

Occupational health and Safety for Sewing Machine Operators in Pakistan: Revealing Hazards in Small and Medium Garment Enterprises

Iqra Javed^{1,2*}, Ashfaq Ahmad³, Yusoff Nukman¹, Raja Ariffin bin Raja Ghazilla¹, Siti Zawiah Md Dawal⁴ & Nurul Izzah Abd Rahman⁵

¹Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur (50603), Malaysia

²Department of Computer Science, School of Systems and Technology, University of Management and Technology, Lahore (54000), Pakistan

³Department of Artificial Intelligence, School of Systems and Technology, University of Management and Technology, Lahore (54000), Pakistan

⁴Ergonomic Research and Design, Salsabila Enterprise, Selangor, Malaysia

⁵Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, Serdang (43400), Selangor, Malaysia

Received 01 August 2024; revised 28 February 2025; accepted 07 July 2025

Work fatigue and Work-Related Musculoskeletal Disorders (WMSDs) are major occupational health issues, driven by physical, psychosocial, individual, and environmental risk factors. Identifying the significant work-related factors affecting workers' health and safety is crucial. Therefore, the study aims to evaluate the prevalence of work fatigue and WMSDs among Sewing Machine Operators (SMOs), and to identify the associated most significant work-related risk factors. A comprehensive survey was conducted among 313 sewing machine operators using the Nordic Musculoskeletal Questionnaire (NMQ) and Chalders Fatigue Scale (CFS) to assess the prevalence of WMSDs and work fatigue among participants. Descriptive statistics and univariate analysis of variance were used for data analysis. The results indicated that 67.2% of SMOs experienced physical fatigue, and 56.0% reported mental fatigue. The highly affected body parts were the shoulders (78.3%) and lower back (76.7%). Gender, experience, vibration, payment type and quantitative demands were identified as the most significant ($p < 0.05$) work-related risk factors. These findings align with global studies showing that 70% of SMOs in Bangladesh and 72% in China report physical fatigue, while 58% of Indian SMOs experience high levels of stress and anxiety. Compared to global averages, the prevalence of fatigue and WMSDs among SMOs is notably high, emphasizing the need for targeted interventions. The study highlights the importance of implementing robust occupational health and safety regulations and developing strategies focused on ergonomics, risk management, and mental health to mitigate these risks. Future initiatives should focus on improving work conditions, introducing technological solutions, and addressing psychosocial factors to enhance workers' physical and mental wellbeing.

Keywords: Physical risk factors, Psychosocial risk factors, Workstation design-related risk factors, Work fatigue, Work-related musculoskeletal disorders

Introduction

Worker health and safety have become an increasingly prominent issue, particularly in industries.¹ Workers are subjected to different work-related risk factors that affect their physical and mental health. These work-related risk factors instigate a feeling of fatigue among workers. Fatigue is defined as the state of feeling reduced physical or mental capability, resulting from sleep deprivation, circadian rhythm disruption, extended stress or anxiety, and prolonged physical or mental workload.² Physical and mental

fatigue have different symptoms and conditions.³ Physical fatigue (muscle fatigue) is conceptualized as a failure to sustain the expected or required force, strength, or power.^{4,5} While mental fatigue is an ongoing process that causes reluctance for any effort, decreases efficiency, increases the feeling of tiredness, reduces the level of alertness, and decline in mental performance that leads to a loss of work productivity, presenteeism, absenteeism, accidents, and health degradation.⁶⁻⁸ A large number of industrial populations have been subjected to work fatigue in recent years.⁹ According to the World Health Organization¹⁰ approximately 12 billion workdays per year are lost due to anxiety and depression, costing

*Author for Correspondence
E-mail: iqra.javed@umt.edu.pk

nearly US\$1 trillion to the global economy. In a recent study conducted in Pakistan,¹¹ it was observed that depressive disorders are one of the leading causes of disability in all age groups. Exposure to work fatigue leads to the development of Work-Related Musculoskeletal Disorders (WMSDs).^{12,13} Approximately 1.71 billion people globally have musculoskeletal disorders.¹⁴ Musculoskeletal disorders significantly restrict dexterity and mobility, leading to early work retirement, decreased well-being, and reduced societal engagement.

In Pakistan, musculoskeletal disorders showed the highest age-standardized rise from 1990 to 2019, followed by diabetes and road injuries.¹¹ Approximately 9.5–71.5% of all occupational diseases were WMSDs in a given year and were most common in the manufacturing industry. By body parts, the shoulder, the lower back, and the elbow or lower arm were the most vulnerable to chronic WMSDs.¹⁵

The incidence of work-related musculoskeletal disorders is affected by multiple work-related risk factors including long working hours, inadequate break time, long hours of mental and physical activity, inadequate rest, job rotations, extreme stress, performing various jobs, or a combination of these factors.² The development of interventions to decrease the prevalence of work-related risk factors that lead to work fatigue is necessary. In a press release,¹⁶ World Health Organization (WHO) and the International Labour Organization (ILO) have also demanded certain actions to deal with mental health issues among workers. However, the first step in this process is the identification and understanding of the major influencing risk factors. It is of great significance to assess work fatigue and associated work-related risk factors to maintain the physical and mental health of the occupational population. It is inevitable to determine the influencing work-related risk factors to overcome the occupational health and safety risks that lead to the development of work fatigue and work-related musculoskeletal disorders especially within small and medium scale industries that often face unique challenges.

Occupational Health and Safety of Sewing Machine Operators of Small and Medium Enterprises

Small and medium-scale enterprises (SMEs) are self-regulating enterprises and have no specific definition. The definition of SMEs can vary by country and by industry based on the annual revenue,

number of employees, energy consumption, and value of assets.¹⁷ For example, Canada defines SMEs as having 10–499 employees. In Singapore, industries with assets less than \$15 million are small-scale industries. However, in Pakistan, the State Bank of Pakistan¹⁸ and SMEDA¹⁹ (Small and Medium Enterprise Development Authority) define SMEs based on their annual sales turnover (up to PKR 800 million). SMEs make a significant contribution to world trade and provide employment to a large population. The SME sector contributes 40% of Pakistan's GDP and has a positive impact on the country's economy.²⁰ However, SMEs are often neglected as compared to large-scale manufacturing industries in developing countries.^{21,22}

These enterprises often face challenges in implementing robust Occupational Health and Safety (OHS) measures due to limited financial and human resources, lack of training and information, and weak regulatory enforcement.²³ SMEs have failed to protect workers' rights in terms of occupational health and safety.²⁴ An unsafe work environment that comprises physical, psychosocial, and workstation design-related risk factors can result in illnesses, injuries, and even serious fatalities, which directly affect workers' physical and mental health. Ensuring occupational health and safety is closely tied to worker's physical and mental well-being, productivity, efficiency, economic growth, and the overall sustainable development of SMEs.

Among SMEs, the garment industry is a labor-intensive sector and contributes significantly to world trade. According to a fact sheet (Solidarity Center, 2019), the garment industry employed more than 75 million workers around the world and is estimated to be worth around \$2.4 trillion in 2017, with the export of textiles and garments worth more than \$750 billion. Workers in the garment industry engage in the design, cutting, stitching, pressing, and wholesaling of fabric. Due to the nature of these tasks, the prevalence of work fatigue has been reported to be very high.^{25–27} Sewing machine operators (SMOs) perform repetitive tasks²⁸ in different awkward working postures,²⁹ in a non-adjustable workstation for 8–10 hours per day and 5–6 days per week,³⁰ in a competitive occupational environment that intensifies the effect of fatigue among workers.²

Joseph and Kiran³¹ conducted a study among 8 garment industries with more than 4000 workers in India and found that musculoskeletal disorders were

the most common existing illnesses prevailing among workers. Kabir *et al.*,³² performed a systematic literature review to identify the most distinct physical and psychological health issues among garment industry workers in South and Southeast Asian countries.

