function impairment (question 6,8,9,10), and motor function impairment (question 7,11). For each of these groups, we calculated the participants' risk scores, by adding the corresponding values of the responses.

The data used in this study were collected from May to September 2022 in an online questionnaire, through different forms of social media, using the snowball method. The recorded data were further analysed using StatPlus: mac, AnalystSoft Inc. - statistical analysis program for macOS. Version v8. https://www.analystsoft.com/en).

We analysed quantitative variables by calculating the means, the medians, the standard deviation and the normal distribution. We analysed qualitative variables by reporting them as absolute values and percentages of the total. We compared different subgroups of samples using the chi-square test or the Mann-Whitney test. We used binary logistic regression to understand the associations between risk factors and specific symptoms. A p-value of less than 0.05 was the threshold for the statistical significance [14].

First, we analysed the data by studying the relationship between the occupational factors and the symptoms indicative of the TCS present in the Boston scale, clustered into the three groups mentioned above: pain (the severity of night pain, the frequency with which the patient woke up during the night due to the pain, the length of the episode, the frequency and duration of a painful episode during the day), sensory function impairment (the presence of hand numbness or tingling, the frequency with which a patient woke up during the night due to hand numbness or tingling) and motor function impairment (hand or wrist weakness, the presence of difficulty when grasping and using small objects such as keys or pens). For each group, the mean, the standard deviation and the 75th percentile were calculated. Participants with a score equal to or above the 75th percentile were considered patients with a high risk of pain (equivalent to a score above 6), sensory function impairment (equivalent to a score above 6) or motor function impairment (equivalent to a score above 4).

Through the multiple regression method, we identified which occupational risk factors were associated with each of the above-mentioned groups. Similarly, we studied the relationship between non-occupational risk factors such as the total number of computer usage hours outside of work, demographical factors, BMI, smoking, comorbidities and the presence of one of the high-risk symptom groups for CTS. We entered both the occupational and non-occupational risk factors found statistically significantly associated with each of the CTS symptom groups into a multiple regression equation and then selected only those that remained statistically supported [14].

Results

We collected data from 130 office workers from various domains and analyzed the general characteristics of this sample. As stated before, we divided the recorded risk factors for CTS into occupational and non-occupational (Table 1, Table 2).

From the non-occupational CTS risk factors standpoint, the sample included in the study had the following general characteristics: 59 % were women and 57 % were smokers, with a pack-year mean index of 7.24. From a BMI standpoint, 66% had normal weight, 25% were overweight, and 8% were obese. In addition, 33% of respondents practised sports regularly, with a statistically significant negative association between BMI and level of exercise ($p = 0.01$). We found that 49% of the respondents had no comorbidities, 23% had a previous musculoskeletal pathology, 5% had a history of diabetes, 8% had

hypertension, another 8% had hypothyroidism, and 4% had a diagnosis of CTS.

Table 1. Non-occupational risk factors for CTS

Non-occupational risk factors for CTS	Total (N=130)	High pain score (N=29)	High sensitivity impairment score (N=31)	High motor impairment score (N=17)
Age (years)(average ± StDev)	40.86±19.8	44.03±8.08*	43.42±8.8*	45.75±5.17
Gender				
Women (N, %)	77 (59.23%)	23 (79.31%)*	19 (61.29%)	10 (58.83%)
Men (N, %)	53 (40.76%)	6 (20.69%)	12 (38.71%)	7 (41.17%)
Education				
High school	9 (6.925)	5 (17.24%)*	3 (9.68%)	1 (5.88%)
University	121 (93.07%)	24 (82.75%)	28 (90.32%)	16 (94.12%)
BMI (kg/m^2)				
< 18.5	1 (0.76%)	0 (0%)	0 (0%)	0 (0%)
>18.5-25	86 (66.15%)	23 (79.31%)	23 (74.19%)	13 (76.47%)
>25-30	33 (25.38%)	4 (13.79%)	4 (16.13%)	2 (11.76%)
>30	10 (7.69%)	2 (6.89%)	2 (9.68%)	2 (11.76%)
Pack-years (average ± StDev)	7.3±9.76	12.41±11.36*	9.52±10.63	13.78±12.77*
Smokers				
Smokers (N, %)	56 (43.07%)	9 (31.03%)	12 (38.71%)	6 (35.29%)
Non smokers (N, %)	74 (56.92%)	20 (68.97%)	19 (61.29%)	11(64.71%)
Computer hours/day apart from the working hours (average ± StDev)	1.7 ± 2.39	0.6±0.88*	1.21±2.34*	0.25±0.58*

