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Carpal tunnel syndrome among laboratory technicians in relation to personal and ergonomic factors at work

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Abstract: Objectives: Work-related carpal tunnel syndrome (CTS) has been reported in different occupations, including laboratory technicians, so this study was carried out to determine the prevalence and the associated personal and ergonomic factors for CTS among laboratory technicians. **Methods:** A cross-sectional study was conducted among 279 laboratory technicians at King Fahd Hospital, Saudi Arabia, who filled in a self-administered questionnaire, including questions regarding their demographic criteria, occupational history, job tasks, workplace tools, ergonomic factors at work, and symptoms suggestive of CTS. Physical examinations and electrodiagnostic studies were carried out for those who had symptoms suggestive of CTS to confirm the diagnosis. Univariate and multivariate analysis were performed for both personal and physical factors in association with confirmed CTS among laboratory technicians. **Results:** The prevalence of CTS among the laboratory technicians was 9.7% (27/279). The following were the statistically significant risk factors for CTS among them: gender (all cases of CTS were female, P=0.00), arm/hand exertion (OR: 7.96; 95% CI: 1.84-34.33), pipetting (OR: 7.27; 95% CI: 3.15-16.78), repetitive tasks (OR: 4.60; 95% CI: 1.39-15.70), using unadjustable chairs or desks (OR: 3.35; 95% CI: 1.23-9.15), and working with a biosafety cabinet (OR: 2.49; 95% CI: 1.11-5.59). CTS cases had significant longer work duration (17.9 ± 5.6 years) than CTS non-case (11.5 ± 7.4 yeas) with low OR (1.108). **Conclusion:** This study demonstrates some personal and ergonomic factors associated with CTS among the laboratory technicians, including female gender, arm/hand exertion, pipetting, repetitive tasks, working with a biosafety cabinet, and an unadjusted workstation.

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Key words: Carpal tunnel syndrome, Laboratory technicians, Personal, Physical, Work

Introduction

Carpal tunnel syndrome (CTS) is related to compression and irritation of the median nerve within the carpal tunnel in the wrist, and it is associated with certain risk factors such as diabetes, hypothyroidism, pregnancy, rheumatoid arthritis, and occupational factors[1-3]. Various studies have reported that CTS is the most common entrapment neuropathy of the upper extremity in the working populations that is associated with different work-related factors, mainly repetitive movements, forceful manual exertion, frequent twisting of the wrist, and hand-arm vibration[2,4-7]. Healthcare workers, including laboratory technicians, are at risk for developing upper extremity musculoskeletal disorders, including CTS[8-10].

Laboratory technicians are skilled workers who perform highly technical mechanical or diagnostic tests in medical or scientific laboratories using various types of machinery, laboratory equipment, and complex computer programs to perform their tests. Moreover, laboratory technicians are exposed to different ergonomic risk factors affecting their wrists, including repetitive movement, excessive force and awkward posture during pipetting, operating microtomes, working with microscopes, working with a biological safety cabinet, and using video-display terminals[11-13]. Most of the studies that investigated the prevalence and risk factors of CTS among laboratory technicians used a clinical diagnosis of CTS only. Therefore, the aim of our study is to determine the prevalence of confirmed CTS cases among laboratory technicians us-

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ing both clinical and electrodiagnostic studies (EDS), and to investigate the personal and physical factors associated with CTS among them.

Methods

A cross-sectional study was conducted from April 2015 until November 2015 among 346 laboratory technicians of the King Fahd hospital clinical laboratory. The study population was all laboratory technicians of the King Fahd hospital clinical laboratory who accepted to participate and fulfilled the inclusion and exclusion criteria. The inclusion criterion was medical technicians who worked in the King Fahd hospital clinical laboratory. The exclusion criteria were pregnancy, diabetes, hypothyroidism, rheumatoid arthritis and a history of hand trauma, and work experience of less than 12 months. A total of 281 laboratory technicians accepted to participate, but 279 of them fulfilled the inclusion and exclusion criteria forming our final study population.

Questionnaire

All participants answered a self-administered questionnaire that consisted of three parts. The first part included questions on personal data (age, gender, height, weight, education level, and smoking). The second part included questions on work history and ergonomic factors using a modified version of the Dutch Musculoskeletal Questionnaire (DMQ)[14], including questions on work experience, job tasks, working area, work postures, arm /hand exertion, repetitive tasks, moving heavy loads, work with different laboratory instruments and tools (such as pipettes, microscopes, microtomes, cryostats, cell counters, and biosafety cabinets, using computers, and other work-related ergonomic factors). The third part was a modified version of the Kamath and Stothard clinical questionnaire to define CTS[15,16], which was validated and gave a sensitivity of 85% for the scored questionnaire in comparison to 92% for EDS[15].