While these global statistics highlight the widespread impact of work-related fatigue and musculoskeletal disorders, it is crucial to examine the specific context of Pakistan, where the industrial workforce, particularly in SMEs, faces unique challenges in managing occupational health and safety. Although Pakistan is a hub for ready-made garment manufacturers, the studies to evaluate the occupational health and safety issues due to the working conditions of sewing machine operators are limited. Ahmad *et al.*²¹ and Anwar *et al.*³³ performed studies to evaluate ergonomic working conditions based on worker's working postures during work using direct observational techniques like REBA and QEC. Javed *et al.*³⁴ evaluated work-related risk factors among garment industry workers but did not find their impact on workers' health and safety. However, these studies did not compare or evaluate their results using any available relevant standards, like OSHA³⁵, OSHA³⁶, OSHA³⁷ and ISO.³⁸ Hence, a comprehensive study to evaluate the working conditions and worker's health and safety considering a set of physical, psychosocial, and workstation design-related risk factors among sewing machine operators in Pakistan has not been conducted so far.

Explicit knowledge of the prevalence of work fatigue and work-related musculoskeletal disorders emphasizes their social and financial impact on the worker, and the organization urges the researcher to perform an in-depth analysis to scrutinize the work-related risk factors that enhance occupational health and safety risks and eventually lead to work fatigue in workers. Currently, there is a dearth of studies that have evaluated the prevalence of physical and mental fatigue among sewing machine operators. The research to reveal the most significant work-related risk factors resulting in work fatigue among workers is still missing.³⁹ The identification and evaluation of these associations will help industrial engineers and policy makers optimize working conditions by implementing occupational health and safety practices and approaches. Therefore, the objectives of this research are:

- To investigate the working conditions of small and medium garment enterprises of Pakistan, focusing

on factors contributing to work fatigue and musculoskeletal disorders.

- To evaluate the prevalence of WMSDs and to assess the severity of perceived work fatigue among sewing machine operators.
- To identify the most significant work-related risk factors that lead to work fatigue of garment industry workers in SMEs.

Material and Methods

Study Design

A cross-sectional research was conducted among garment manufacturing industries in Faisalabad, Punjab, Pakistan. Faisalabad was selected as the study location because it is the hub of the garment industry in Punjab, providing a representative sample of the sector's workforce. Data was acquired from a sample of 313 SMOs after getting official approval from industrial management. An ethical approval was obtained from the University Malaya Research Ethics Committee (UMREC). The workers were contacted personally and properly briefed about the objectives of the study. A written consent was taken from all the participants for conducting this research. This survey was conducted from August 2021 to March 2022. The complete survey was self-administered, and workers' participation in this survey was entirely voluntary and anonymous. They were free to withdraw from the session at any time or decline to answer any question that made them feel uncomfortable. Those sewing machine operators who were under 18 years of age or had any critical health illnesses or had disabilities unrelated to their work that could confound the results were excluded from this study. The workers were working one 9-h shift (9:00 a.m. to 6:00 p.m.) with a 1-h rest break at 1:00 p.m. The data was collected between 9:00 a.m. and 12:00 p.m. All the workers who were recently recruited or had prior sewing experience were allowed to fill out the questionnaire. This inclusion helps to better examine the effect of work-related factors over time.

Sample Size and Sampling Procedure

The sample size for this study was calculated using Cochran's formula ($n_o = Z^2 pq/e^2$),⁴⁰ where n_o = sample size, p is the estimated proportion of the population based on previous research, $q = 1 - p$, e = margin of error, and the value of Z is extracted from the Z -table. The Cochran formula is the widely used sample size calculation formula. It calculates an optimal sample size for a selected

confidence level, precision level, and the anticipated proportion of the attribute present in the population. For this study, the sample size was estimated at a 5% margin of error, 95% confidence interval, and a prevalence of 82.5% from a previous study⁴¹ on SMOs. Using this formula, the appropriate sample size was 222 workers. However, the data was collected from 313 workers, which is more than the calculated sample size.

A two-stage sampling procedure was adopted. At first, the top-ranked industries of the Faisalabad region were selected and approached, as Faisalabad is the hub of the garment industries of Punjab, Pakistan. After getting official approval from industrial management, data was collected from sewing machine operators.

Data Collection

Data was collected using a self-administered questionnaire. The content of the questionnaire includes questions related to demographics, work-related physical risk factors, psychosocial risk factors, and workstation design-related risk factors. Questions related to physical risk factors and workstation design were selected from previous studies.^{34,42,43} For psychosocial risk factor analysis, questions from the Copenhagen Psychosocial Risk Assessment Questionnaire (COPSOQ) was used.⁴⁴ Chalders' Fatigue Scale (CFS)⁴⁵ was used in this study to assess physical fatigue, mental fatigue, and overall fatigue among SMOs. Workers were asked 11 questions, ranging from better than usual = 0 to much worse than usual = 3. The average of the first seven questions shows physical fatigue, and the last four questions give mental fatigue, whereas the average of all the questions shows the severity of total fatigue among SMOs. The Standardized Nordic Musculoskeletal Questionnaire (SNMQ)⁴⁶ aided by a body map, was used to identify the prevalence of WMSDs among SMOs. The workers were asked about the discomfort they had experienced in different body parts in the last year and in the past 7 days and the WMSD symptoms that prevented them from doing their normal work activities. The questionnaire was translated into the native language (Urdu) from English by a committee of language experts, researchers, and industrial engineers. The reliability of the translated questionnaire was checked after conducting a pilot study of 50 workers. Cronbach's $\alpha = 0.78$ using SPSS version 25 shows that the questionnaire has acceptable reliability.

Data Analysis Technique

The research analysis was carried out using SPSS (version 25.0). Descriptive statistics and inferential statistics were used to analyse and interpret the data. All the categorical variables are presented in the form of frequency and percentage. Tables and graphs were used to present the data. The multivariate analysis of variance test was applied to determine the differences between work-related risk factors leading to physical fatigue, mental fatigue, or overall fatigue of the worker.⁴⁷ While the cross-sectional design of this study doesn't show cause-and-effect relationships, but it gives an overview of the factors affecting worker health at a specific point in time. These differences will help to identify the most significant work-related risk factor with respect to each outcome.