StDev: standard deviation
* $p < 0.05$
Note: Comparisons for statistical significance were performed inside each of the study groups (e.g. subjects with high pain scores versus subjects with low pain scores), using the chi-square test for nonparametric values and the Mann-Whitney test for the numerical ones.

As seen in Table 1, there was a relatively wide range of ages in our sample. There was also considerable variability in smoking habits (as indicated by the standard deviation of pack years). The computer usage habits of the sample also showed a high degree of variability among the participants.

From the occupational risk factors standpoint, the study group had the following general characteristics: the mean number of work-related computer usage hours per day was 7.97, the mean number of computer usage hours per day was 9.67 and the mean number of years with this program was 12.78. Using this data, we estimated an average of 33502 hours of computer usage during a respondent's lifetime.

In terms of ergonomic risk factors, we found that 58% typed at a keyboard more than 4 hours a day, 74% used in their daily activity a mouse and an external keyboard, 90% considered their work chair comfortable, 81% had an adjustable work chair, 55% had a chair with adequate arm support, 69% said they had appropriate alignment between keyboard, mouse and elbow level.

We evaluated the position of the different segments of the upper limb during work and assessed the angle between the arm and forearm supported by the work surface (50% had an angle greater than 90 degrees, 50% had an angle smaller than 90 degrees) and the angle between hand and forearm (47% had a perfect alignment, 38% had a hand flexion of 15 degrees, 15% had a hand extension of 15 degrees).

Table 2. Occupational risk factors for CTS

Occupational risk factors	Total (N=130)	High pain score (N=29)	High sensitivity impairment score (N=31)	High motor impairment score (N=17)
External keyboard				
Yes (N, %)	56 (43.07%)	14 (51.73%)	13 (41.93%)	9 (52.94%)
No (N, %)	74 (56.92%)	15 (48.27%)	18 (58.06%)	8 (47.06%)
Adjustable chair				
Yes (N, %)	24 (18.46%)	5 (17.24%)	4 (12.9%)	4 (23.53%)
No (N, %)	106 (81.54%)	24 (82.76%)	27 (87.1%)	13 (76.47%)
Elbow support				
Yes (N, %)	59 (45.38%)	18 (62.07%)*	17 (54.84%)	12 (70.59%)*
No (N, %)	71 (54.62%)	11 (15.49%)	14 (45.16%)	5 (29.41%)
Appropriate alignment between keyboard, mouse and elbow				
Yes (N, %)	40 (30.77%)	11 (37.93%)	10 (32.26%)	5 (29.41%)
No (N, %)	90 (69.23%)	18 (62.07%)	21 (67.74%)	12 (70.59%)
Type of tasting				
one hand (N, %)	57 (43.85%)	5 (17.24%)	7 (22.58%)	3 (17.66%)
predominatly one hand (N, %)	51 (39.23%)	13 (44.83%)	14 (45.16%)	7 (41.17%)
both hands (N, %)	22 (16.92%)	11 (37.93%)	10 (32.26%)	7 (41.17%)
The angle between the arm and forearm, when the forearm is supported by the work surface				
> 90° (N, %)	81 (62.31%)	21 (72.41%)	22 (70.97%)	13 (76.47%)
≈ 90° (N, %)	33 (25.38%)	5 (17.24%)	5 (16.13%)	2 (11.76%)
< 90° (N, %)	16 (12.31%)	3 (10.35%)	4 (12.9%)	2 (11.76%)
The angle between hand and forearm during typing				
angle of 0° (N, %)	61 (46.92%)	15 (51.72%)	11 (35.48%)	10 (58.83%)
hand flexion of 15° (N, %)	50 (38.46%)	12 (41.38%)	15 (48.39%)	7 (41.17%)
hand extension of 15° (N, %)	19 (14.62%)	2 (6.9%)	5 (16.13%)	0 (0%)
Work organization (breaks)				
break after 1h (N, %)	34 (26.15%)	7 (24.14%)	8 (25.81%)	4 (23.53%)
break after 2h (N, %)	25 (19.23%)	5 (17.24%)	6 (19.35%)	3 (17.65%)
break after 3h (N, %)	50 (38.46%)	10 (34.48%)	10 (32.26%)	7 (41.17%)
flexible schedule for breaks (N, %)	21 (16.15%)	7 (24.14%)	7 (22.58%)	3 (17.65%)

