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Musculoskeletal Disorders in Thermal Plant Workers: Prevalence and Determinants

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ABSTRACT

Background: Musculoskeletal Disorders (MSDs) are associated with long-term pain, fatigue, and physical disability, often leading to reduced productivity, job restrictions, absenteeism, and transfer to alternative work roles. These have a considerable impact on quality of life with an economic toll on the individual, the organization, and the society as a whole.

Purpose: However, research on MSDs in thermal power plant workers is limited; thus, the objective of the study was to determine the prevalence and risk factors of MSDs in thermal plant workers.

Method: A sample size of 200 workers was obtained, and data was collected using a questionnaire designed for the same via the interview schedule method.

Results: The 12-month prevalence of MSDs in workers was found to be 59.7%. The majority of the workers had a higher prevalence of low back pain (45.29%). Upon univariate analysis, age (OR=7.30, 95% CI: 2.15-24.76, p=0.001), BMI (OR=8.10, 95% CI: 1.80-36.44, p=0.006), nature of work (OR=5.13, 95% CI: 1.34-19.63, p=0.017), work experience (OR=4.41, 95% CI: 1.86-10.45, p=0.001), and socioeconomic status (OR=2.03, 95% CI: 1.02-4.04, p=0.044) were found to be risk factors for MSDs.

Conclusion: Low back and neck pain emerged as the most prevalent MSDs. Contributing factors included long-term poor posture, heavy lifting, and previous trauma or injury. Age, BMI, nature of work, years of experience, and socioeconomic status were identified as significant risk factors. Preventive measures, such as ergonomic workplace modifications and structured exercise programs, are strongly recommended to reduce the occurrence and impact of MSDs.

1. Introduction

Musculoskeletal disorders (MSDs) are among the most prevalent occupational health concerns worldwide (European Agency for Safety and Health at Work, 2010). They encompass a wide range of inflammatory and degenerative conditions affecting muscles, tendons, joints, ligaments, and peripheral nerves (Laura, 2004). MSDs are associated with long-term pain, fatigue, and physical disability, often leading to reduced productivity, job restrictions, absenteeism, and reassignment to alternative work roles (Tinubu *et al.,* 2010). When occupational exposures are the primary cause, these conditions are classified as work-related musculoskeletal disorders (WMSDs), which typically manifest as discomfort, joint pain, tingling, swelling, and functional limitations (Halim *et al.,* 2011; Hanley & Belfus, 1996). Symptoms generally develop after prolonged exposure to occupational risk factors, often spanning several years. Thermal power stations represent complex occupational environments where workers are engaged in diverse operations ranging from coal crushing to energy generation. These tasks expose employees to varied biomechanical demands and environmental stressors depending on their specific workstations, predisposing them to MSDs and other health challenges (Kawalkar *et al.*, 2014). Although substantial evidence exists on MSDs in industrial and healthcare settings (Kaur *et al.,* 2015; Ferguson *et al.,* 2019; Yang *et al.,* 2016; Aleku *et al.,* 2021), research specifically targeting thermal power plant workers remains scarce. This paucity of data makes it difficult to quantify the true prevalence and identify workplace-specific risk factors associated with MSDs in this sector. Therefore, the present study was undertaken to determine the prevalence and occupational risk factors of MSDs among thermal power plant workers.

2. Methodology

2.1. Study Design

The present study employed a cross-sectional survey design and was conducted among workers at a thermal power

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plant in Punjab, North India. Participants who met the predefined eligibility criteria were recruited and included in the study.

2.2. Inclusion and Exclusion Criteria

Workers involved in the coal handling plant, turbine, boiler, water treatment plant, electrical maintenance, vehicle maintenance, and administration sections of the thermal power plant, aged between 20 and 60 years, either male or female, and having completed a period of 1 year in the job were included in the study. Workers with any history of trauma to the spine, a diagnosed case of local and systemic infection, malignancy, a history of neurological disorders, orthopedic disorders or fracture, psychological disorders, or any injury sustained during sports were excluded.

2.3. Sample Size Calculation

A study of 30–50-year-old adults in Northern India reported the prevalence of MSDs to be 68%. In view of the paucity of data regarding the prevalence of MSDs in the study, for the purpose of estimating the minimum sample size required for the study, the prevalence of 68% is presumed. Hence the minimum sample size required with 10% of allowable error and a 95% confidence limit, using the formula given by Snedecor and Cochran (1967) (Table 1).

Table 1: Sample Size Calculation

Sample Size Calculation	
$n=4pq/L^2$	p=0.68
n=4×68×326.8×6.8	q=(0.32)
n=8704/46.24	L=0.05
n=188.23	n=minimum sample size

A total of 200 workers were interviewed, out of which 4 refused to participate, thus yielding a sample size of 196 workers.

2.4. Data Collection

Ethical approval was obtained from the Institutional Ethical Committee (IEC) at Sri Guru Granth Sahib World University, Fatehgarh Sahib (Punjab), India. Ref. No. SGGSWU/IEC/2021/04. The e-Thermal Power Plant cooperated and granted authorization to gather information from the employees. Workers had the right to withdraw from the study at any point after providing informed consent. The prevalence of musculoskeletal disorders was documented using the Nordic Musculoskeletal Questionnaire (NMQ). The demographic detail of subjects was documented utilizing the interview schedule technique.