Results

Demographic Variables

The demographic details of the SMOs (68.7% males and 31.3% females) who participated in this study are shown in Table 1. About 54% of the sample's age was within the age group of 18–25

Table 1 — Demographic details

	Demographics	<i>n</i>	%	Mean
Gender	Male	215	68.7	—
	Female	98	31.3	
Age (years)	18–25	169	54.0	29.7 ± 2.32
	26–30	52	16.6	
	31–35	34	10.9	
	>35	58	18.5	
Education	Uneducated	37	11.8	—
	Primary	97	31.0	
	Middle	81	25.9	
	Matriculation	93	29.7	
Marital status	Diploma/higher secondary	5	1.6	—
	Never Married	145	46.3	
	Married	149	47.6	
	Widowed	17	5.4	
Experience (years)	Divorced	2	0.6	8.2 ± 4.99
	0–5	190	60.7	
	6–10	80	25.6	
	11–15	17	5.4	
Received training	16–20	18	5.8	—
	>20	8	2.6	
	Yes	251	80.2	
Smoking habit	No	62	19.8	—
	Yes	18	5.8	
	No	295	94.2	—

years. Among 313 participants, 46.3% were unmarried and 47.6% were married. It was found that 11.8% of workers were illiterate, 29.7% completed their matriculation, and only 1.6% got a higher secondary education. It was also found that 60.7% of workers have work experience of less than 5 years, whereas 25.6% have between 6 and 10 years. However, 80.2% of sample workers received training

before starting their work, and 94.2% do not have smoking habits.

Work-related Risk Factors

The work-related risk factors (physical, psychosocial, and workstation design-related risk factors) evaluated in this study are presented in Table 2. The percentage ratings of 4 (poor/high) and

Table 2 — Work-related risk factors identified in this study.

<i>Physical risk factors</i>												
Factor	Category	n	%	Factor	Category	n	%	Factor	Category	n	%	
Lighting	Very good	23	7.3	Temperature	Very good	0	0	Fabric waste	Very good	24	7.7	
	Good	61	19.5		Good	28	8.9		Good	44	14.1	
	Satisfactory	168	53.7		Satisfactory	105	33.5		Satisfactory	104	33.2	
	Poor	32	10.2		Poor	131	41.9		Poor	101	32.3	
	Very poor	29	9.3		Very poor	49	15.7		Very poor	40	12.8	
Vibration	Very low	2	0.6	Dust	Very low	0	0.0	Noise	Very low	3	1.0	
	Low	17	5.4		Low	6	1.9		Low	3	1.0	
	Average	111	35.5		Average	80	25.6		Average	51	16.3	
	High	143	45.7		High	129	41.2		High	172	55.0	
	Very high	40	12.8		Very high	98	31.3		Very high	84	26.8	
Break periods (mins)	≤30	22	7.0	Work cycle (s)	≤30	130	41.5	Repetitive work (hrs)	<2	11	3.5	
	31–60	224	71.6		31–60	69	22.0		2–4	21	6.7	
	>60	67	21.4		>60	114	36.4		>4	281	89.8	
Works overtime	Never	135	43.1	Overtime (hrs)	0–2	221	70.6	Payment type	Piece rate	104	33.2	
	Sometimes	159	50.8		3–5	54	17.3		Monthly	107	34.2	
	Often	19	6.1		>5	38	12.1		Piece + Monthly	102	32.6	
<i>Psychosocial risk factors</i>												
Factor	Category	n	%	Factor	Category	n	%	Factor	Category	n	%	
Job rotation	Never	16	5.1	Quantitative demands	Never	23	7.3	Supervisor support	Never	0	0	
	Seldom	51	16.3		Seldom	92	29.4		Seldom	7	2.2	
	Sometimes	86	27.5		Sometimes	103	32.9		Sometimes	33	10.5	
	Often	96	30.7		Often	70	22.4		Often	163	52.1	
	Always	64	20.4		Always	25	8.0		Always	110	35.1	
Rewards	Small extent	0	0.0	Justice	Small extent	0	0	Leadership quality	Small extent	7	2.2	
	Somewhat	33	10.5		Somewhat	2	0.6		Somewhat	22	7.0	
	Large extent	88	28.1		Large extent	66	21.1		Large extent	120	38.3	
	Very large extent	192	61.3		Very large extent	245	78.3		Very large extent	164	52.4	
Job satisfaction	Very unsatisfied	11	3.5									
	Unsatisfied	26	8.3									
	Satisfied	185	59.1									
	Very Satisfied	91	29.1									
<i>Workstation design related risk factors</i>												
Factor	Category	n	%	Factor	Category	n	%	Factor	Category	n	%	
Machine type	Single needle	206	65.8	Chair Type	No cushion	131	41.9	Adj. Table	Yes	123	39.3	
	Overlock	63	20.1		With cushion	125	49.9		No	190	60.7	
	Flat lock	25	8.0		Backrest	37	11.8		Knee Switch	Not appropriate	58	18.5
	Other tools	19	6.1		Arms + Backrest	20	6.4		Appropriate	255	81.5	
Working position	Sitting	294	93.9	Chair-Table Space	Less space	67	21.4					
	Standing	9	2.9		Sufficient	199	63.6					
	Sit+Stand	10	3.2		Large space	47	15.0					

5 (very poor/very high) were summed up to highlight the significant critical risk factors. Among physical work-related risk factors, SMOs identified noise level at the workplace (81.8%), dust due to fabric (72.5%), vibration from sewing machines (58.5%), temperature conditions (57.6%), fabric waste disposal management (45.1%), and lighting conditions (19.5%) as physical risk factors in their workplace. The average working hours per day of the SMOs were 9.56 ± 1.67 . The workers were given more than one break. The total break time (mins per day) of workers was between 31 and 60 mins for 71.6% of workers, and 21.4% took break/s greater than 60 mins. The majority of the workers (89.8%) worked for more than four hours continuously without taking a break. The work cycle of 41.5% of workers was ≤ 30 s, whereas the usual work cycle of 36.4% of workers was > 60 s. About 43.1% of respondents never stay at work for overtime work. While 50.8% of workers sometimes spent more time at work than their routine work hours, as shown in Table 2

SMOs were also exposed to psychosocial risk factors. The results indicated that 30.4% of workers felt that their quantitative demands were always or often very high. However, 32.9% of workers claimed that sometimes they need to work at high speed to fulfil production demands. It was stated by 56.2% of workers that they do not have influence at their work. They performed their tasks within the time frame given by supervisors under their strict instructions. It was found that 88.2% of workers were satisfied with their job. Their supervisors were always there to listen to their problems. Workers were very satisfied (61.3%) with the rewards given to them. It was believed by 78.3% of workers that the management have maintained justice among workers, and 52.4% workers were also very satisfied with the work planning and leadership skills of their supervisors.

SMO workstation was also assessed. Sitting posture was adopted by 93.9% of workers. The most used sewing machine was the single needle lockstitch machine (65.8%), followed by the overlock machine (20.1%). It was observed that 49.9% of workers were sitting on a stool or a bench without a cushion as shown in Fig. 1. While 41.9% were sitting on stools or benches with cushions, and only 11.8% were using chairs with backrests. Adjustable sewing machine tables were provided to 60.7% of workers. Space between the chair and table was found sufficient by 63.6% of workers and the location of the knee switch

was appropriate according to 81.5% of workers, as shown in Table 2.

Prevalence of Work Fatigue among SMOs

The results of physical fatigue, mental fatigue, and overall fatigue are shown in Fig.2. It was analysed that workers were facing high levels of physical fatigue (67.2%), mental fatigue (56.0%), and overall fatigue (63.1%). Physical fatigue was higher than mental fatigue among SMOs. It was observed that physical fatigue and total fatigue were very high among workers, as most of the workers' severity levels of fatigue fell under the category of worse than usual or much worse than usual. While mental fatigue was also worse than usual, according to 59.7% of workers.



