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Association of Occupational and Non-occupational Risk Factors with the Prevalence of Work Related Carpal Tunnel Syndrome

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Abstract *Purpose* Several occupational and personal risk factors cause the development of carpal tunnel syndrome (CTS). The purpose of the study was to evaluate both non-occupational and occupational factors associated with CTS in industrial workers. *Methods* A cross sectional study was designed with 400 industrial workers (77% male, 23% female) randomly selected. Workers' upper extremities were examined and related signs and symptoms were assessed. Questionnaires about personal and occupational risk factors were completed and suspicious cases were referred for NCV (nerve conduction velocity) testing and documentation of diagnosis. *Results* About 395 workers from automobile industry factories in Iran were assessed by interview and electrodiagnostic studies. Among 395 workers, 47 met the definition of CTS to yield a prevalence of 11.9%. These 47 workers averaged 29.85 years of age (SD = 6.28), and the mean age of the healthy group was 27.95 (SD = 4.86). 395 workers included 91 women (23%) and 304 men (77%). Using multivariate logistic regression model the largest adjusted odds ratios of personal and occupational factors for CTS were: exertion of force over one kilogram 6.38 (1.91–2.02); bending/twisting of the hands/wrists > 30°, 5.62 (0.56–55.6); history of cigarette smoking 4.68 (1.80–11.80); rapid movement of hands 4.44 (1.41–14.02); and use of vibrating tools 3.23 (1.46–7.15). *Conclusion* Some occupational factors including force exertion, bending/twisting of the hands, rapid movement of the hands and vibration are associated with CTS.

Keywords Carpal tunnel syndrome · Repetitive manual work · Electrodiagnosis · Force

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Introduction

Carpal tunnel syndrome (CTS) is a manifestation of median nerve compression within the carpal tunnel of the wrist due to increased intra-tunnel pressure from a variety of sources [1]. It has been reported that CTS is associated with certain diseases and conditions such as diabetes, hypothyroidism, pregnancy, rheumatoid arthritis, and work-related factors. In some cases, two or more of these risk factors may coexist, placing the individual at a higher risk of developing CTS [2].

Carpal tunnel syndrome is one of the most common causes of occupational disabilities. Although less than half of all cases of CTS are identified as work related in medical claims, a definitive role of work activities as the central cause of CTS is unclear [3]. In addition, the role of common lifestyle and personal characteristics as predictors of CTS has received substantially less scrutiny [4].

It seems individual factors often obscure an underlying relation between workplace factors and CTS rather than being potentially important independent causal factors [5]. Among the major medical risk factors, hormone-related disorders and/or hormone supplementation have been implicated as potential risk factors for CTS [6]. There is also evidence from case–control and cross-sectional studies that cigarette smoking and obesity may contribute to risk for CTS [7].

Tanaka et al. in a study on data from National Health Interview Survey analyzed the relationship between occupational and non-occupational factors and CTS and found that repetition and vibration remain important risk factors for work related CTS [8]. Thus it would seem reasonable to examine the role of these lifestyle factors in conjunction with medical risk and potential exposure to workplace-related ergonomic stressors in explaining of the cause of CTS.

The purpose of this study was to examine workers with a moderately high risk occupation to identify factors that influence the development of CTS; we determined suspicious cases by physical examination and with standardized questionnaires, and referred them for further evaluation by conducting NCV study. Finally, CTS cases were compared with workers free from CTS.

Materials and Methods

This was a cross sectional study of industrial workers who were randomly selected from three factories in Iran. There are only two major auto factories in Iran: the most important one with 28,000 workers and the second one, with 6,000 workers. The other factories in Iran are much smaller. We selected our cases from these two factories and another smaller one. Not all of the workers have been invited to participate, workers were selected randomly. About 456 workers were selected. Of these 456 workers 400 agreed to participate in the study.

All subjects underwent a directed physical examination of the upper extremities and history taking. Two questionnaires were completed for all participants. One questionnaire inquired about occupational and non-occupational risk factors. The other questionnaire concerned symptoms and signs of the syndrome and it included a hand diagram. The physician decision regarding whether the patient was suspicious or not was made according to the results of the history and clinical exam (guided by the questionnaire) as well as the hand diagram.

