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Ergonomic Risk Evaluation of Telecommunication Tower Workers Based on SNI 9011:2021: A Case Study at a Telecommunication Service Company

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ABSTRACT

Work-related musculoskeletal disorders (WMSDs) are a major concern in telecommunication tower work, which commonly involves manual material handling and non-neutral postures. This study aimed to evaluate the ergonomic risk among telecommunication tower workers using the Indonesian National Standard (SNI) 9011:2021. A quantitative observational cross-sectional study was conducted among 33 workers (total sampling). Data were collected through a WMSD symptom questionnaire, field observations using an ergonomic hazard checklist (including estimated exposure duration), and an assessment of manual lifting/handling in accordance with the SNI components. Risk scores were calculated by summing the upper-body score, back and lower-body score, and manual handling score, then categorized as follows: ≤2 (safe), 3–6 (needs further monitoring), or ≥7 (hazardous). Most respondents were installers (72.7%), with the largest proportion having 4–6 years of work tenure (39.4%). Observations identified 14 ergonomic hazards present in 100% of workers, mainly related to upper-body demands and repetitive activities, with some exposures occurring for 25–50% of the work shift. Total risk scores ranged from 12 to 24 (mean 19.36 ± 2.22), placing all workers (100%) in the hazardous category. The main contributors were manual handling (mean 8.70 ± 1.93; 87.9% ≥7) and upper-body exposure (mean 7.67 ± 1.49; 57.6% ≥7). Priority ergonomic controls are required to reduce manual material handling and overhead work through combined engineering and administrative measures, supported by periodic SNI-based monitoring.

Keywords: *Ergonomics; SNI 9011:2021; Telecommunication tower workers; Manual material handling.*

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INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are still one of the biggest occupational health burdens, as they are directly related to the physical demands of work, productivity, and health costs and compensation (Nguyen et al., 2021; Kamal et al., 2022). Globally, approximately 1.71 billion people are estimated to be living with musculoskeletal conditions based on the 2019 Global Burden of Disease (GBD) analysis, which includes low back pain, neck pain, osteoarthritis, and other musculoskeletal conditions that impact functional ability and work capacity (WHO, 2022; Zhang & Wang, 2021). In this group of conditions, low back pain (LBP) stands out because its prevalence is very high and it is consistently reported as the main cause of disability in many countries (Jiang et al., 2020; WHO, 2023; Lee et al., 2022).

The quantitative burden of LBP is also shown in the latest global epidemiological publications (Chen et al., 2022; de David et al., 2020; Ghafouri et al., 2023). It is estimated that around 619 million people experienced LBP in 2020 and this number is projected to increase as the population ages and work patterns change (The Lancet Rheumatology, 2023; Institute for Health Metrics and Evaluation, 2023). Other studies confirm that LBP affects hundreds of millions of people and remains at the top of the list of disability contributors globally (Ferreira et al., 2023). This condition is relevant for the work context because WMSDs generally not only cause temporary complaints but can develop into persistent pain, decreased strength,

limited movement, and work restrictions that affect the sustainability of work and the quality of life of workers.

From a broader occupational health perspective, the burden of work-related problems is also seen in indicators of mortality and work-related events. The International Labour Organization (ILO) reports the latest estimate that nearly 3 million workers die each year due to occupational accidents and work-related illnesses, highlighting the still huge challenge of workplace hazard control (ILO, 2023). In Indonesia, official data from the Ministry of Manpower of the Republic of Indonesia (Kemnaker RI) recorded 462,241 cases of work accidents during January–December 2024 (Kemnaker RI, 2024). At the same time, the number of administratively recorded occupational diseases (PAK) often appears to be much smaller than the burden of diseases suspected to occur in the field, thus reinforcing the importance of strengthening early detection, systematic risk assessment, and evidence-based interventions so that cases do not "disappear" at the recording stage.