Fig.1 — Sewing machine operator performing sewing operation

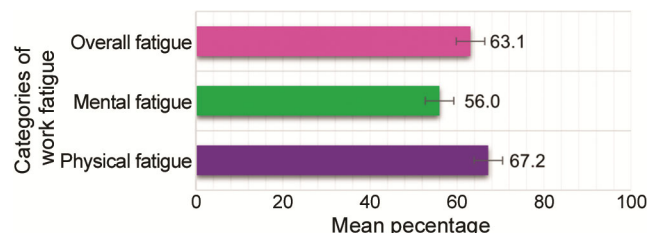


Fig. 2 — Prevalence of work fatigue among sewing machine operators

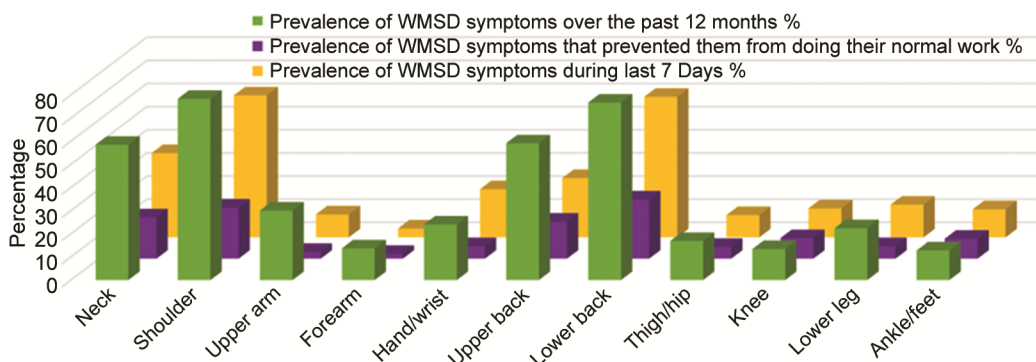


Fig. 3 — Prevalence of WMSDs Symptoms among sewing machine operators

Prevalence of WMSDs among SMOs

The prevalence of WMSD symptoms among SMOs over the last 7 days and in the past 12 months, along with the symptoms that prevented them from doing their normal work are presented in Fig. 3. The results indicated that there was a high prevalence of WMSD symptoms in the shoulders (78.3%), lower back (76.7%), upper back (59.1%), and neck (58.5%) during the last 12 months. The symptoms did not significantly affect their normal work. Lower back symptoms prevented 25.6% of workers, and shoulder pain affected 22.1% of workers from doing their normal work. The data from the last 7 days showed that the prevalence of WMSD symptoms was high in the shoulders (61.3%) and in the lower back (60.7%).

Identification of Significant Work-related Risk factors associated with Work Fatigue of SMOs

The most significant work-related risk factors eliciting work fatigue in SMOs were identified and presented in Table 3. The results highlighted that gender, experience, vibration, payment type, and quantitative demands were the most significant work-related risk factors associated with physical and mental work fatigue in SMOs ($p < 0.05$).

The effects of work fatigue on males and females were further evaluated. It was observed that work fatigue was higher among males as compared to females. Physical fatigue was 69.0% among males and 63.2% among females, while mental fatigue was 59.3% among males and 48.6% among females, as shown in Fig. 4. Age and smoking habits have a significant ($p = 0.026$ and $p = 0.039$ respectively) impact on physical fatigue but do not cause mental fatigue in workers. It is explicitly known that smoking is injurious to health, and the research results endorse that smoking habits increase the effect of physical fatigue among workers. However, experience has an impact on the physical fatigue ($p = 0.007$) and mental

fatigue ($p = 0.004$) of SMOs, as workers with greater work experience feel more fatigue as compared to younger or less experienced workers.

Among physical work-related risk factors, vibration ($p = 0.013$ for physical fatigue and $p = 0.000$ for mental fatigue) and payment type ($p = 0.000$ for physical fatigue and $p = 0.008$ for mental fatigue) were identified as the most significant work-related risk factors. However, poor lighting conditions, high noise, dust, and temperature, shorter work cycles, and higher overtime hours per week also lead to physical fatigue in workers.

Quantitative demand was the most significant ($p = 0.000$) work-related psychosocial risk factor that has a significant impact on physical fatigue, mental fatigue, and overall fatigue. Social support from supervisors also has a significant ($p = 0.015$) impact on the mental fatigue of workers. The type of chair and adjustable table were significant ($p = 0.000$ and $p = 0.012$ respectively) work-related risk factors to inculcate physical fatigue among SMOs.

Discussion

These results highlighted the serious concern of work fatigue among SMOs. This research revealed that the prevalence of physical fatigue was higher than that of mental fatigue. The majority of the workers rated their severity of fatigue as worse or much worse than usual. Previous studies^{47,48} support this, indicating that SMOs were exposed to significant physical fatigue. While Mental health is not categorized as yes or no. It is a complicated continuum that ranges from an optimal state of mind to emotional pain and great suffering. At any one time, a multifactorial work environment may help to improve or worsen mental health conditions.¹⁰ Gnanaselvam *et al.*²⁶ also found that depression and anxiety led to suicidal thoughts among SMOs. Yet,

Table 3 — Analysis of work-related risk factors and work fatigue

Dependent Variable:	Physical fatigue			Mental fatigue			Total fatigue		
	Mean square	F	Sig.	Mean square	F	Sig.	Mean square	F	Sig.
Corrected Model	1359.368	12.990	0.000	1658.863	6.675	0.000	1296.939	12.557	0.000
Intercept	4146.284	39.622	0.000	5136.056	20.667	0.000	4486.000	43.435	0.000
Gender	2515.758	24.041	0.000	4036.878	16.244	0.000	3021.659	29.257	0.000
Age	526.518	5.031	0.026	127.104	0.511	0.475	349.458	3.384	0.067
Education	2.972	0.028	0.866	75.940	0.306	0.581	17.629	0.171	0.680
Marital status	44.929	0.429	0.513	29.309	0.118	0.732	4.809	0.047	0.829
Experience	769.852	7.357	0.007	2123.340	8.544	0.004	1186.524	11.488	0.001
Training	99.265	0.949	0.331	919.199	3.699	0.055	302.755	2.931	0.088
Smoking habit	448.595	4.287	0.039	6.254	0.025	0.874	206.094	1.995	0.159
Light conditions	1750.776	16.730	0.000	234.668	0.944	0.332	1041.106	10.080	0.002
Noise level	426.912	4.080	0.044	6.625	0.027	0.870	196.095	1.899	0.169
Vibration	651.330	6.224	0.013	6291.761	25.317	0.000	2036.100	19.714	0.000
Dust level	1942.196	18.560	0.000	140.814	0.567	0.452	1050.998	10.176	0.002
Temperature	511.263	4.886	0.028	327.350	1.317	0.252	439.821	4.259	0.040
Fabric waste management	54.247	0.518	0.472	493.555	1.986	0.160	162.446	1.573	0.211
Breaktime (mins)	996.358	9.521	0.002	343.010	1.380	0.241	178.794	1.731	0.189
Work cycle	6.324	0.060	0.806	784.947	3.159	0.077	76.670	0.742	0.390
Continuous repetitive work	154.163	1.473	0.226	15.955	0.064	0.800	87.757	0.850	0.357
Works overtime	231.234	2.210	0.138	163.909	0.660	0.417	208.645	2.020	0.156
Overtime (hrs/week)	372.601	3.561	0.060	2.353	0.009	0.923	163.992	1.588	0.209
Payment type	2474.699	23.648	0.000	1796.775	7.230	0.008	2214.994	21.446	0.000
Job rotation	27.464	0.262	0.609	152.533	0.614	0.434	61.388	0.594	0.441
Quantitative demands	2084.055	19.915	0.000	2107.974	8.482	0.004	2087.770	20.215	0.000
Influence at work	1.849	0.018	0.894	6.630	0.027	0.870	0.008	0.000	0.993
Job satisfaction	7.657	0.073	0.787	187.757	0.756	0.385	45.888	0.444	0.506
Social support from supervisor	2.735	0.026	0.872	1496.767	6.023	0.015	171.744	1.663	0.198
Justice	108.307	1.035	0.310	955.122	3.843	0.051	318.950	3.088	0.080
Rewards	1116.531	10.670	0.001	364.256	1.466	0.227	796.448	7.712	0.006
Quality of leadership	315.416	3.014	0.084	346.562	1.395	0.239	21.354	0.207	0.650
Working position	190.708	1.822	0.178	237.692	0.956	0.329	207.547	2.010	0.157
Machine type	126.880	1.212	0.272	42.443	0.171	0.680	23.357	0.226	0.635
Type of chair	2544.895	24.319	0.000	853.277	3.434	0.065	1823.912	17.660	0.000
Adjustable table	675.614	6.456	0.012	602.851	2.426	0.120	647.799	6.272	0.013
Space between table and chair	73.817	0.705	0.402	6.724	0.027	0.869	40.974	0.397	0.529
Location of knee switch	56.113	0.536	0.465	9.872	0.040	0.842	34.028	0.329	0.566