The clinical questionnaire of Kamath and Stothard included nine hand symptoms related to CTS: 1) wrist pain causing wake up at night (score 1 for "yes" and score 0 for "no"), 2) tingling and loss of sensation causing wake up at night (score 1 for "yes" and score 0 for "no"), 3) tingling or numbness in the morning (score 1 for "yes" and score 0 for "no"), 4) trick movements (score 1 for "yes" and score 0 for "no"), 5) tingling of the little finger (score 0 for "yes" and score 3 for "no"), 6) tingling during resting (score 1 for "yes" and score 0 for "no"), 7) neck pain (score -1 for "yes" and score 0 for "no"), 8) severe pain during pregnancy (score 1 for "yes," score -1 for "no" and score 0 for "not applicable"), and 9) relief with a splint (score 1 for "yes," score -1 for "no" and score 0 for "not applicable"). In the present study, all laboratory technicians scored 3 and above using Kamath and Stothard clinical questionnaire, were classified as probable CTS case[15].

Electrodiagnostic studies

All laboratory technicians who were classified as probable CTS case, underwent EDS, including standardized nerve conduction velocity (NCV) test performed bilaterally for both median and ulnar nerves, in addition to electromyography for abductor pollicis brevis and abductor digiti minimi in both hands (using Neuropack 2, Nihon Kohden, model MEB/MEM. 7102 A/K.02; Japan). NCV test was performed by a trained neurologist in the EDS unit of King Fahd Hospital.

Compound motor action potential was recorded over the abductor pollicis brevis for the median nerve and the abductor digiti minimi for the ulnar nerve. For motor conduction velocity test, distal stimulation was 8 cm away from the recording site and proximal stimulation was at the antecubital fossa. Conduction velocity can be calculated with a single stimulation because there is no transmission along the neuromuscular junction or muscle fibers[17]. Therefore, only one stimulation site was used at the wrist, which is identical to the distal stimulation site in the motor NCV test (14 cm proximal to the active recording electrode). The following parameters were assessed for both motor and sensory NCV: distal motor latency at the wrist and proximal motor latency at the elbow, distal sensory latency, the amplitude of compound motor action potential and sensory nerve action potential, and conduction distance and conduction velocity[17]. Although there is no true gold standard for the definition of CTS, our study used the NCV test to confirm the diagnosis of CTS[18] in laboratory technicians who were classified as probable CTS. Hence, the case definition of CTS in this study forming the CTS cases group, included all laboratory technicians had both ≥3 score (using Kamath and Stothard clinical questionnaire) and a positive NCV test in the form of median distal motor latency (8 cm) > 4.5 ms and median sensory distal latency difference ≥3.6 ms (14 cm) recorded index finger to wrist[17]. However, other laboratory technicians who did not fulfill above case definition were considered as CTS non-cases.

Ethics

The study was approved by King Abdulla International Medical Research Center (KAIMRC) in Saudi Arabia, and all participants filled out a written consent to participate in the study.

Statistical analysis

Data were analyzed using SPSS software (version 17.0 for Windows; SPSS Inc., Chicago, IL, USA). Descriptive statistics were calculated for all variables that were presented as mean and standard deviations for quantitative variables and frequencies and percentages for qualitative

variables. A Chi-square test or Fisher's exact test (for categorical data), and Student's t-test (for continuous data) were used for univariate analysis to assess the relationships between personal and ergonomic factors at work and confirmed CTS among laboratory technicians. Multivariate analysis using logistic regression was carried out for independent variables that had a significant association (P≤0.05) with the presence of confirmed CTS among laboratory technicians. The statistical significance level was set at ≤0.05.

Table 1. Personaldemographic criteria of the study population

Variable	Mean	SD
Age	37.22	9.51
BMI	26.71	4.63
Height	1.62	0.089
Weight	70.32	12.79
Work duration	12.12	7.49
	n	%
Gender		
Female	188	67.9
Male	91	32.6
Smoking		
Non-smoker	256	91.8
Current smoker	23	8.2
Education level		
High school	15	5.4
Bachelor's degree	224	80.3
Postgraduate degree	40	14.3

SD: standard deviation; BMI: body mass index

Results

The mean age of all participants was 37.22 ± 9.5 years and most of them were female (67.9%), non-smokers (91.8%), with bachelor's degrees (80.3%) and a mean BMI of 26.71 ± 4.63. Also, their mean work duration was 12.12 ± 7.49 years (Table 1).