2.5. Statistical Analysis

The completed questionnaires were reviewed, organized, and serially coded at the end of each day. Data were analyzed using IBM SPSS Statistics, version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics were applied to summarize the demographic characteristics and clinical symptoms of musculoskeletal disorders. The chi-square test was used to assess differences between workers with MSDs and those without MSDs at the time of the survey, and Cramer's V was calculated to examine the strength of associations. Univariate analysis was performed to identify risk factors associated with MSDs. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). A *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Prevalence of MSDs

The presence of MSDs in the past 12 months among thermal plant workers was found to be 59.7% (Table 2).

Table 2: Presence of Musculoskeletal Disorders Among Thermal Plant Workers in the Past 12 Months

Presence of MSD's in Past 12 Months	Absolute No. (n)	%
Yes	117	59.7
No	79	40.3

3.2. Region-wise Prevalence of MSDs

Low back pain was found to be more prevalent (45.29%), followed by neck pain (23.07%), knee pain (19.65%), as shown in Table 3.

Table 3: Region-wise Prevalence of MSD's Among Thermal Plant Workers

Region	Absolute No.	%
Neck	27	23.07
Shoulders	2	1.7
Elbows	3	2.56
Wrist/Hands	1	0.85
Upper Back	1	0.85
Lower Back	53	45.29
Hips/Thighs	5	4.27
Knees	23	19.65
Ankles/feet	2	1.7

3.3. Univariate Analysis

In univariate analysis, age was identified as substantially associated with MSD (X^2 = 18.50, P < 0.001). Age and MSD had a moderately strong correlation (Cramer's V = 0.30). Workers in the age range of 30 to 40 years had 7.30 times (OR=7.30) higher risk of having MSD compared to those in the 20 to 30 years' age group. BMI and MSD were identified to be strongly associated (X^2=5.41, p<0.001). The association between MSD and BMI was moderately high (Cramer's V=0.16). Workers with normal BMI had 26.66 times (OR=26.66) higher risk of having MSD compared to those who were underweight. The nature of one's employment was found to be associated with MSD (X^2=9.95, P<0.001). MSD and work had a moderately strong correlation (Cramer's V=0.225). The risk of MSDs was 5.13 times (OR=5.13) higher for turbine employees. It has been found that work experience, measured in terms of years of employment, is associated with MSD (X^2=13.76, P<0.001). MSD and job experience had a moderately strong correlation (Cramer's V = 0.26). The strength of connection between MSD and socioeconomic level was moderate (Cramer V = 0.16). Workers from the upper middle class had a 1.90 times (OR=1.90) higher probability of developing MSD compared to workers from the upper class. On the other hand, gender, marital status, number of children, level of education, migratory status, and working hours/day were not found to be risk factors of musculoskeletal disorders in thermal plant workers.

Table 4: Demographic Risk Factors of MSDs in Thermal Power Plant Workers

Factors	With MSD's (n=117)	Without MSD's (n=79)	Total (N=196)	X^2 value	Cramer's V	Odds Ratio (95% CI)	P
Age (years)							
20-30	4	11	15	18.505***	0.307	Ref.	
30-40	12	14	26			7.302(2.15-24.76)	0.001*
40-50	24	25	49			3.098(1.28-7.47)	0.012*
50-60	77	29	106			2.766(1.36-5.59)	0.005*
BMI							
Underweight	4	7	11	5.411**	0.166	Ref.	
Normal weight	60	45	105			26.66(3.72-190.85)	0.001*
Pre-obesity	37	21	58			8.103(1.80-36.44)	0.006*
Obese	16	6	22			6.111(1.30-28.71)	0.22NS
Nature of Work							
Coal handling plant	30	33	63	9.954**	0.225	Ref.	
Turbine	20	14	34	-	-	5.133(1.34-19.63)	0.017*
Boiler	18	11	29	-	-	3.267(0.78-13.53)	0.103NS
Water treatment plant	8	7	15	-	-	2.852(0.66-12.22)	0.158NS
Electrical maintenance	19	7	26	-	-	4.083(0.81-20.37)	0.086NS
Vehicle maintenance	8	4	12	-	-	1.719(0.37-7.84)	0.484NS
Administration	14	3	17	-	-	2.333(0.41-13.17)	0.337NS
Work Experience (years)							
1 -10	14	21	35	13.761***	0.265	Ref.	
10-20	13	14	27	-	-	4.417(1.86-10.45)	0.001*
20-30	37	26	63	-	-	3.171(1.25-7.99)	0.014*
30-40	53	18	71	-	-	2.069(0.99-4.30)	0.052*

Socioeconomic Status							
Upper	11	10	21	5.367**	0.165	Ref.	
Upper middle	24	12	36	-	-	1.901(0.70-5.14)	0.206^{NS}
Lower middle	36	35	71	-	-	1.045(0.44-2.46)	0.919^{NS}
Upper lower	46	22	68	-	-	2.033(1.02-4.04)	0.044*
Lower middle	0	0	0	-	-	-	-