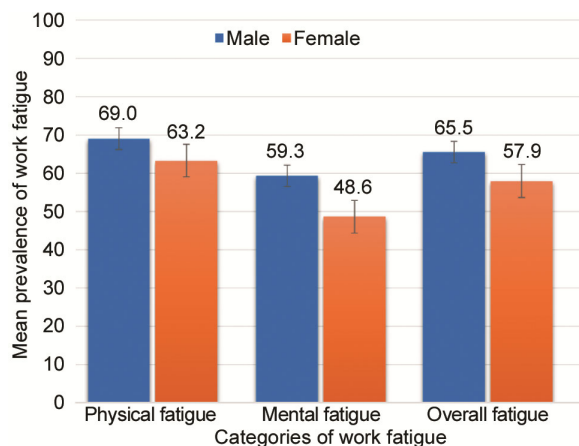


Fig. 4 — Prevalence of work fatigue with respect to gender

there is no research available that measures the prevalence of mental fatigue among SMOs.

Work fatigue leads to the pervasiveness of WMSDs over time and causes disability among workers.^{49,50} The WMSDs were also evaluated and found to be very high among SMOs. The highly affected body parts during the last 12 months were shoulders (78.3%) and lower back (76.7%), whereas lower back discomfort prevented 25.6% of workers from doing their normal work, which agreed with previous studies.^{29,41,51,52} Hence, the identification of work-related risk factors that lead to work fatigue among SMOs was crucial and holds high practical and scientific value.

The most significant work-related risk factors identified in this research were gender, experience, vibration, payment type, and quantitative demands. The research revealed that male participants were higher in number as compared to female participants, which may be due to the cultural restrictions or physical demands of labour-intensive roles that often place higher physical and economic pressure on men. As a result, work fatigue was more prevalent in males compared to females. This aligns with previous studies^{34,43,53} that also report higher male participation in sewing operations as compared to females. These societal expectations may lead men to work longer hours and endure physical discomfort in order to meet production targets, particularly in piece-rate systems. In contrast, women are often underrepresented in these roles due to traditional gender norms, which could lead to less exposure to such fatigue. These gender differences underscore the importance of further research to explore how cultural and workplace dynamics affect the physical and mental fatigue of male and female workers differently within the garment industry.

Experience was also observed as a significant factor in the prevalence of work fatigue. It was found that with increased experience, work fatigue increases.^{29,51,54} SMOs with longer years of service were experiencing more fatigue than those workers who were young and had fewer years of service. Another study⁵⁵ highlights the association of longer years of service with back pain among SMOs. Work fatigue after a long time leads to WMSDs and causes disability among workers. The accumulation of physical fatigue results in functional disability in workers, which eventually leads to WMSDs.^{49,50} It has also been observed that those SMOs who have left their employment have a high prevalence of severe and moderate disabilities.⁵⁶

Among environmental conditions, vibration was the most significant risk factor that has a high impact on physical and mental fatigue.⁴² Dust, temperature, and noise also lead to physical fatigue in workers. Some workers reported breathing issues due to inhaling fabric dust from the work environment. Lack of proper ventilation, the unavailability of air conditioners, and the noise of hundreds of sewing machines make the environment more uncomfortable for workers. The findings of this study align with those of other studies.^{42,43,57,58} OSHA standards also recommend workers use personal protective

equipment, respiratory devices, and protective shields to protect their faces, eyes, hands, and fingers from occupational environmental risk factors.⁵⁹ By implementing anti-fatigue mats, improved artificial lighting facilities, earplugs, dust masks, air ventilators, or chillers, occupational environmental risks can be avoided, which will help to decrease the effect of physical and mental fatigue among SMOs.

The method of payment to workers was also identified as a critical risk factor. Those industrial workers who followed the piece rate plus monthly rate scheme have reported higher physical fatigue than others. Kebede Deyyas and Tafese⁶⁰ also identified payment type as a risk factor. Bizuneh and Kidanemariam⁶¹ Found that payment type was significantly associated with the severity of pain in hand or wrist. Workers paid by piece rate were about twice as likely as those paid by hourly rate to suffer elbow/forearm and hand/wrist disorders. This might be due to the reason that after achieving monthly production targets, workers try to earn extra money on the piece rate by completing more garment pieces per day.

Quantitative demand was the most significant work-related psychosocial risk factor identified in this study. In order to meet productivity targets, workers have to work at a high pace, which leads to physical and mental fatigue. Industries should avoid overburdening their workers to safeguard their health and safety. The standard production based on the standard allowable minutes should be strictly followed. Öztürk and Esin⁵¹ highlighted work pressure as the most significant psychosocial risk factor for SMOs that cause WMSDs. Javed *et al.*⁶² found that higher work pace leads to higher muscle activity that results in muscular fatigue and health degradation of sewing machine operators. The current research findings also relate to other studies.^{29,54,63} Social support from supervisors has a positive impact on the worker's mental health. Therefore, industrial management should focus on developing a supportive and trustworthy relationship between the worker and the supervisor.

The majority of workers (93.9%) were working while seated, while 2.9% worked standing, and 3.2% had the option to choose between sitting or standing based on their needs. In this research, no significant impact of the working position was observed, likely because most workers were seated. Sakthi *et al.*⁵⁴ found that standing sewing machine operators have a

high prevalence of discomfort in their upper limbs. Working posture is also a key factor that has a significant impact on a worker's health and safety. A detailed analysis of working posture needs to be conducted, and recommendations should be made to reduce the impact of poor working postures. Literature also shows that upright posture can help to reduce fatigue, depression and improve mood and self-esteem among workers.⁶⁴ Kar and Hedge⁶⁵ showed that sit-stand-walk interventions reduce musculoskeletal discomfort in sedentary workplaces. Future research should focus on incorporating sit-stand workstations for sewing machine operators.