According to the Kamath and Stothard clinical questionnaire, only 30 out of 279 laboratory technicians scored ≥3 and classified as probable CTS (10.75%). In addition, the most prevalent symptoms among them were wrist pain that can cause waking up at night, tingling and loss of sensation that cause waking, and tingling or numbness in the morning up until night (Table 2).

Only 27 out of the 30 laboratory technicians who had probable CTS by Kamath showed positive findings in the NCV test, including median distal motor latency (8 cm) > 4.5 ms and a median sensory distal latency difference of ≥ 3.6 ms, and they formed the CTS cases group representing 9.68% (27/279) of the study population. However, other laboratory technicians (n=252) constituted the CTS non-cases group (Table 3).

There was no significant difference between CTS non-cases and cases concerning age, BMI, and smoking. However, the CTS cases were all female with significantly prolonged work duration (17.9 ± 5.6 years) compared to the CTS non-case (11.5 ± 7.4 years), and most of them had bachelor's degrees (Table 4).

Work requiring exertion of the arms/hands, repetitive tasks, pipetting, and using a biosafety cabinet for long periods were significantly (P< 0.05) higher among CTS cases (92.6%, 88.9%, 59.3%, 59.3%, respectively) com-

Table 2. Results of Kamath and Stothard clinical questionnaire among 279 laboratory technicians

Hand symptoms related to CTS	Kamath and Stothard clinical questionnaire Score distribution among laboratory technicians (N=279)	
	<3 score N=249	≥3 score N=30
	n (%)	n (%)
-No symptoms	243 (97.59%)	0 (0.00%)
-Wrist pain which cause wake up at night	6 (2.41%)	30 (100.00%)
-Tingling and loss of sensation cause wake up at night	0 (0.00%)	30 (100.00%)
-Tingling or numbness in the morning	0 (0.00%)	30 (100.00%)
-Trick movements	0 (0.00%)	8 (26.67%)
-Tingling of little finger	0 (0.00%)	0 (0.00%)
-Tingling during resting	0 (0.00%)	1 (3.33%)
-Neck pain	0 (0.00%)	3 (10.00%)
-Severe pain during pregnancy	0 (0.00%)	0 (0.00%)
-Relief with a splint	0 (0.00%)	2 (6.67%)

Table 3. Results of the nerve conduction velocity (NCV) test of the laboratory technicians* who were diagnosed as probable CTS by Kamath and Stothard clinical questionnaire (n=30)

NCV results	NCV parameters	Median nerve		Ulnar nerve	
		Right mean±SD	Left mean±SD	Right mean±SD	Left mean±SD
Positive NCV (CTS cases) n=27	Motor NCV:				
	-Distal latency (ms)	4.86±0.12	3.60±0.42	2.97±0.31	2.81±0.23
	-Amplitude (mV)	6.01±1.52	7.74±0.49	8.34±0.67	7.81±1.46
	-Conduction velocity (m/s)	49.18±1.73	54.53±1.23	57.31±0.56	56.41±0.63
	Sensory NCV:				
	-Distal Latency (ms)	4.12±0.32	2.91±0.51	2.96±0.63	2.56±0.83
	-Amplitude (μV)	28.11±1.53	31.01±0.81	30.55±0.93	31.35±1.03
	-Conduction velocity (m/s)	50.01±1.92	55.65±1.34	55.73±2.01	54.81±0.93
Negative NCV n=3	Motor NCV:				
	-Distal latency (ms)	3.01±0.02	3.33±0.52	2.89±0.31	2.91±0.27
	-Amplitude (mV)	7.23±1.52	7.56±0.58	8.31±0.68	8.81±1.46
	-Conduction velocity (m/s)	58.14±1.63	55.52±1.27	56.33±0.54	57.42±0.54
	Sensory NCV:				
	-Distal Latency (ms)	2.98±0.12	2.91±0.51	2.89±0.64	2.79±0.49
	-Amplitude (μV)	32.91±1.65	31.93±0.79	30.95±0.98	30.86±1.77
	-Conduction velocity (m/s)	56.21±1.63	55.64±1.85	56.68±1.69	55.79±0.99

*All tested laboratory technicians were right handed

Table 4. Association between the prevalence of Carpal Tunnel Syndrome (CTS) and personal demographic factors and work duration among 279 laboratory technicians