Classification of symptom quality and location for use with hand diagrams or focused questions, modified from Katz and Stirrat [9] and Franzblau et al. [10], was used as follows: The patient who had classic/probable symptoms (numbness, tingling, burning or pain in at least 2 of digits 1, 2, or 3; palm pain, wrist pain, or radiation proximal to the wrist) regardless of the signs (positiveness of Phalen test or Tinel sign and 2-point discrimination) was regarded as suspicious. The patient who had possible symptoms (tingling, numbness, burning, or pain in at least 1of digits 1, 2, or 3) and also had at least one positive sign was also regarded as suspicious. Rempel et al. also used this symptom questionnaire (Katz Hand Diagram) to classify symptoms as “classic/probable”, “possible” or “unlikely” [11]. Participants’ were weighed and height was also recorded.

Suspicious CTS patients underwent electrodiagnostic testing. Although there is no true gold standard for the definition of CTS, we used electrodiagnostic studies to confirm a median nerve abnormality in workers with suspected CTS. Our electrodiagnostic criteria were: Median distal motor latency >4.5 ms/8 cm and median-ulnar palmar sensory latency difference >0.3 ms.

Those workers who did not have CTS were considered as “controls”. The ethics committee of university approved the study. Written informed consents were obtained from participants.

A univariate analysis using t test or χ^2 analysis was performed on the two groups (CTS cases vs. healthy workers) comparing them for baseline demographics, medical history, ergonomic stresses, psychosocial factors, and electrophysiological results. Multivariate logistical regression was performed using CTS as the dependent variable to examine the contributions of the following independent variables: age, gender, race, body mass index (BMI), smoking, education, and marital status (as non work-related variables); and bend/twist of wrist, force, work speed, job rotation and vibration (as work-related variables). SPSS 10 was used for statistical analysis. P-value was considered to be 0.05.

Results

About 400 workers agreed to participate in the study but 5 workers were excluded because they had a history of wrist trauma. Of the 395 workers included in the study, 75 workers were suspicious of CTS .We conducted NCV test for all of suspicious cases to detect true cases. The electrodiagnostic test was positive in 47(62.6%) of these 75 suspicious cases. So, overall prevalence of CTS in our sample was 11.9%. These 47 CTS patients averaged 29.85 years of age (SD = 6.28), and the mean age of the healthy group was 27.95 years (SD = 4.86). The 395 workers included 91 women (23%) and 304 men (77%).

The results of univariate regression analyses examining the relationship of all workplace factors and personal characteristics to CTS are shown in Table 1. Male gender, marriage, and cigarette smoking were significant predictors of CTS. Among the group of workplace factors included in this analysis, using vibratory tools, force exertion over 1 Kgf, high speed manual work, bending/twisting of hands/wrists, and longer breaks were significantly associated with

Table 1 Univariate odd ratios for relationship of workplace variables and lifestyle factors to CTS in industrial workers

Variable	H group no (%)	CTS group no (%)	Odd ratio (95% confidence interval)	*P* value
Gender (male/female)	259 (74.4)/89 (25.6)	45 (95.7)/2 (4.3)	7.73 (1.88–32.52)	0.00
Marital status	192 (55.2)	35 (74.5)	2.37 (1.19–4.71)	0.01
Cigarette smoking	23 (6.6)	16 (34.0)	7.29 (3.49–15.23)	0.00
Hormone diseases	8 (2.3)	1 (2.1)	0.92 (0.11–7.55)	0.94
Hormone drug	17 (4.9)	1 (2.1)	0.42 (0.05–3.25)	0.39
Rheumatologic disease	1 (0.3)	0 (0.0)	0.88 (0.85–0.91)	0.61
Force exertion >1 kgf	155 (44.7)	43 (91.5)	13.31 (4.67–37.90)	0.00
Rapid hand movement	237 (68.3)	41 (87.2)	3.17 (1.30–7.69)	0.004
Break time >75 min	215 (62.0)	40 (85.1)	3.50 (1.52–8.06)	0.001
Wrist bending/twisting	247 (71.2)	46 (97.9)	18.62 (2.53–136.88)	0.000
Job rotation	193 (55.6)	25 (53.2)	0.90 (0.49–1.67)	0.75
Using vibratory tools	97 (28.0)	34 (72.3)	6.74 (3.41–13.31)	0.000