Among other workstation design-related risk factors, the type of chair and table used by workers emerged as the most significant risk factors for physical fatigue. Workers using stools or benches without cushions and backrests were experiencing higher level of physical fatigue than those with more ergonomic seating.^{43,58} However, the type of chair and table did not impact on the mental fatigue of workers. The use of ergonomically designed chairs with no wheels or wheels with locks, with adjustable height, backrest position, and seat tilt is strongly recommended.³⁵ The chair should also have a padded backrest, and a contoured or cushioned seat. As with chairs, tilt- and height-adjustable tables will help to improve the working postures of workers and will reduce the impact of these risk factors on their physical fatigue.

Henceforth, this study has great scientific and practical implications. This research pointed out that SMOs are not only experiencing high levels of physical fatigue but also mental fatigue. This study also helped to scrutinize the most significant work-related risk factors that lead to physical and mental fatigue in workers. Addressing work-related risk factors will help reduce the physical and mental fatigue of the workers. This insistence would have broader socioeconomic benefits. It can improve the quality of life of the workers, reduce healthcare costs, and contribute to the overall well-being of families and societies. Minimizing work fatigue will help Pakistani garment manufacturers maintain their global competitiveness by minimizing sewing defects and errors and reducing their rework and rejection costs. This study has also helped to better understand the working conditions of sewing machine operators in the garment industries of Pakistan. The study's findings indicate that Pakistani labour laws and regulations are not consistently

enforced, particularly regarding the use of personal protective equipment and ensuring a safe, healthy work environment. Hence, in consideration of the occupational health and safety of the worker, workers' health is compromised to meet productivity targets. There is a need to use emerging technologies and adhere to OSHA standards and procedures for sewing-related work³⁵ to reduce the impact of work-related risk factors on workers' health and safety. Industrial managers, engineers, and policymakers should prioritize these identified most significant work-related risk factors when planning, scheduling, or designing the workstations to avoid the adverse implications of work fatigue on workers' health and well-being. The WHO, for the first time, proposed the training for managers to enhance their ability to prevent stressful work environments and deal with their workers suffering from distress. The WHO Mental Health Atlas reported that only 35% of countries have national-level programmes for promoting and preventing work-related mental health issues.¹⁶ Similarly, US-NIOSH has also launched a strategic plan for 2019–2026 to prepare occupational safety and health and allied fields to address future work and known or unknown hazards, risks, and exposures that may arise at the workplace.^{66,67} Henceforth, developing countries, including Pakistan, should also launch special programs for SMEs that address ergonomic design, workload planning, environmental sustainability, psychosocial interactions, risk management practices, occupational health, and safety measures to optimize the workers' mental and physical health conditions.

The major limitation of this study is that the data collection was cross-sectional, and subjective methods were adopted to evaluate the prevalence of work fatigue and WMSDs, which may impact the research results. However, it would be interesting to conduct an experimental study to further investigate the impact of these work-related risk factors on the physical and mental fatigue of SMOs. In this study, work-related risk factors were considered; however, there is a need to consider the political or economic impact on the organization and the worker's health and well-being.

Conclusions

This study highlights significant compromises to workers' health and safety in small and medium enterprises, particularly among sewing machine operators, who experience high levels of physical and

mental fatigue, with shoulder and lower back as the most adversely affected body parts. The key work-related risk factors identified are gender, experience, vibration, payment type, and quantitative demands that demand immediate, practical attention. To mitigate these issues, policy makers and industrial managers should implement actionable interventions, such as ergonomic redesign of workstations, technological advancements, shift-based work planning, introduction of a fair wage system, and revised industry standards, alongside targeted training programs for both workers and supervisors. Addressing these risk factors will foster a safer and healthier work environment. Future research should focus on longitudinal studies to explore long-term effects and experimental designs to test the efficacy of specific interventions. The study's findings have immediate applicability for improving workplace safety, reducing fatigue, and enhancing operational efficiency—contributing to sustainable development within Pakistan's garment industry.

Declaration on Conflict of Interest

There is no financial or non-financial conflict of interests to declare.

Acknowledgement

The authors would like to thank the Higher Education Commission Pakistan for awarding the HRDI-UESTPS fellowship scheme to Ph.D. Scholars that helped them in carrying out this research.

References

- 1 Karanikas N & Hasan S M T, Occupational Health & Safety and other worker wellbeing areas: Results from labour inspections in the Bangladesh textile industry, *Saf Sci*, **146** (2022) 105533, doi:https://doi.org/10.1016/j.ssci.2021.105533.
- 2 Canadian Centre for Occupational Health and Safety, OSH Answers Fact Sheet: Fatigue, (2017) [Internet], [updated Feb 16, 2021; cited 2022 May 15]. Available from: https://ccohs.ca/oshanswers/psychosocial/fatigue.html.
- 3 Lieberman H R, Mental energy and fatigue, in *Diet, Brain, Behavior: Practical Implications*, edited by R B Kanarek, H R Lieberman (CRC Press, Boca Raton, FL) 2011, p. 1–6.
- 4 Jensen B R, Laursen B & Sjøgaard G, Aspects of shoulder function in relation to exposure demands and fatigue—a mini review, *Clin Biomech*, **15** (2000) S17–S20, doi:https://doi.org/10.1016/s0268-0033(00)00054-1.
- 5 Mota D D & Pimenta C A, Self-report instruments for fatigue assessment: A systematic review, *Res Theory Nurs Pract*, **20(1)** (2006) 49–78, doi:https://doi.org/10.1891/rtnp.20.1.49.
- 6 Tyagi R, Shen K, Shao S & Li X, A novel auditory working-memory vigilance task for mental fatigue assessment, *Saf*