From Table 2, the following data can be inferred: the majority of the participants in this study use a mouse and keyboard during their daily work activities, with a higher-than-average incidence of this happening in the groups with a high pain score and high motor impairment score, and few have an adjustable chair at work. However, the use of a chair with adequate arm support is relatively frequent and even more frequent in groups with a high CTS symptom score.

The majority do not have an appropriate alignment between the keyboard, mouse and elbow during computer work, and do not respect the in-place recommendations for the elbow or wrist angles during work.

Typing with both hands is more frequent in the groups with a high CTS symptom score, but did not reach the statistical significance threshold.

The majority has an 8-hour work day, and the most frequent structuring of this working time is to take a break after 3 hours. However, a quarter of them respect the recommendation to take a break after each hour of work.

We further analysed specific variables that may contribute to this relationship through logistic regression. The data obtained has been summarised in Tables 3-10.

Table 3. Multivariate correlation between non-occupational risk factors and pain

Non-occupational risk factors and pain	Beta	p-value	Odds Ratio	LCL	UCL
Age (number of years)	-0.003	0.8	0.99	0.97	1.02
Gender (M=0; W=1)	1.45	0.015	4.27	1.33	13,7
Level of education (University level =1; High school level=0)	-0.96	0.24	0.38	0.08	1.88
BMI	0.15	0.014	1.16	1.03	1,32
Pack-years	-0.02	0.57	0.98	0,93	1.04
Computer hours/day apart from the working hours	0.19	0.04	1.21	1.01	1.45

Table 4. Multivariate correlation between occupational risk factors and pain

Occupational risk factors and pain	Beta	p-value	Odds Ratio	LCL	UCL
Mouse and an external keyboard	0.45	0.38	1.56	0.57	4.25
Number of work-related computer usage hours/day	-0.34	0.012	0.71	0.54	0.93
Adequate arm support	-1.97	0.002	0.14	0.04	0.49
Appropriate alignment between keyboard, mouse and elbow	-0.95	0.2	0.39	0.09	1.63
Type of tasting	-0.14	0.7	0.87	0.42	1.78
The angle between the arm and forearm, when the forearm is supported by the work surface	-0.66	0.09	0.51	0.24	1.1
The angle between hand and forearm during typing	-0.11	0.71	0.89	0.49	1.62
Work organization (breaks)	0.14	0.56	1.15	0.72	1.81

Table 5. Multivariate correlation between occupational and non-occupational risk factors and pain

Risk factors	Beta	p-value	Odds Ratio	LCL	UCL
Gender (M=0; W=1)	1.76	0.005	5.8	1.68	20.02
BMI	0.14	0.03	1.15	1.01	1.3
Work-related computer usage hours/day	0.11	0.24	1.12	0.93	1.34
Computer hours/day apart from the working hours	-0.29	0.03	0.75	0.57	0.97
Adequate arm support	-1.87	0.003	0.15	0.044	0.54

Logistic regression tests showed that pain is mostly associated with the following non-occupational CTS risk factors: female sex, high BMI and a higher number of hours spent in front of the computer outside of work hours and the following occupational CTS risk factors: mean number of work-related computer usage per day and having a chair with adequate arm support. Additional logistic regression tests for these selected risk factors showed that being female, having a higher BMI and not having a chair with adequate arm support have higher odds of resulting in the development of pain. The classification model's quality has been assessed through a confusion matrix and showed high accuracy (78%) and specificity (95%). However, the model's precision is moderate and the recall sensitivity is low, both reflected in a low F1 score of 0.47.