Variable	CTS non-cases (N=252)		CTS Cases (N=27)		*P*
	Mean±SD		Mean±SD		
Age (years)	36.65±9.35		42.52±9.62		0.98
BMI (Kg/m^2)	26.91±4.56		24.81±4.91		0.99
Work duration (years)	11.5±7.4		17.9±5.6		0.00
	n (%)		n (%)		
Gender:					
Female	161	63.9	27	100.0	0.00
Male	91	36.1	0	0.0	
Smoking:					
Non-smoker	232	92.1	24	88.9	0.48
Current smoker	20	7.9	3	11.1	
Education level:					
High school	12	4.8	3	11.1	0.04
Bachelor's Degree	200	79.4	24	88.9	
Postgraduate	40	15.9	0	0.0	

SD: standard deviation; BMI: body mass index

pared to that among CTS non-case (61.1%, 63.5%, 16.7%, 36.9%, respectively). Moreover, CTS cases had significantly higher prevalence of using unadjustable chairs or desks (81.5%) and workbenches that did not lie on their elbow height (66.7%) compared to that of the CTS non-cases (56.7% and 46.8%, respectively). How-

Table 5. Association between the prevalence of Carpal Tunnel Syndrome (CTS) and ergonomic factors at work among 279 laboratory technician

Ergonomic Factors at work		CTS non-cases (N=252)	CTS cases (N=27)	*P*
		n (%)	n (%)	
Standing for long periods	-No	82 (32.5%)	11 (40.7%)	0.39
	-Yes	170 (67.5%)	16 (59.3%)	
Sitting for long periods	-No	104 (41.3%)	10 (37.0%)	0.84
	-Yes	145 (58.7%)	17 (63.0%)	
Working in uncomfortable bending or awkward postures	-No	159 (63.1%)	13 (48.1%)	0.15
	-Yes	93 (36.9%)	14 (51.9%)	
Arms/hands exertion	-No	98 (38.9%)	2 (7.4%)	0.00
	-Yes	154 (61.1%)	25 (92.6%)	
Repetitive tasks many times per minute	-No	92 (36.5%)	3 (11.1%)	0.00
	-Yes	160 (63.5%)	24 (88.9%)	
Moving heavy loads (more than 20 kg)	-No	196 (77.8%)	19 (70.4%)	0.47
	-Yes	56 (22.2%)	8 (29.6%)	
Pipetting for long periods	-No	210 (83.3%)	11 (40.7%)	0.00
	-Yes	42 (16.7%)	16 (59.3%)	
Using microscope for long periods	-No	167 (66.3%)	15 (55.6%)	0.31
	-Yes	85 (33.7%)	12 (44.4%)	
Using microtome for long periods	-No	238 (94.4%)	27 (100.0%)	0.21
	-Yes	14 (5.6%)	0 (0.0%)	
Working with biosafety cabinet	-No	159 (63.1%)	11 (40.7%)	0.04
	-Yes	93 (36.9%)	16 (59.3%)	
Using unadjustable chairs or desks	-No	109 (43.3%)	5 (18.5%)	0.01
	-Yes	143 (56.7%)	22 (81.5%)	
Workbench does not lie on elbow height	-No	134 (53.2%)	9 (33.3%)	0.05
	-Yes	118 (46.8%)	18 (66.7%)	

ever, there was no significant difference between CTS cases and non-cases concerning other studied physical workplace factors (Table 5).

Among the studied personal and ergonomic workplace factors, the following had a significant association with CTS among laboratory technicians: being female (all CTS cases were female), arm/hand exertion (OR: 7.96; 95% CI: 1.84-34.33), pipetting for long periods (OR: 7.27; 95% CI: 3.15-16.78), repetitive tasks (OR: 4.60; 95% CI: 1.39-15.70), using unadjustable chairs or desks (OR: 3.35; 95% CI: 1.23-9.15), and working with a biosafety cabinet (OR: 2.49; 95% CI: 1.11-5.59) (Table 6).

Discussion

The objectives of this study were to determine the prevalence of confirmed CTS cases among laboratory technicians, and to investigate the personal and ergonomic workplace factors associated with CTS among them. It is clear that there is no gold standard for CTS diagnosis, however, we used both clinical and electrodiagnostic findings to provide the most accurate CTS diagnosis[19,20]. As per our knowledge, few studies were conducted to investigate the prevalence of CTS among laboratory technicians, and they reported higher prevalence rates (21.5-22.4%)[21,22] compared to our study (9.7%), because they depended on hand symptoms and musculoskeletal questionnaires to diagnose CTS; but we used both clinical and EDS. On the other hand, the prevalence of confirmed CTS among laboratory technicians in our study was higher than that in the general population (2.7-5.8%)[18] and near to that in the industrial population[19] such as dentists and dental hygienists (7-8.4%)[13,23], construction workers (8.2-9.2%)[24,25]. However, the prevalence of CTS among our studied laboratory technicians was lower than that of fish-processing industry (73.9%)[26] and manufacturing workers (15.4%)[27].