- Sci*, **47(7)** (2009) 967–972, doi:https://doi.org/10.1016/j.ssci.2008.10.018.
- 7 Zhang C & Yu X, Estimating mental fatigue based on electroencephalogram and heart rate variability, *Pol J Med Phys Eng*, **16(2)** (2010) 67–84, doi:https://doi.org/10.2478/v10013-010-0007-7.
- 8 Doran C M, The evidence on the costs and impacts on the economy and productivity due to mental ill health: A rapid review, (2013) Sax Institute.
- 9 Caldwell J A, Caldwell J L, Thompson L A & Lieberman H R, Fatigue and its management in the workplace, *Neurosci Biobehav Rev*, **96** (2019) 272–289, doi:https://doi.org/10.1016/j.neubiorev.2018.10.024.
- 10 World Health Organization, World mental health report: transforming mental health for all, (2022).
- 11 Hafeez A, Dangel W J, Ostroff S M, Kiani A G, Glenn S D, Abbas J, Afzal M S, Afzal S, Ahmad S, Ahmed A, Ahmed H, Ali L, Ali M, Ali Z, Arshad M, Ashraf T, Bhutta Z A, Bibi S, Butt Z A, Das J K, Fadoo Z, Hanif A, Hayat K, Humayun A, Iqbal K, Iqbal U, Khalid N, Khan E A, Khan M S, Malik A A, Naveed M, Naz S, Niazi R K, Piracha Z Z, Saeed U, Salman M, Samad Z, Saqib M A N, Shah S M, Shahid I, Shaikh M A, Shamshad H, Shuja K H, Suleman M, Ullah A, Ullah I, Ullah S, Ullah S, Waheed Y, Waris A, Hay S I, Murray C J L & Mokdad A H, The state of health in Pakistan and its provinces and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019, *Lancet Glob Health*, **11(2)** (2023) e229–e43, doi:https://doi.org/10.1016/S2214-109X(22)00497-1.
- 12 Westgaard R H & Winkel J, Guidelines for occupational musculoskeletal load as a basis for intervention: a critical review, *Appl Ergon*, **27(2)** (1996) 79–88, doi:https://doi.org/10.1016/0003-6870(95)00062-3.
- 13 Mohd Nur N, Dawal S & Dahari M, A conceptual model of work productivity associated with work-related musculoskeletal disorders in the industrial repetitive task, *Adv Mat Res*, **845** (2013) 623–626, doi:https://doi.org/10.4028/www.scientific.net/AMR.845.62.
- 14 World Health Organization, Musculoskeletal health, (2022); 14 July 2022.
- 15 Kee D, Characteristics of work-related musculoskeletal disorders in Korea, *Intl J Environ Res Public Health*, **20(2)** (2023) 1024, doi:https://doi.org/10.3390/ijerph20021024.
- 16 WHO and ILO call for new measures to tackle mental health issues at work [press release]; Geneva, Switzerland, 28 September 2022.
- 17 Cunningham L X & Rowley C, The development of Chinese small and medium enterprises and human resource management: A review, *Asia Pacific J Hum Resour*, **46(3)** (2008) 353–379, doi:https://doi.org/10.1177/1038411108095763.
- 18 State Bank of Pakistan, Prudential Regulations for Small & Medium Enterprises Financing (2022), in *Infrastructure HSF*, Karachi, Pakistan.
- 19 SMEDA, SME Definition & Application, (2023), [Available from: https://smeda.org/index.php?option=com_content&view=article&id=3&Itemid=103.
- 20 SMEDA, Small & Medium Enterprise Development Authority Annual Report 2019-2020, (2020), in Ministry of Industries & Production GoP, editor. Pakistan.
- 21 Ahmad A, Javed I, Abrar U, Ahmad A, Jaffri N R & Hussain A, Investigation of ergonomic working conditions of

- sewing and cutting machine operators of clothing industry, *Ind Text*, **72(3)** (2021) 309–314, doi:https://doi.org/10.35530/IT.072.03.1723.
- 22 Ahmed T, Hoque A S M, Karmaker C L & Ahmed S, Integrated approach for occupational health and safety (OHS) risk Assessment: An Empirical (Case) study in Small enterprises, *Saf Sci*, **164** (2023) 106143, doi:https://doi.org/10.1016/j.ssci.2023.106143.
 - 23 Aziz Khan M M, Alam M J, Saha S & Sayem A, Critical barriers to adopt sustainable manufacturing practices in medium-sized ready-made garment manufacturing enterprises and their mitigation strategies, *Heliyon*, **10(20)** (2024), doi:https://doi.org/10.1016/j.heliyon.2024.e39195.
 - 24 Naveed R T, Rehmani M, Khokhar M N, Shah S R U, Ali A, Shahzadi S & Irshad H, Small and medium-sized enterprises failure in providing workers' rights concerning Sustainable Development Goals-2030 in Pakistan, *Front Psychol*, **13** (2022), doi:https://doi.org/10.3389/fpsyg.2022.927707.
 - 25 Abate A E & Hailemariam S S, Improving work-related musculoskeletal disorders for sewing machine operators in Ethiopia, *Int J Occup Saf Ergon*, (2023) 1–13, doi:https://doi.org/10.1080/10803548.2022.2058747.
 - 26 Gnanaselvam N A, Joseph B & Arasu S, Mental health status of garment industry employees in South India, *Saf Health Work*, **13** (2022) S235–S236, doi:https://doi.org/10.1016/j.shaw.2021.12.1488.
 - 27 Carrillo-Castrillo J A, Guadix J, Rubio-Romero J C & Onieva L, Estimation of the relative risks of musculoskeletal injuries in the Andalusian manufacturing sector, *Int J Ind Ergon*, **52** (2016) 69–77, doi:https://doi.org/10.1016/j.ergon.2015.09.001.
 - 28 Chan J, Janowitz I, Lashuay N, Stern A, Fong K & Harrison R, Preventing musculoskeletal disorders in garment workers: preliminary results regarding ergonomics risk factors and proposed interventions among sewing machine operators in the San Francisco Bay Area, *Appl Occup Environ Hyg*, **17(4)** (2002) 247–253, doi:https://doi.org/10.1080/10473220252826547.
 - 29 Dianat I, Kord M, Yahyazade P, Karimi M A & Stedmon A W, Association of individual and work-related risk factors with musculoskeletal symptoms among Iranian sewing machine operators, *Appl Ergon*, **51** (2015) 180–188, doi:https://doi.org/10.1016/j.apergo.2015.04.017.
 - 30 Bernard B P & Putz-Anderson V, *Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back*, Bruce P. Bernard, editor, (1997), National Institute for Occupational Safety and Health.
 - 31 Joseph B & Kiran P R, A stitch in time... annual health appraisal of garment industry employees, *Pak J Med Sci*, **24(1)** (2008) 104,
 - 32 Kabir H, Maple M, Usher K & Islam M S, Health vulnerabilities of readymade garment (RMG) workers: A systematic review, *BMC Public Health*, **19(1)** (2019), doi:http://doi.org/10.1186/s12889-019-6388-y.
 - 33 Anwar N, Riaz H, Saeed A & Ashraf F, Frequency of work related musculoskeletal disorders and ergonomic risk assessments among tailors, *J Pak Med Assoc*, **70(12(A))** (2020) 2164–2167, doi:https://doi.org/10.5455/jpma.24765
 - 34 Javed I, Md Dawal S Z, Nukman Y & Ahmad A, Prediction of work productivity outcomes by identifying critical risk factors among garment industry workers, *Int J Occup Saf Ergon*, **28(4)** (2022) 2238–2249, doi:https://doi.org/10.1080/10803548.2021.1984673.
 - 35 OSHA, Sewing and Related Procedures eTool, (2001) Washington, DC, US, Department of Labor, Available from: https://www.osha.gov/etools/sewing.
 - 36 OSHA, Recommended practices for safety and health programs, (2016). Washington, DC, USA, Occupational Safety Health Administration.
 - 37 OSHA, *Training requirements in OSHA standards*, (2020), Occupational Safety and Health Administration.
 - 38 ISO 10821:2005 Industrial sewing machines — Safety requirements for sewing machines, units and systems, (2005). Switzerland.
 - 39 Bispo L G M, Moreno C F, Silva G Hd O, Albuquerque N L Bd & Silva J M Nd, Risk factors for work-related musculoskeletal disorders: A study in the inner regions of Alagoas and Bahia, *Saf Sci*, **153** (2022) 105804, doi:https://doi.org/10.1016/j.ssci.2022.105804.
 - 40 Bluman A G, *Elementary statistics: A step by step approach*, 10th ed, New York, (2018), McGraw-Hill Education.
 - 41 Shazzad M N, Ahmed S, Haq S A, Islam M N, Abu Shahin M, Choudhury M R, Hasan A T M T, Abdal S J & Rasker J J, Musculoskeletal symptoms and disorders among 350 garment workers in Bangladesh: A cross-sectional pilot study, *Int J Rheum Dis*, **21(12)** (2018) 2063–2070, doi:https://doi.org/10.1111/1756-185X.13423.
 - 42 Tebyetekerwa M, Tayari N & Memon I, The current working conditions in uganda apparel assembly plants, *Saf Health Work*, **8** (2017) 378–385, doi:https://doi.org/10.1016/j.shaw.2017.01.005.
 - 43 Okareh O T, Solomon O E & Olawoyin R, Prevalence of ergonomic hazards and persistent work-related musculoskeletal pain among textile sewing machine operators, *Saf Sci*, **136** (2021) 105159, doi:https://doi.org/10.1016/j.ssci.2021.105159.
 - 44 Pejtersen J H, Kristensen T S, Borg V & Bjorner J B, The second version of the Copenhagen psychosocial questionnaire, *Scand J Pub Health*, **38(SUPPL. 3)** (2010) 8–24, doi:https://doi.org/10.1177/1403494809349858.
 - 45 Chalder T, Berelowitz G, Pawlikowska T, Watts L, Wessely S, Wright D & Wallace E, Development of a fatigue scale, *J Psychosom Res*, **37(2)** (1993) 147–153, doi:https://doi.org/10.1016/0022-3999(93)90081-p.
 - 46 Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G & Jørgensen K, Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms, *Appl Ergon*, **18(3)** (1987) 233–237, doi:https://doi.org/10.1016/0003-6870(87)90010-X.
 - 47 Hellig T, Mertens A & Brandl C, The interaction effect of working postures on muscle activity and subjective discomfort during static working postures and its correlation with OWAS, *Int J Ind Ergon*, **68** (2018) 25–33, doi:https://doi.org/10.1016/j.ergon.2018.06.006.
 - 48 Zhang F, He L-h, Wu SS, Li JY, Ye KP & Wang S, Quantify work load and muscle functional activation patterns in neck-shoulder muscles of female sewing machine operators using surface electromyogram, *Chin Med J*, **124(22)** (2011) 3731–3737, doi:https://doi.org/10.3760/cma.j.issn.0366-6999.2011.22.024.
 - 49 Bosch T, de Looze M P & van Dieen J H, Development of fatigue and discomfort in the upper trapezius muscle during