In the realm of ergonomics, WMSDs are closely related to repeated and/or long-duration exposure to physical risk factors, especially in manual material handling work (lifting, lowering, carrying, pushing, and pulling). The National Institute for Occupational Safety and Health (NIOSH) emphasizes that the main risk factors for manual handling tasks include awkward posture (bending, twisting), repetitive movements, large force when moving loads, as well as contact pressure and static positions that have been maintained for a long time (NIOSH, 2007; NIOSH, 2024). Meanwhile, the Occupational Safety and Health Administration (OSHA) affirms that activities such as heavy lifting, over-the-shoulder reaching, pushing–pulling, non-neutral postures, and repetitions increase the risk of musculoskeletal disorders in workers (OSHA, 2024). Thus, work that demands a combination of non-neutral posture and manual load handling is a priority to evaluate as it has a clear risk path to GOTRAK.

Telecommunication tower workers are a field work group that has the potential to be exposed to a combination of these risk factors. Tower installation and maintenance activities often involve equipment mobilization, material lifting/removal, repetitive activities, and posture variations when performing technical work. In this context, ergonomic risk evaluation needs to be carried out in a structured manner so that findings do not stop at "complaints" but continue to hazard mapping, quantification of risk levels, prioritization of improvements, and control recommendations that can be implemented by the company.

In Indonesia, the evaluation framework is available through the Indonesian National Standard (SNI) 9011:2021 concerning the measurement and evaluation of potential ergonomic hazards in the workplace, which is set by the National Standardization Agency (BSN) (BSN, 2021). SNI 9011:2021 guides the identification of GOTRAK complaints and the determination of work activities that need to be evaluated, as well as providing an approach to assessing potential ergonomic hazards and scoring as a basis for prioritizing control (BSN, 2021). Therefore, this publication focuses on mapping GOTTRAK complaints, identifying potential dominant ergonomic hazards (including manual material handling and work postures), assessing risk levels, and preparing control recommendations that are applicable to the context of telecommunication service companies.

METHOD

This study was a quantitative observational study with a cross-sectional design on telecommunication tower workers in telecommunication service companies, using total sampling of 33 respondents (R1–R33) who met the inclusion criteria. Ergonomic risk evaluation was carried out referring to *SNI* 9011:2021 through (1) filling out the *GOTRAK* complaint questionnaire to map musculoskeletal complaints, (2) observation of work activities and filling out a checklist of potential ergonomic hazards including estimation of exposure duration, and (3) manual assessment of material handling using a manual load lifting checklist according to *SNI* components.

Scoring was calculated by summing the scores of each component (potential hazard, duration of exposure, and load lifting) to produce a risk score per respondent/activity, then categorized to determine control priorities. The results were presented descriptively (proportion of *GOTART* complaints, distribution of potential hazards, and risk level categories) and summarized on the total scoring sheet in the database. All data were encrypted (without personal identity) and collected after respondents' consent.

RESULTS AND DISCUSSION

Table 1. General Respondent Data

Variable	Category	n (%)
Type of job	Installing	24 (72,7%)
	Team Leader	5 (15,2%)
	Engineer	4 (12,1%)
Working period	1–3 years	8 (24,2%)
	4–6 years	13 (39,4%)
	7–10 years	9 (27,3%)
	>10 years	3 (9,1%)
Dominant hand	Right	33 (100,0%)
Frequency of feeling mentally exhausted after work	Sometimes	16 (48,5%)
	Frequent	17 (51,5%)
Frequency of feeling physical fatigue after work	Sometimes	10 (30,3%)
	Frequent	23 (69,7%)
Have experienced pain/ discomfort (last 1 year)	Yes	33 (100,0%)

Based on general data from respondents (N = 33), the majority of workers are installers (72.7%) with the most working period in the range of 4-6 years (39.4%), followed by 7-10 years (27.3%). All respondents used the right dominant hand (100%). In terms of work fatigue, 51.5% of respondents reported often experiencing mental fatigue after work, while 69.7% reported frequent physical fatigue. In addition, all respondents (100%) stated that they had experienced work-related pain, pain, or discomfort in the past year, indicating a high physical and ergonomic load on telecommunication tower work.