Table 2 Comparison of quantitative variables in CTS group and control (H) group

Variable	H group	CTS group	*P* value
Age (mean ± SD) (years)	27.9 ± 4.8	29.8 ± 6.2	0.05*
Cigarette smoking duration (mean ± SD) (years)	0.59 ± 2.52	3.68 ± 6.47	0.002*
Job duration (mean ± SD) (years)	5.1 ± 4.3	6.2 ± 4.46	0.12*
BMI (mean ± SD) (kg/m^2)	24.31 ± 3.67	24.43 ± 3.28	0.80*

* Student *t*-test

CTS (Table 1). Quantitative risk factors are shown in Table 2.

When we performed multivariate logistic regression analyses, among the group of workplace factors included in these analyses, the presence of vibratory tasks, force exertion more than 1 kgf, and high speed manual work were the only workplace factors significantly associated with CTS. Other workplace factors did not approach conventional levels of statistical significance (Table 3).

Table 3 Multivariate odd ratios for relationship of workplace variables and lifestyle factors to CTS in industrial workers (Cox and Snell $r^2 = 0.21$, Nagelkerke $r^2 = 0.40$)

Variable	Odd ratio (95% confidence interval)	*P* value
Age	1.08 (0.99–1.18)	0.05
Gender (male/female)	0.27 (0.30–2.09)	0.21
BMI	0.94 (0.86–1.04)	0.27
Marital status	0.85 (0.34–2.13)	0.74
Cigarette smoking	4.68 (1.80–11.80)	0.001
Education	0.19 (0.05–0.66)	0.009
Job duration	0.93 (0.79–1.01)	0.45
Force exertion >1 kgf	6.38 (1.91–2.02)	0.003
Rapid hand movement	4.44 (1.41–14.02)	0.01
Break time >75 min	1.22 (0.54–6.79)	0.31
Wrist bending/twisting	5.62 (0.56–55.6)	0.14
Job rotation	0.72 (0.33–1.58)	0.42
Using vibratory tools	3.23 (1.46–7.15)	0.004

Discussion

The incidence of disorders associated with repetitive trauma has increased dramatically during these recent years. Since the major portion of these disorders is CTS, there has been much debate as to whether or not repetitive manual work is a risk factor for CTS and, if so, to what extent. The degree of work-relatedness of CTS reported in the literature ranged from very high to very low.

The purpose of our study was to determine the occupational and non-occupational risk factors affecting CTS and also to estimate prevalence rate in these industrial workers.

There is no perfect gold standard for CTS. Electrodiagnostic study findings are considered the most accurate single test. The combination of electrodiagnostic findings and symptom characteristics provides the most accurate CTS diagnosis. Physical examination findings add little diagnostic value if electrodiagnostic findings and symptom characteristics are available [11]. Patients may report symptoms of numbness, tingling, and/or burning in any or all of the fingers. The hand symptom diagram is useful in documenting the distribution of symptoms and has high sensitivity and specificity even when used alone. Using this diagram, symptoms may fit a classic, probable, or unlikely pattern [12].

We selected our suspicious cases according to symptom characteristics, using hand diagram and demographic and occupational risk factor (this leads into questionnaires). Suspicious cases underwent electrodiagnostic studies to be confirmed as definite cases, as previously mentioned.