- light manual work, *Ergonomics*, **50(2)** (2007) 161–177, doi:https://doi.org/10.1080/00140130600900282.
- 50 Ma L, Chablat D, Bennis F & Zhang W, A new simple dynamic muscle fatigue model and its validation, *Int J Ind Ergon*, **39(1)** (2009) 211–220, doi:https://doi.org/10.1016/j.ergon.2008.04.004.
- 51 Öztürk N & Esin M N, Investigation of musculoskeletal symptoms and ergonomic risk factors among female sewing machine operators in Turkey, *Int J Ind Ergon*, **41(6)** (2011) 585–591, doi:https://doi.org/10.1016/j.ergon.2011.07.001.
- 52 Merisalu E, Männaste M, Hiir K & Traumann A, Predictors and prevalence of musculoskeletal disorders among sewing machine operators, *Agron Res*, **14(4)** (2016) 1417–1426,
- 53 Maduagwu S, Sokunbi G, Bwala M, Akanbi O, Jajere A, Jaiyeola O, Maduagwu B & Ojiakor A, Work-related musculoskeletal disorders among self employed sewing machine operators in Maiduguri, Nigeria, *Occup Med Health Aff.* (2015), doi:https://doi.org/10.4172/2329-6879.1000219.
- 54 Sakthi N T, Jeyapaul R & Mathiyazhagan K, Evaluation of ergonomic working conditions among standing sewing machine operators in Sri Lanka, *Int J Ind Ergon*, **70** (2019) 70–83, doi:https://doi.org/10.1016/j.ergon.2019.01.006.
- 55 Abraha T H, Demoz A T, Moges H G & Ahmmed A N, Predictors of back disorder among Almeda textile factory workers, North Ethiopia, *BMC Res Notes*, **11(1)** (2018) 304, doi:https://doi.org/10.1186/s13104-018-3440-4.
- 56 Brisson C, Vinet A, Vezina M & Gingras S, Effect of duration of employment in piecework on severe disability among female garment workers, *Scand J Work Environ Health*, **15(5)** (1989) 329–334, doi:https://doi.org/10.5271/sjweh.1842.
- 57 Akhter S, Rutherford S & Chu C, Sewing shirts with injured fingers and tears: exploring the experience of female garment workers health problems in Bangladesh, *BMC Int Health Hum Rights*, **19(1)** (2019) 2, doi:https://doi.org/10.1186/s12914-019-0188-4.
- 58 Abeyssekera J & Illankoon P, The demands and benefits of ergonomics in Sri Lankan apparel industry: A case study at MAS holdings, *Work*, **55(2)** (2016) 255–261, doi:https://doi.org/10.3233/WOR-162393.
- 59 Occupational Safety & Health Administration (OSHA), *Occupational Safety and Health Standards -1910, Subpart, I "Personal Protective Equipment"*. Washington, DC, Department of Labor, United States.
- 60 Kebede Deyyas W & Tafese A, Environmental and organizational factors associated with Elbow/Forearm and Hand/Wrist disorder among sewing machine operators of garment industry in Ethiopia, *J Environ Public Health*, **2014** (2014), doi:https://doi.org/10.1155/2014/732731.
- 61 Bizuneh B & Kidanemariam B, Prevalence of musculoskeletal disorders among industrial sewing machine operators and their associated factors, *Int J Occup Saf Ergon*, (2025) 1–15, doi:https://doi.org/10.1080/10803548.2025.2506229.
- 62 Javed I, Nukman Y, Ghazilla R Ab R, Ahmad A, Dawal S Z M, Tayyab A & Rashid Z, Electromyographic analysis of bilateral upper trapezius muscles at different levels of work-space among sewing machine operators, *BMC Musculoskeletal Disord*, **25(1)** (2024) 757, doi:https://doi.org/10.1186/s12891-024-07874-4.
- 63 Steinisch M, Yusuf R, Li J, Rahman O, Ashraf H M, Strümpell C, Fischer J E & Loerbroks A, Work stress: Its components and its association with self-reported health outcomes in a garment factory in Bangladesh-Findings from a cross-sectional study, *Health Place*, **24** (2013) 123–130, doi:https://doi.org/10.1016/j.healthplace.2013.09.004.
- 64 Wilkes C, Kydd R, Sagar M & Broadbent E, Upright posture improves affect and fatigue in people with depressive symptoms, *J Behav Ther Exp Psychiatry*, **54** (2017) 143–149, doi:https://doi.org/10.1016/j.jbtep.2016.07.015.
- 65 Kar G & Hedge A, Effects of a sit-stand-walk intervention on musculoskeletal discomfort, productivity, and perceived physical and mental fatigue, for computer-based work, *Int J Ind Ergon*, **78** (2020) 102983, doi:https://doi.org/10.1016/j.ergon.2020.102983.
- 66 NIOSH Strategic Plan: FYs 2019–2026, (2022), in *Prevention CfDca*, U.S, National Institute for Occupational Safety and Health.
- 67 Felknor S A, Streit J M, Edwards N T & Howard J, Four futures for occupational safety and health, *Intl J Environ Res Public Health*, **20(5)** (2023) 4333, doi:https://doi.org/10.3390/ijerph20054333.