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Prevalence of Carpal Tunnel Syndrome in Textile Workers

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ABSTRACT

Background: *Carpal tunnel syndrome (CTS) is a common entrapment neuropathy frequently associated with repetitive and forceful hand activities in occupational settings. Textile workers are particularly vulnerable due to sustained wrist movements, prolonged working hours, and limited ergonomic modifications. Despite the scale of the textile workforce in Pakistan, evidence quantifying CTS burden and associated workplace factors remains limited.* ***Objective:*** *To determine the prevalence of suspected CTS among textile workers in Lahore, Pakistan, and to examine associations between CTS and occupational risk factors including repetition frequency, work breaks, wrist stretching practices, and job role.* ***Methods:*** *A cross-sectional observational study was conducted among 160 textile workers aged 20–35 years at a textile factory in Lahore. Suspected CTS was defined by a positive Phalen test. Symptom severity and functional limitation were assessed using the Boston Carpal Tunnel Questionnaire (BCTQ). Descriptive statistics were calculated, and associations between occupational variables and Phalen-test positivity were evaluated using chi-square tests ($p < 0.05$).* ***Results:*** *The prevalence of suspected CTS was 27.5% (44/160; 95% CI 21.2%–34.9%). At least mild symptom burden and functional limitation were each reported by 30.6% of workers. Significant associations were observed between CTS and repetition frequency ($p = 0.002$), absence of wrist stretching ($p = 0.005$), lack of regular breaks ($p < 0.01$), and job role ($p = 0.040$).* ***Conclusion:*** *More than one-quarter of textile workers demonstrated clinical signs suggestive of CTS, and nearly one-third reported symptom or functional burden. Modifiable workplace factors were significantly associated with suspected CTS, underscoring the need for ergonomic interventions, scheduled breaks, and preventive education programs in textile production environments.*

Keywords: *Carpal tunnel syndrome; textile workers; Phalen test; Boston Carpal Tunnel Questionnaire; occupational health; repetitive strain injury*

INTRODUCTION

The textile industry remains a major economic driver in many low- and middle-income countries, yet its production model is inherently dependent on high-frequency, hand-intensive tasks performed for prolonged hours, creating sustained biomechanical loading of the upper limb and predisposing workers to work-related musculoskeletal disorders (WRMSDs) (1). Within this spectrum, carpal tunnel syndrome (CTS) is a common entrapment neuropathy caused by compression of the median nerve within the carpal tunnel, a confined osteofibrous passage at the wrist, where even modest increases in tunnel contents or reductions in tunnel volume can provoke nerve ischemia and altered nerve conduction (2). Individual susceptibility is influenced by non-occupational determinants including sex, age, anthropometrics, smoking, and anatomical variability, while systemic conditions such as diabetes, hypothyroidism, obesity, pregnancy-related fluid shifts, and inflammatory arthropathies may further increase risk by altering synovial or soft-tissue volume within the tunnel (3). However, occupational exposures remain central in many working populations, particularly where tasks require repetitive flexion–extension cycles, forceful gripping or pinching, awkward wrist postures, and tool- or machine-related vibration, all of which are repeatedly linked to CTS occurrence across systematic reviews and meta-analytic evidence (4).

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Clinically, CTS typically manifests with pain, nocturnal paresthesia, numbness, and tingling in the median nerve sensory distribution and may progress to weakness, reduced dexterity, and thenar muscle atrophy with prolonged compression (5). Because symptom intensity and functional impact can vary substantially across workers, case identification in occupational settings often requires pairing a symptom/functional severity assessment with an objective clinical screening sign to improve interpretability at the workplace level (2). In this context, understanding both symptom burden and functional limitation is critical, as early or subclinical CTS may exist in workers who continue to perform tasks despite minimal perceived impairment, potentially delaying preventive action until nerve compromise becomes more advanced (2).