Table 6. Correlations between non-occupational risk factors for CTS and sensory impairment

Non-occupational risk factors and Sensory Impairment	Beta	p-value	Odds Ratio	LCL	UCL
Age (years)	0.006	0.55	1.006	0.99	1.03
Sex (M=0; W=1)	0.17	0.72	1.18	0.47	2.96
Level of education (University =1; High school =0)	-0.91	0.26	0.4	0.08	1.94
BMI	-0.008	0.89	0.99	0.88	1.12
Pack-year	0.02	0.27	1.025	0.98	1.07
Computer hours/day apart from the working hours	-0.12	0.27	0.89	0.71	1.1

Table 7. Correlations between occupational risk factors and Sensory Impairment

Occupational risk factors and Sensory Impairment	Beta	p-value	Odds Ratio	LCL	UCL
External keyboard	-0.87	0.06	0.42	0.17	1.04
Work-related computer hours/ day	0.21	0.19	1.24	0.9	1.7
Adequate arm support	0.24	0.64	1.27	0.5	3.45
Appropriate alignment between keyboard, mouse and elbow level	-0.28	0.6	0.75	0.26	2.17
Type of tasting	0.84	0.008	2.31	1.24	4.33
The angle between the arm and forearm	-0.01	0.97	0.99	0.51	1.91
The angle between hand and forearm when typing	0.44	0.16	1.56	0.84	2.89
Work schedule (breaks)	0.05	0.81	1.05	0.69	1.61

Logistic regression tests showed that sensory function impairment is not associated with non-occupational CTS risk factors but is associated with computer typing. Namely, individuals who type with one hand have approximately 2.31 times higher odds of developing CTS and sensory function impairment compared to those typing with both hands for an equal amount of time. There was also a moderate negative correlation, close to the statistical threshold, between using a mouse and a keyboard and developing sensory function impairment.

Table 8. Correlations between non-occupational risk factors for CTS and motor function impairment

Non-occupational risk factors and Motor Impairment	Beta	p-value	Odds Ratio	LCL	UCL
Age (number of years)	0.03	0.14	1.03	0.99	1.06
Gender (M=0; F=1)	0.57	0.39	1.77	0.48	6.56
Level of education (University level =1; Highschool level=0)	-0.17	0.89	0.84	0.07	10.27
BMI	0.05	0.57	1.05	0.88	1.26
Pack-year	0.04	0.12	1.04	0.99	1.1
Computer hours/day apart from the working hours	-1.32	0.01	0.27	0.1	0.72

Table 9. Correlations between occupational Risk factors for CTS and motor function impairment

Occupational risk factors and Motor Impairment	Beta	p-value	Odds Ratio	LCL	UCL
External keyboard	0.005	0.99	1.005	0.3	3.32
Work-related computer usage hours per day	0.18	0.4	1.2	0.78	1.84
Adequate arm support	1.34	0.04	3.83	1.05	14.01
Appropriate alignment between keyboard, mouse and elbow level	-0.88	0.19	0.42	0.11	1.56
Type of tasting	1.12	0.01	3.05	1.3	7.2
The angle between the arm and forearm, when the forearm is supported	-0.16	0.72	0.85	0.36	2.02
The angle between hand and forearm during typing	-1.02	0.07	0.36	0.12	1.08
Work schedule (breaks)	0.15	0.6	1.16	0.66	2.02

Table 10. Final correlations between occupational risk factors for CTS and motor function impairment

Occupational risk factors and motor impairment	Beta	p-value	Odds Ratio	LCL	UCL
Computer hours/day apart from the working hours	-0.93	0.05	0.39	0.16	0.99
Adequate arm support	0.23	0.72	1.26	0.36	4.35
Type of tasting	0.72	0.08	2.06	0.92	4.59

Logistic regression tests showed that motor function impairment is mostly associated with the following non-occupational CTS risk factor: a higher number of hours spent in front of the computer outside of work hours and the following occupational CTS risk factors: using both a mouse and an external keyboard for computer input, having a chair with adequate arm support and computer typing (individuals who type with one hand have approximately 3.05 times higher odds compared to those who type with both hands for an equal amount of time). Additional logistic regression tests for these selected risk factors showed that a higher number of hours spent in front of the computer outside of work hours has higher odds of resulting in both CTS and motor function impairment.