Note: $P\{X^2(1,0.05)\} \leq 3.84^{*} P\{X^2(1,0.01)\} \leq 6.64^{**} P\{X^2(1,0.001)\} \leq 10.83^{***}$ NS: Non-significant

4. Discussion

This study describes the prevalence and risk factors of MSD among thermal plant workers of North India. The 12-month prevalence of musculoskeletal disorders in thermal plant workers was found to be 59.7%. Low back pain showed the highest prevalence (45.29%), followed by neck pain (23.07%). A study conducted on security guards of the thermal power plant in Rupnagar reported the overall prevalence of MSDs to be 68% and the prevalence of low back pain to be 42.6% (Kaur *et al.*, 2015), which is similar to the results of our study. The general prevalence of low back pain (LBP) ranges from 25% to 73.9% among different professions (Ferguson *et al.*, 2019; Yang *et al.*, 2016; Aleku *et al.*, 2021; Bawab *et al.*, 2015; Hameed, 2013; Alnaami *et al.*, 2019). However, there is difficulty in generalizing the results owing to the paucity of literature reporting the prevalence of MSDs among thermal plant workers.

In this study, the highest proportion (54.1%) of the sample consisted of workers from the age group of 50–60 years, followed by those in the age group of 40–50 years (25%). The 12-month prevalence of MSDs was found to be higher among workers aged 50–60 years (65.8%). The prevalence was lower in the younger age group of 20–30 years (3.4%). Our findings are consistent with Guo *et al.* (2004), who reported that workers between 45 and 64 years of age in Taiwan had the highest prevalence of MSDs. Based on univariate analysis, five independent variables—age, BMI, nature of work, work experience, and socioeconomic status—were found to be significantly associated risk factors for MSDs. Workers aged 30–40 years (OR = 7.30) had seven times higher risk for developing musculoskeletal disorders, which then tended to decrease among workers aged 40–50 years (OR = 3.09) and 50–60 years (OR = 2.76). Breslin and Smith (2005) examined age-related differences in work injuries using a cross-sectional design and reported that younger male workers (≤ 35 years) had higher rates of work-related injury compared to older workers, although job characteristics explained part of the elevated risk.

The study found a significant association between BMI and MSDs. Workers with normal BMI had 26.66 times higher risk (OR = 26.66) of developing MSDs compared to underweight workers. Pre-obese workers had 8.10 times higher risk (OR = 8.10). However, contrasting findings were reported by Viester *et al.* (2013), who demonstrated that the association between BMI and MSD symptoms was modified by physical overload. Obesity was positively related to the development of symptoms (OR = 1.37) and inversely related to recovery (OR = 0.76). The nature of work was also a significant risk factor for MSDs. Workers in the turbine section had the highest risk (OR = 5.133), followed by those in electrical maintenance (OR = 4.083) and vehicle maintenance (OR = 1.719). This difference may be attributed to variation in work demands, with turbine workers frequently required to carry and lift heavy turbine parts. Quemelo *et al.* (2013) analyzed the association between workplace activities and MSDs and found a high prevalence of lower back MSDs, which they linked to static postures, repetitive movements, poor ergonomic conditions, physical inactivity, and stress. Work experience was another factor. Workers with 20–30 years of experience had a risk of OR = 3.17, while those with 30–40 years had OR = 2.06. Most workers experienced MSDs within the first 20 years of work. Farhadi *et al.* (2014) similarly reported that hydropower plant workers with greater job experience had more symptoms, especially in the upper limbs, with prevalence highest among those with over 25 years of work. Socioeconomic status was also significantly associated with MSDs. Workers belonging to the lower socioeconomic class had higher risk (OR = 2.033) compared to those from higher classes. Bandyopadhyay *et al.* (2012) studied small-scale industry workers in Kolkata and found that low per capita income was significantly associated with musculoskeletal problems (OR = 6.11).

The present study is unique, since to date, only one study has been reported in thermal plant workers, which was limited to security guards and did not account for variations associated with the nature of work. Thus, it is difficult to generalize results based on a single study. Additionally, the cross-sectional design limited causal inference, and the use of a self-report questionnaire may have introduced recall bias.

5. Conclusion

The findings of the present study indicate that the prevalence of MSDs among thermal power plant workers is comparable to that reported in other occupational groups. Thermal plant workers were particularly prone to musculoskeletal complaints involving the lower back, neck, and knees. Several risk factors, including age, body mass index (BMI), nature of work, years of experience, and socioeconomic status, were identified as contributing to MSD occurrence. These results underscore the need for targeted ergonomic measures and exercise-based interventions, both for prevention and for the rehabilitation of affected workers in thermal power plants.

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Authorship Contribution

All authors have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Declarations

The authors declare that the submitted manuscript has not been published, accepted for publication, or is currently under editorial or peer-review consideration for publication elsewhere.

Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethical Committee of Sri Guru Granth Sahib World University, Fatehgarh Sahib (Ref. No. SGGSWU/IEC/2021/04).

Conflict of Interest

The authors declare no conflict of interest related to this study.

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