The estimated prevalence rates for CTS have been 1–5% in the general population [13] and 5–15% in the industrial setting [14]. In our study 11.9% of industrial workers with manual work were diagnosed with CTS. In a follow up study lasting for 11 years, Nathan et al. reported CTS prevalence among industrial workers about 13% [15]. In a National Health Interview Survey, Tanaka et al. studied 30,074 workers and reported a prevalence of 1.5% [8]. In general, prospective studies that used active surveillance, produced rates that were 10–100 times greater than prospective studies that relied on passive surveillance (e.g., workers' compensation cases) [16, 17]. Hagberg et al. completed a survey on work related CTS prevalence. They indicated widespread range of prevalence (0.6–61%) regarding to the occupation [18].

According to the results of our study, force exertion >1 kgf, high speed manual work, and using vibratory tools, are the only occupational factors significantly associated with CTS. (Odds ratios 6.38, 4.44, 3.23, respectively) High speed manual work was determined during interview and was described as working on an assembly line.

Tanaka et al. have also studied occupational factors. Among these factors, wrist bending/twisting and using vibratory tools were the only occupational factors significantly associated with CTS. Adjusted odds ratios for exposure to bending/twisting was 5.5 and for vibration, 1.9 [8]. As previously mentioned in our study bending/twisting was not significantly associated with CTS (bending >30^ was positive).

In another study force exertion >1 kgf, shortest elementary operation <10 s, lack of change in tasks or lack of breaks for at least 15% of the daily work time, and the lack of job rotation were associated with CTS. No posture of the upper limb was associated with CTS [19]. In our study, job rotation and also short breaks (less than one hour and a quarter which is usual breaks for workers) were not significant. The explanation might be the similar time for breaks in all groups of workers.

Non-occupational factors were also assessed in our study. The adjusted odds ratio (AOR) for cigarette smoking was the highest (AOR = 4.68, P value = 0.001). Nathan et al. found significant relationship for cigarette smoking as we have in our study [15].

AOR of the other personal factors such as age, marital status, BMI, was not significant. AOR for age was 1.08 (P value = 0.05), and it can be concluded that the risk increase by 1.08 each year. Nathan et al. found age factor as an important risk factor over 50 (AOR = 15.88, P value = 0.001), [15]; but in our study most of the workers were young, so we cannot judge age accurately. The issue of age is not related to the greater prevalence of CTS in men. The mean age of female workers was 27.99 years ± 6.28 in comparison with male workers mean age, 28.24 years ± 4.67, which shows that difference is not significant.

BMI did not show a significant relationship in our model, in contrast to other studies [8, 15]. Obesity has been associated with CTS in previous studies [20]. The reason for this discrepancy might be the difference in patient characteristics like, race, age, and sex between our cases and the cases in the other studies. Another study supporting the hypothesis of higher BMI increases CTS development indicates that individuals who were classified as obese (BMI > 29) were 2.5 times more likely than slender individuals (BMI < 20) to be diagnosed with CTS. Although these findings are about general population, and not a younger working population who are healthier and more fit [21].

Previous studies which have examined the effect of education could not find a significant relationship [8]. But in our study AOR of education was 0.19 (P value = 0.009). This discrepancy with our sample may be explained by the fact that more educated workers start manual labor later, therefore education may be a protective factor in our sample.

We could not find significant association between gender and CTS (P value = 0.21), although there was significant association reported in other studies [8, 15]. One possible explanation for the discrepancy is that male workers engage in more risky occupations, so occupational CTS was more prevalent in men (2.19% vs. 14.8%).

In our study we could not find any association between hormonal diseases, rheumatologic diseases, hormonal drugs, and CTS incidence. Some studies have identified diabetes as a significant predictor of new-onset CTS [22]. Several cross-sectional studies have demonstrated a threefold increase in CTS among diabetics both in the workplace and the general population [4]. This discrepancy might be reflective of the worker selection in our factories in which only healthy young people are hired.

In some studies assessing occupational CTS risk factors, CTS syndrome was identified by patient self-report or medical history, so the possibility of information bias increased, but in our study case diagnosis was performed by history taking, physical examination, and NCV test making recall bias improbable. Finally, we recommend further research on psychosocial and also ergonomic factors in order to intervene and/or decrease the probability of occupational CTS development.

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