Discussion

In this study, we evaluated 130 office workers, and we analysed the complex relationships between occupational and non-occupational CTS risk factors and CTS symptoms (grouped as pain, sensory function impairment and motor function impairment). Our analysis showed that the non-occupational risk factors primarily associated with the development of CTS-related symptoms are the female sex, a high BMI, and a lower number of hours spent on the computer outside of work. The shorter time spent on the computer outside of work hours may indicate the current status of CTS and may be a way for the worker to alleviate their symptoms. These findings are in accordance with the previous studies conducted on CTS development, which showed a higher ratio of females to males in CTS patients [16-18]. Some studies suggest that these differences may be related to the higher gender-specific contribution of the female sex participants in the household chores [19] and a higher rate of CTS diagnosis in patients with higher BMI [20-22]. What our study highlighted regarding CTS-related symptoms is that pain is chiefly associated with both the female sex and a higher BMI. Thus, there is a need for specific preventive measures in this group. It supports the idea that lowering the BMI might have some benefit in alleviating the pain associated with CTS. This suggestion is backed by the multiple pathological links between CTS and obesity [23]. For the clinical practitioners, it is also important to note that patients presenting with CTS and pain are predominantly women who would likely need more frequently the prescription of NSAIDs. These are preliminary findings, and a larger dataset, in association with longitudinal studies, is necessary for further confirmations. Additionally, the treatment and prevention of CTS' different clinical presentations would benefit from a targeted, individual approach.

In our study, the occupational risk factors primarily associated with CTS-related symptoms are the number of work-related computer usage per day, having a chair with adequate arm support, using both a mouse and an external keyboard and computer typing with one hand. While it was clear that the number of working hours on the computer was a significant risk factor, and using an external mouse and keyboard were protective factors, the presence of elbow support in high-pain and high-motor impairment groups was somewhat puzzling. However, since our study was cross-sectional and did not investigate the use of elbow support before or after the start of the symptoms, we cannot draw any definitive conclusions from this data. We can only speculate that either the elbow support is used to alleviate the symptoms or it isn't adequate. One possible explanation for the latter is the lack of adjustable seats, which was a common issue in 81.54% of the total sample, but at this stage, this is purely speculative.

Our study has found that individuals who type with one hand have 2.31 times increased odds of sensory function impairment and 3.05 times increased odds of motor function impairment compared to individuals typing with both hands. Typing is a complex movement, with previous research showing that the intervals between key presses are lower when typing is done by hand alternation instead of hand repetition [24]. However, the number of hand movements and not the cycle time is the best predictor of the CTS [25], so we have to take into consideration when we interpret these results that the total number of movements by the dominant hand in one hand typers is double than in two-hand typers. These results are consistent with previous studies [24-26].

A unique aspect of our research is our analysis of how different occupational and non-occupational risk factors contribute to the development of specific CTS symptoms like pain, sensitivity, and motor function impairment. This approach can help tailor prevention and treatment strategies for individuals based on their particular symptoms. Through the logistic regression analysis, we concluded that while sensory function impairment is chiefly associated with occupational factors such as computer typing with one hand, motor function impairment is associated with both non-occupational risk factors: number of hours on the computer outside of work, and occupational risk factors like using both a mouse and an external

keyboard, having a chair with adequate arm support and typing with one hand. These findings are consistent with previous meta-analyses done on the subject of computer use and CTS [27-28] that show long hours of computer usage, and the use of a mouse and keyboard as minor risk factors in CTS.

Taking into account the diversity of the risk factors associated with the development of CTS-related symptoms and the clear involvement of occupational risk factors, it is highly advisable that ergonomic improvements should be made in the workplace to reduce the prevalence of inadequate work chairs, with a presumed impact on the motor function impairment associated with CTS, as well as further education should be made on healthy computer usage habits such as two hand computer typing and the promotion of regular breaks from computer typing, with potential benefits on all subtypes of CTS-related symptoms.

Conclusion

While both occupational and non-occupational risk factors contribute to the development of CTS-related symptoms, this study tries to emphasize the importance of a targeted, individual approach in the treatment of CTS, as well as the need for ergonomic improvements in the workplace and education on computer usage habits. Further studies are needed for the confirmation of the data presented here.