Globally, CTS prevalence differs widely by occupation, with higher rates typically observed in repetitive manual industries and settings characterized by sustained hand–wrist loading (6). Evidence from textile-related occupations supports this concern; studies among textile industry workers and garment-related roles have reported meaningful CTS prevalence and have highlighted repetition intensity, inadequate rest breaks, and task-specific exposure as plausible contributors (7–9). Despite the scale of the textile workforce in Pakistan and the ergonomic realities of factory production lines, locally grounded evidence that simultaneously quantifies CTS screening positivity and characterizes modifiable workplace exposures (e.g., repetition rate, breaks, stretching practices, and job role) remains limited, constraining targeted prevention strategies and screening policies.

Accordingly, this study aimed to determine the prevalence of CTS among textile workers in Lahore using a standardized clinical screening sign (Phalen test) as the primary outcome and to evaluate associations between suspected CTS and workplace factors including repetition frequency, breaks, wrist stretching practices, working hours, and job role, while describing symptom severity and functional limitation using the Boston Carpal Tunnel Questionnaire (BCTQ) (2).

MATERIALS AND METHODS

A cross-sectional observational study was conducted among textile workers employed at the Sapphire Factory in Lahore, Pakistan, with data collected over a three-month period. A non-probability convenience sampling approach was used to recruit workers present during data-collection visits who met eligibility criteria and provided written informed consent. Adult male and female workers aged 20–35 years were eligible if they had been employed in the factory for at least 12 months and were working a minimum of three days per week at the time of recruitment. Workers were excluded if they reported musculoskeletal trauma within the prior six months, chronic systemic disease with potential neuropathic or endocrine contribution (including cardiac or thyroid disorders), substance abuse, or inability to understand the study purpose sufficiently to complete the questionnaire and participate in the examination.

The primary outcome was suspected CTS defined operationally as a positive Phalen test, treated as a workplace screening indicator rather than a confirmatory diagnosis (2). For the Phalen test, the participant's wrists were placed in maximal comfortable flexion with the dorsum of both hands opposed; the test was considered positive if pain, numbness, tingling, or paresthesia occurred in a median nerve distribution during the maneuver. In parallel, symptom burden and functional limitation were assessed using the Boston Carpal Tunnel Questionnaire (BCTQ), comprising the Symptom Severity Scale (SSS) and Functional Status Scale (FSS), and categorized for reporting as asymptomatic, mild, or moderate based on the study's prespecified scoring categorization approach, enabling interpretation of impairment

levels alongside the screening outcome (2). Occupational and work-related exposures were captured using a self-administered questionnaire adopted from prior similar studies and adapted for the textile setting; collected variables included sex, marital status, hand dominance, current job role (weaving, stitching, quality check, dyeing), average working hours per day (5–8 vs 9–12), presence of regular breaks during work (yes/no), wrist stretching practices (yes/no), and repetition frequency of hand/wrist movements per minute (≤10, 11–20, >20), in addition to anthropometrics (height and weight) and work experience in years.

A precision-based rationale was used to support the sample size: assuming an expected prevalence near one-quarter based on textile-occupation reports, a 95% confidence level and an absolute precision of approximately 7% yields a required sample near 147 participants; the final sample was set at 160 to preserve precision in the presence of incomplete responses and to maintain stable subgroup estimates for categorical analyses (7–9). Data were entered and analyzed in SPSS (version 26). Continuous variables (age, weight, height, years of experience) were summarized using mean and standard deviation and assessed graphically using histograms, while categorical variables were summarized using frequencies and percentages. The prevalence of suspected CTS was calculated as the proportion of workers with a positive Phalen test.

Associations between Phalen test positivity and occupational factors (repetition category, breaks, stretching practice, and job role) were evaluated using chi-square tests of association with a two-sided significance threshold of $p < 0.05$. For transparency and clinical interpretability, effect size estimates were planned as odds ratios with 95% confidence intervals derived from 2×2 (or category-collapsed) contingency tables for key exposure contrasts, reported alongside p-values. Analyses were conducted as complete-case for variables included in each test.