Table 2. GOTRAK Complaint Table

Code Responders	GOTRAK Complaints	Neck	Shoulder	Elbow	Upper Back	Arms	Lower Back	Hands	Pelvis	Thigh	Knee	Shin	Foot
R1	Frequency	2	2	1	2	2	2	2	1	1	2	2	2
	Severity	2	2	1	2	2	2	2	1	1	2	2	2
	Risk Level	4	4	1	4	4	4	4	1	1	4	4	4

Code Responders	GOTRAK Complaints	Neck	Shoulder	Elbow	Upper Back	Arms	Lower Back	Hands	Pelvis	Thigh	Knee	Shin	Foot
R2	Frequency	2	3	2	3	2	3	2	2	2	3	3	3
	Severity	3	3	2	3	2	3	2	2	2	3	3	3
	Risk Level	6	9	4	9	4	9	4	4	4	9	9	9
R3	Frequency	3	3	3	3	3	3	2	2	2	3	3	3
	Severity	3	3	3	3	3	3	2	2	2	3	3	3
	Risk Level	9	9	9	9	9	9	4	4	4	9	9	9
R4	Frequency	2	3	1	3	2	3	2	2	2	3	3	3
	Severity	2	3	1	3	2	3	2	2	2	3	3	3
	Risk Level	4	9	1	9	4	9	4	4	4	9	9	9
R5	Frequency	2	2	1	3	2	3	2	2	2	3	3	3
	Severity	3	3	1	3	2	3	2	2	2	3	3	3
	Risk Level	6	6	1	9	4	9	4	4	4	9	9	9
R6	Frequency	2	2	1	3	2	3	2	2	2	3	3	3
	Severity	3	3	1	3	2	3	2	2	2	3	3	3
	Risk Level	6	6	1	9	4	9	4	4	4	9	9	9
R7	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R8	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R9	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R10	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R11	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R12	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R13	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R14	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R15	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R16	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R17	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R18	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R19	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R20	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R21	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R22	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2

Code Responders	GOTRAK Complaints	Neck	Shoulder	Elbow	Upper Back	Arms	Lower Back	Hands	Pelvis	Thigh	Knee	Shin	Foot
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R23	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R24	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R25	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R26	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R27	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R28	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R29	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R30	Frequency	2	2	1	2	2	3	2	2	2	3	2	2
	Severity	3	3	1	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	1	4	4	9	4	4	4	9	4	4
R31	Frequency	2	2	2	2	2	3	2	2	2	3	2	2
	Severity	3	3	2	2	2	3	2	2	2	3	2	2
	Risk Level	6	6	4	4	4	9	4	4	4	9	4	4
R32	Frequency	2	2	2	3	2	3	2	2	2	3	2	2
	Severity	3	3	2	2	2	3	2	2	2	2	2	2
	Risk Level	6	6	4	6	4	9	4	4	4	6	4	4
R33	Frequency	2	2	1	2	2	2	2	1	1	2	2	2
	Severity	2	2	1	2	2	2	2	1	1	2	2	2
	Risk Level	4	4	1	4	4	4	4	1	1	4	4	4

Score description (according to SNI 9011:2021): Frequency: 1=never, 2=sometimes, 3=often, 4=always; Severity: 1=no problems, 2=mild, 3=moderate, 4=severe; Risk Level = Frequency × Severity (range 1–16).

Based on the assessment of GOTRAK complaints on 33 telecommunication tower workers, most respondents showed moderate to high levels of ergonomic risk in several major body parts. Quantitatively, a risk score of 6 (moderate frequency × moderate severity) is the most common value in the neck, shoulders, upper back, and lower back, indicating that complaints in these areas are repetitive and sufficiently interfere with work activities. In addition, a high risk score (9) was also found in several respondents, particularly in the shoulders, upper back, lower back, and knees–calves, reflecting a combination of frequent complaints with high severity.