References

1. Anisur Rahman, Ian Giles. Rheumatology. In: Adam Feather, David Rhonda, Mona Waterhouse. Kumar and Clarke's Clinical Medicine. 10th edition., Elsevier Ltd; 2021. p 420-443.
2. Musculoskeletal disorders. In: Latha Ganti, David Lebowitz, Javier Rosario, Ariel Vera. Step-U to USMLE STEP 2 CK. 5th edition. Wolters Kluwer Health; 2014. p 117-128.
3. Newington L, Harris EC, Walker-Bone K. Carpal tunnel syndrome and work. Best Pract Res Clin Rheumatol. 2015 Jun;29(3):440-53. doi: 10.1016/j.berh.2015.04.026.
4. Trillos-Chacón MC, Castillo-M JA, Tolosa-Guzman I, Sánchez Medina AF, Ballesteros SM. Strategies for the prevention of carpal tunnel syndrome in the workplace: A systematic review. Appl Ergon. 2021 May;93:103353. doi: 10.1016/j.apergo.2020.103353.
5. Balogh I, Arvidsson I, Björk J, Hansson GÅ, Ohlsson K, Skerfving S, Nordander C. Work-related neck and upper limb disorders - quantitative exposure-response relationships adjusted for personal characteristics and psychosocial conditions. BMC Musculoskelet Disord. 2019 Apr 1;20(1):139. doi: 10.1186/s12891-019-2491-6.
6. Harris AHS, Ding Q, Trickey AW, Finlay AK, Schmidt EM, Curtin CM, Sears ED, Yoshida R, Lashgari D, Nuckols TK, Kamal RN. Do Proposed Quality Measures for Carpal Tunnel Release Reveal Important Quality Gaps and Are They Reliable? Clin Orthop Relat Res. 2022 Sep 1;480(9):1743-1750. doi: 10.1097/CORR.0000000000002175.
7. Jerosch-Herold C, Leite JC, Song F. A systematic review of outcomes assessed in randomized controlled trials of surgical interventions for carpal tunnel syndrome using the International Classification of Functioning, Disability and Health (ICF) as a reference tool. BMC Musculoskelet Disord. 2006 Dec 5;7:96. doi: 10.1186/1471-2474-7-96.
8. Verdugo RJ, Salinas RS, Castillo J, Cea JG. Surgical versus non-surgical treatment for carpal tunnel syndrome. Cochrane Database Syst Rev. 2003;(3):CD001552. doi: 10.1002/14651858.CD001552.
9. Gerritsen AA, de Vet HC, Scholten RJ, Bertelsmann FW, de Krom MC, Bouter LM. Splinting vs surgery in the treatment of carpal tunnel syndrome: a randomized controlled trial. JAMA. 2002 Sep 11;288(10):1245-51. doi: 10.1001/jama.288.10.1245.
10. Ly-Pen D, Andréu JL, de Blas G, Sánchez-Olaso A, Millán I. Surgical decompression versus local steroid injection in carpal tunnel syndrome: a one-year, prospective, randomized, open, controlled clinical trial. Arthritis Rheum. 2005 Feb;52(2):612-9. doi: 10.1002/art.20767.
11. Scholten RJ, Mink van der Molen A, Uitdehaag BM, Bouter LM, de Vet HC. Surgical treatment options for carpal tunnel syndrome. Cochrane Database Syst Rev. 2007 Oct 17;2007(4):CD003905. doi: 10.1002/14651858.CD003905.pub3.
12. Sanati KA, Mansouri M, Macdonald D, Ghafghazi S, Macdonald E, Yadegarfar G. Surgical techniques and return to work following carpal tunnel release: a systematic review and meta-analysis. J Occup Rehabil. 2011 Dec;21(4):474-81. doi: 10.1007/s10926-011-9310-8.
13. Schulze DG, Nilsen KB, Killingmo RM, Zwart JA, Grotle M. Clinical Utility of the 6-Item CTS, Boston-CTS, and Hand-Diagram for Carpal Tunnel Syndrome. Front Neurol. 2021 Jul 27;12:683807. doi: 10.3389/fneur.2021.683807.
14. Axente DT, Sindromul de tunel carpian asociat personalului cu munca de birou, 2023.
15. Mokhtarinia HR, Parsons D, Bain CR, Gabel CP. Independent risk factors of carpal tunnel syndrome: Assessment of body mass index, hand, wrist and finger anthropometric measurements. Work. 2022;73(1):157-164. doi: 10.3233/WOR-210910.
16. Evanoff B, Zeringue A, Franzblau A, Dale AM. Using job-title-based physical exposures from O*NET in an epidemiological study of carpal tunnel syndrome. Hum Factors. 2014 Feb;56(1):166-77. doi: 10.1177/0018720813496567.
17. Nicolakakis N, Stock SR, Abrahamowicz M, Kline R, Messing K. Relations between work and upper extremity musculoskeletal problems (UEMSP) and the moderating role of psychosocial work factors on the relation between computer work and UEMSP. Int Arch Occup Environ Health. 2017 Nov;90(8):751-764. doi: 10.1007/s00420-017-1236-9.
18. Nordstrom DL, Vierkant RA, DeStefano F, Layde PM. Risk factors for carpal tunnel syndrome in a general population. Occup Environ Med. 1997 Oct;54(10):734-40. doi: 10.1136/oem.54.10.734.
19. Yang Z, Cheung TW. The inclusion of homemakers as an occupation amongst people with upper limb repetitive stress injuries. Work. 2016 Sep 27;55(1):181-186. doi: 10.3233/WOR-162372.
20. Becker J, Nora DB, Gomes I, Stringari FF, Seitensus R, Panosso JS, Ehlers JC. An evaluation of gender, obesity, age and diabetes mellitus as risk factors for carpal tunnel syndrome. Clin Neurophysiol. 2002 Sep;113(9):1429-34. doi: 10.1016/s1388-2457(02)00201-8.
21. Costa R, Barros R, Campos D, Lima D, Barbosa G. An epidemiological profile of cashiers holders carpal tunnel syndrome in a grocery store chain. Work. 2012;41 Suppl 1:5794-8. doi: 10.3233/WOR-2012-0954-5794.
22. Hlebs S, Majhenic K, Vidmar G. Body mass index and