RESULTS

Table 1. Descriptive Statistics of Study Participants (n = 160)

Categorical Variable	Frequency (n)	Percentage (%)
Gender		
Male	**124**	**77.5**
Female	**36**	**22.5**
Marital Status		
Single	**47**	**29.4**
Married	**105**	**65.6**
Separated	**8**	**5.0**
Hand Dominance		
Right	**141**	**88.1**
Left	**19**	**11.9**
Current Job Role		
Weaving	**63**	**39.4**

Categorical Variable	Frequency (n)	Percentage (%)
Stitching	56	35.0
Quality Check	27	16.9
Dyeing	14	8.8
Average Working Hours per Day		
5–8 hours	75	46.9
9–12 hours	85	53.1
Regular Breaks During Work		
Yes	106	66.3
No	54	33.8
Wrist Stretching Practice		
Yes	30	18.8
No	130	81.3
Repetitive Hand/Wrist Movements		
≤10 times/min	33	20.6
11–20 times/min	80	50.0
>20 times/min	47	29.4
BCTQ – Symptom Severity Scale (SSS)		
Asymptomatic	111	69.4
Mild	26	16.3
Moderate	23	14.4
BCTQ – Functional Status Scale (FSS)		
Asymptomatic	111	69.4
Mild	35	21.9
Moderate	14	8.8
Phalen Test		
Positive	44	27.5
Negative	116	72.5

Ethical approval to conduct the study was obtained through the relevant academic synopsis/research approval process at the University of Lahore, and administrative permission was obtained from the factory management prior to recruitment. Participation was voluntary, confidentiality was maintained by de-identifying data prior to analysis, and written informed consent was obtained from all participants before questionnaire completion and clinical screening.

Continuous Variable	Mean ± SD
Age (years)	28.54 ± 2.63
Body weight (kg)	64.88 ± 6.48
Body height (cm)	163.81 ± 6.76
Years of experience	3.93 ± 2.13

The workforce was predominantly male (124/160, 77.5%) and married (105/160, 65.6%), with right-hand dominance reported by 141/160 (88.1%). The most common job roles were weaving (63/160, 39.4%) and stitching (56/160, 35.0%), and over half of workers reported 9–12 working hours/day (85/160, 53.1%). Regular breaks were reported by 106/160 (66.3%), whereas wrist stretching practices were uncommon (30/160, 18.8%). Repetition exposure was high: 80/160 (50.0%) reported 11–20 movements/min and 47/160 (29.4%) reported >20 movements/min. The prevalence of suspected CTS based on Phalen-test positivity was 44/160 (27.5%). On BCTQ, most workers were asymptomatic (111/160, 69.4%) on both SSS and FSS, while 49/160 (30.6%) reported at least mild symptom burden (SSS mild+moderate) and 49/160 (30.6%) reported at least mild functional limitation (FSS mild+moderate).

Table 2. Association of Suspected CTS (Phalen Test) With Occupational and Work-Related Factors

Associated Variable	P-value
Repetitive hand/wrist movements per minute	0.002
Wrist stretching practices	0.005
Regular breaks during work	< 0.01
Current job role	0.040

Phalen-test positivity showed statistically significant associations with all evaluated occupational factors: repetition frequency ($p = 0.002$), wrist stretching practice ($p = 0.005$), regular breaks ($p < 0.01$), and job role ($p = 0.040$). These findings indicate that suspected CTS in this workforce clustered meaningfully with modifiable workplace behaviors (breaks and stretching) and exposure intensity (repetition rate), as well as task assignment (job role).

Table 3. Prevalence Estimates With 95% Confidence Intervals (n = 160)

Measure	k	n	%	95% CI (low)	95% CI (high)
Phalen test positive (suspected CTS)	44	160	27.5	21.2	34.9
BCTQ symptomatic (SSS mild+moderate)	49	160	30.6	24.0	38.2
BCTQ functional limitation (FSS mild+moderate)	49	160	30.6	24.0	38.2

Precision estimates demonstrated that Phalen-test positivity was 27.5% (44/160), with a 95% confidence interval of 21.2%–34.9%. In contrast, symptom-defined burden and function-defined burden were each 30.6% (49/160), with identical 95% confidence intervals of 24.0%–38.2%. The overlap of these confidence bounds suggests that the proportion of workers with at least mild symptom or functional impact was broadly comparable to the proportion

demonstrating a positive clinical screening sign, supporting a consistent picture of meaningful CTS-related burden in this setting.