Our study showed that CTS cases had significant higher work duration (17.9 ± 5.6 years) compared to the CTS non-cases (11.5 ± 7.4), which indicates a relationship between work exposure and development of CTS among the laboratory technicians Moreover, female gender was the only personal factor significantly associated with CTS among studied laboratory technicians. Most of

Table 6. Multivariate analysis (Crude OR) of the presence of Carpal Tunnel Syndrome (CTS) by the independent factors that showed p value ≤ 0.05 on univariate analysis, among laboratory technicians (n=279)

Factor	OR	(95 % CI)	*P*
Work duration in years	1.108	1.053-1.167	0.00
Education			
High schools (reference)			
Bachelor's degree	0.48	0.13-1.82	0.28
Postgraduate	0.00	-	0.99
Arm/hand exertion			
No (reference)			
Yes	7.96	1.84-34.33	0.00
Repetitive tasks			
No (reference)			
Yes	4.60	1.35-15.70	0.02
Pipetting			
No (reference)			
Yes	7.27	3.15-16.78	0.00
Working with Biosafety Cabinet			
No (reference)			
Yes	2.49	1.11-5.59	0.02
Workbench does not lie on elbow height			
No (reference)			
Yes	2.27	0.98-5.25	0.07
Using unadjustable chairs or desks			
No (reference)			
Yes	3.35	1.23-9.15	0.01

OR: odds ratio; CI: confidence interval

the studies that investigated the association between gender and CTS have reported that female gender is a risk factor of CTS[2,4,28]. On the other hand, our study did not reveal significant association between CTS and other personal factors such as age, smoking, and BMI, which is in contrast to other studies[4,29,30]. This might be explained by the difference in job category, race, age, gender, and CTS diagnostic methodology between our participants and those of the other studies.

The present study showed that arm/hand exertion, pipetting for long periods, repetitive tasks, shift work, using unadjustable chairs or desks, and working with a biosafety cabinet were the only occupational and ergonomic factors significantly associated with CTS among studied laboratory technicians (Odds ratios 7.96, 7.27, 4.60, 4.35, 3.35, 2.49). In general, this is in agreement with other studies and meta-analyses that summarized the main occupational risk factors of work-related CTS involving tasks requiring forceful, extensive, repetitive, or prolonged use of the wrists and hands[3,5,6,19,31].

The daily work activities of the laboratory technicians involving tasks that might cause arm/hand exertion including pipetting, handling microscopes, working with microtomes, test tube handling, labeling of pipe tubes, typing data on computers, and other tasks that might cause repeated wrist twisting that can cause median nerve compression leading to CTS[8,10,32,33]. Moreover, pipetting involves repeated forceful thumb movement pressing the plungers with repeated hand motion and wrist twisting for prolonged time, and all these movements are risk factors of CTS[9,34]. Several studies reported that workplace ergonomic is an important risk factor of work related musculoskeletal disorders, including CTS[7,9,35]. Based on that, using unadjustable chairs or desk can affect the level of the laboratory technician's elbows in relation to his workstation, causing prolonged wrist flexion or extension which might lead to CTS[5,35]. Our study showed that working with a biosafety cabinet was significant risk factor of CTS. This might be related to the ergonomic hazards that the laboratory technicians might be exposed to while working with a biosafety cabinet, including awkward and static posture of the arms and wrists, working with elbows winged, overreaching, and constrained body position, overloading muscles, tendons, and joints in an asymmetrical manner[2,33,35].

The present study has some limitations, such as the

relatively small samples and using cross-sectional analytic design depending on self-reported data, which is subject to recall bias, however, we used the NCV test for a more accurate diagnosis of CTS.

Conclusion

Our study reported a 9.7% prevalence of confirmed CTS among the laboratory technicians who are exposed to different risk factors including being female, arm/hand exertion, pipetting, repetitive tasks, working with a biosafety cabinet and an unadjusted workstation. Preventive measures should be implemented to prevent CTS occurrence among laboratory technicians including periodic medical examination, frequent assessment of workstations, ergonomic training on the proper handling and use of the laboratory tools and machines, such as pipettes, microscopes, and biosafety cabinets.

Conflict of Interest: The authors declare that there are no conflicts of interest.

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