anthropometric characteristics of the hand as risk factors for carpal tunnel syndrome. Coll Antropol. 2014 Mar;38(1):219-26.
23. Otelea MR, Nartea R, Popescu FG, Covaleov A, Mitoiu BI, Nica AS. The Pathological Links between Adiposity and the Carpal Tunnel Syndrome. Curr Issues Mol Biol. 2022 Jun 8;44(6):2646-2663. doi: 10.3390/cimb44060181.
24. Cerni T, Longcamp M, Job R. Two thumbs and one index: A comparison of manual coordination in touch-typing and mobile-typing. Acta Psychol (Amst). 2016;167:16-23. doi: 10.1016/j.actpsy.2016.03.007. Erratum in: Acta Psychol (Amst). 2020;205:103045
25. Kari L. Babski-Reeves, Lesia L. Crumtpon-Young. Comparisons of measures for quantifying repetition in predicting carpal tunnel syndrome. Int J Ind Ergon. 2002;30(1):1-6 https://doi.org/10.1016/S0169-8141(02)00072-0
26. Lund CB, Mikkelsen S, Thygesen LC, Hansson GÅ, Thomsen JF. Movements of the wrist and the risk of carpal tunnel syndrome: a nationwide cohort study using objective exposure measurements. Occup Environ Med. 2019 Aug;76(8):519-526. doi: 10.1136/oemed-2018-105619.
27. Shiri R, Falah-Hassani K. Computer use and carpal tunnel syndrome: A meta-analysis. J Neurol Sci. 2015 Feb 15;349(1-2):15-9. doi: 10.1016/j.jns.2014.12.037.
28. Spahn G, Wollny J, Hartmann B, Schiele R, Hofmann GO. Metaanalyse zur Bestimmung von Risikofaktoren für das Karpaltunnelsyndrom (KTS) Teil I. Allgemeine Risikofaktoren [Metaanalysis for the evaluation of risk factors for carpal tunnel syndrome (CTS) Part I. General factors]. Z Orthop Unfall. 2012 Oct;150(5):503-15. German. doi: 10.1055/s-0032-1315345.