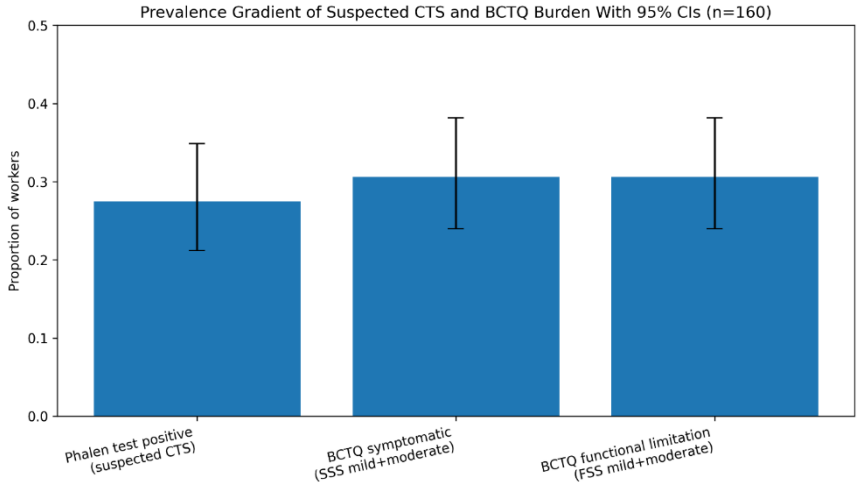

Figure 1 Publication-ready figure based only on aggregated results

The figure shows a clear prevalence gradient across CTS screening and patient-reported burden thresholds: Phalen-test positivity indicating suspected CTS was 27.5% (95% CI 21.2%–34.9%), while the proportion reporting at least mild symptom severity on BCTQ-SSS was 30.6% (95% CI 24.0%–38.2%) and at least mild functional limitation on BCTQ-FSS was also 30.6% (95% CI 24.0%–38.2%). The close alignment of these prevalence estimates, together with the overlapping confidence intervals, suggests that workplace screening positivity and self-reported CTS burden identify similarly sized at-risk subgroups in this factory population, reinforcing the clinical and occupational significance of early detection and preventive strategies.

DISCUSSION

This study quantified CTS burden in a young textile workforce and found that 27.5% of workers screened positive on the Phalen test, indicating a substantial proportion with suspected CTS signs in a setting characterized by repetitive manual exposure. This prevalence is comparable to reports from textile-related occupations in the region; Singh et al. documented a prevalence of 25.4% among textile industry workers, which closely aligns with the present estimate, supporting the plausibility of a similar occupational risk profile in hand-intensive manufacturing environments (10).

Related Pakistani evidence from tailoring work has also reported CTS-related burden near one-quarter, reinforcing that repetitive, fine motor occupational demands within garment and textile workflows may produce a meaningful level of median nerve irritation or compression symptoms (11). Internationally, studies among manual weavers show variability in CTS prevalence, with Zeleke et al. reporting lower rates than those observed here, which may reflect differences in task intensity, ergonomic design, work pacing, and the operational definitions used to classify CTS in workplace studies (12). This heterogeneity is consistent with broader pooled evidence showing wide occupational variation in CTS prevalence, particularly across manual jobs with different combinations of repetition, force, posture, and vibration exposure (13).

An important interpretive finding was that most workers were categorized as asymptomatic on the BCTQ symptom and function scales, yet more than one-quarter screened positive on Phalen testing. This pattern suggests that a clinically detectable screening sign may occur in

workers who report limited symptom burden or functional impairment, which can plausibly represent early or subclinical disease stages, under-reporting due to normalization of symptoms, or misclassification related to the imperfect diagnostic accuracy of provocative tests when used alone (2).

In occupational settings, the overlap between early neuropathic signs and limited perceived disability is clinically relevant because continued exposure without early intervention can increase cumulative nerve stress and potentially progress to more persistent symptoms and functional decline (5).

The present findings therefore support the practical value of combining a symptom/functional instrument such as the BCTQ with a standardized clinical screening sign in workplace surveillance, while maintaining careful language that Phalen positivity represents suspected CTS rather than confirmed disease requiring electrophysiological testing for definitive diagnosis (2).

With respect to occupational determinants, significant associations were observed between suspected CTS and repetition frequency, wrist stretching practices, regular breaks, and job role. The association with higher repetition rates is biologically and ergonomically plausible and aligns with systematic evidence that repetitive hand activity—particularly when combined with forceful exertion and non-neutral wrist positions—contributes to CTS risk (4). Studies in similar factory contexts have likewise linked repetitive motion patterns with CTS complaints and screening positivity, supporting repetition as a modifiable exposure target for ergonomic redesign and workload pacing strategies (15,16).

The observed association with stretching practices is consistent with the broader non-operative management literature emphasizing activity modification, ergonomic optimization, and symptom-directed conservative approaches in CTS, although stretching alone should be viewed as a supportive component rather than a stand-alone preventive solution (17). Evidence from workplace settings has also recommended stretching and preventive education to mitigate CTS complaints, particularly where prolonged hand use and static wrist loading are common (18). Notably, the protective association of regular breaks in this study strengthens a practical intervention pathway; prior occupational studies among weavers and informal workers have similarly highlighted inadequate breaks as a factor associated with CTS complaints, supporting scheduled micro-breaks as a low-cost, implementable strategy to reduce cumulative loading (12,19).

The association between CTS screening positivity and job role suggests that task-specific exposures may concentrate risk, with weaving and stitching likely involving higher repetition and sustained wrist postures than roles such as dyeing or quality checking. This role-based clustering is consistent with occupational surveillance evidence showing that CTS burden varies by workforce subgroups and exposure profiles, reinforcing the need for task-targeted ergonomic interventions rather than uniform factory-wide recommendations (20). At the same time, it is important to interpret these associations within the limits of cross-sectional inference: exposure and outcome were measured simultaneously, and causality cannot be concluded. Additionally, some prior studies in lower-demand occupational groups, such as office-based workforces, have not identified strong relationships between certain occupational factors and CTS complaints, suggesting that exposure intensity and biomechanical load thresholds may influence whether risk-factor associations are detectable (21). Differences in measurement approaches (screening tests versus clinical diagnoses), sample size, and exposure distribution also plausibly contribute to inconsistent findings across studies.

Several limitations should be considered when interpreting these results. The convenience sampling of a single factory limits generalizability to other textile settings, regions, and production systems. The primary outcome relied on Phalen testing as a screening indicator rather than confirmatory diagnosis, introducing potential misclassification. Risk-factor measurement used self-report for repetition rates, breaks, and stretching practices, which may be affected by recall error or social desirability bias. Finally, association testing was based on chi-square analyses without multivariable adjustment, so confounding by correlated variables such as job role, working hours, or anthropometrics cannot be excluded. Despite these limitations, the study provides actionable occupational health signals: suspected CTS was common, and it clustered with modifiable work practices and exposure intensity. These results justify workplace prevention programs emphasizing ergonomic risk reduction, task rotation or redesign for high-repetition roles, scheduled breaks, and structured education on safe wrist positioning and symptom recognition, alongside referral pathways for confirmatory evaluation where screening positivity and symptom burden indicate higher risk.

CONCLUSION

In this textile workforce, suspected carpal tunnel syndrome based on Phalen-test positivity affected more than one-quarter of workers, while approximately one-third reported at least mild symptom burden and functional limitation on the BCTQ, indicating a meaningful CTS-related occupational health burden. Screening positivity was significantly associated with higher repetition frequency, absence of wrist stretching practices, lack of regular breaks, and job role, highlighting modifiable workplace targets for prevention. Given the cross-sectional design and the use of a screening test rather than confirmatory diagnostics, the findings should be interpreted as occupational associations rather than causal effects; however, they support implementing ergonomic exposure reduction, scheduled micro-breaks, preventive education, and early screening/referral strategies in textile production settings to mitigate progression and functional impact.

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DECLARATIONS

Ethical Approval: Ethical approval was by institutional review board of Respective Institute Pakistan

Informed Consent: Informed Consent was taken from participants.

Authors' Contributions:

Concept: AH, AA; Design: AA, AM; Data Collection: AH, AQ, IQ, HT; Analysis: AA, AM; Drafting: AH, AM

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