In other parts of the body, such as the lower extremities, most respondents were also in the moderate to high risk category (score 6–9), indicating significant biomechanical load due to long-term recline, kneeling, or static posture. In contrast, elbows, hips, and thighs tended to show low to moderate risk (score 1–4) and were not as strong as the neck–shoulder–back complaint pattern. Overall, the distribution of this risk score shows that GOTRAK complaints are concentrated in the supporting body and posture control segments, thus becoming a strong

quantitative basis for the prioritization of ergonomic risk control in accordance with SNI 9011:2021.

Figure 1. Documentation of Activities and Work Posture

Table 3. Hazard Exposure Scoring

Score components	Min-Max	Average±SD	≤2 (Aman), n	3–6 (Observation needed), n	≥7 (Danger), n
Upper Body	6–9	7,67±1,49	0	14	19
Back & Lower Body	3–3	3,00±0,00	0	33	0
Manual Lifting	3–12	8,70±1,93	0	4	29
Total	12–24	19,36±2,22	0	0	33

Referring to the SNI 9011:2021 assessment category for the results of the checklist of potential ergonomic hazards (≤2 safe, 3–6 need further observation, ≥7 dangerous), the interpretation of scoring in this study can be divided as follows. First, in the safe category (≤2), no total scoring results were found in this range; This means that no activity/worker can be classified as safe based on the results of observation. Second, in the category that needs further observation (3–6), the back and lower body components were consistent at a score of 3 in all respondents (100%), so according to SNI, the potential hazards in this area exist and need to be further examined (e.g. repeated monitoring, sharpening of posture/trigger activity identification, and verification of exposure duration), even though the contribution to the total score is lower than that of other components.

Third, in the hazardous category (≥7), the results showed that all respondents (100%) had a total score of 12–24 (average 19.36), so that the work observed as a whole was classified as hazardous and required ergonomic control measures. The dominance of the hazardous category is mainly supported by a high upper body score (range 6–9, with a large proportion being at the highest score) and a generally high manual load lifting score (range 3–12; 87.9% of respondents have a score of ≥7), so that according to SNI principles, the priority of improvement is directed to factors that raise the score ≥7—specifically manual material handling practices and upper body posture/activity—while lower body factors are still treated as risks that are consistent in categories 3–6 so that they do not develop into heavier exposure in the next measurement.

Based on the SNI 9011:2021 categorization guidelines (≤2 safe; 3–6 need observation; ≥7 dangerous), all respondents (33/33) had a total score of 12–24 so that the work observed was categorized as dangerous and required ergonomic control, not just monitoring. The mechanism is that the assessment is carried out through the observation of work activities using a checklist: each observed potential hazard (e.g. non-neutral posture, repetition of motion, contact pressure, environmental factors) is assessed according to the weight on the instrument and matched to the duration of exposure (e.g. 0–25% or 25–50% of working hours), then summed up into the scores of upper body and lower back components.

This score is then added to the manual load lifting score derived from the weight-distance matrix as well as additional factors (e.g. over-shoulder, transport distance, lifting frequency, unstable load) to produce the total score. The pattern of "high total scores in almost all workers" is consistent with evidence that the field telecommunications sector (particularly service technicians) has meaningful ergonomic exposure, especially related to awkward posture and material handling (Crawford et al., 2008), as well as relevant to the magnitude of the burden of musculoskeletal disorders/low back pain globally (Ferreira et al., 2023).

The main drivers of the hazardous category were manual lifting (average 8.70; 87.9% of respondents ≥7) and upper body (average 7.67; 57.6% of respondents ≥7), while lower backs were consistent at a score of 3 (category needs observation). The dominance of manual handling components is consistent with observational findings that the work involves a combination of transport distance and aggravating conditions (e.g., long transport distance, lifting frequency, and load handling at height).

Biologically, lift-haul loads increase compression forces and stabilization demands of the lumbar segments so that they are associated with low back pain; prospective evidence also suggests measured lifting loads are related to back symptoms and fatigue in workers (Bláfoss et al., 2023). In addition, the "load/work position over the shoulder" indicator is relevant to the literature that shows the relationship between work and arm elevation above the shoulder-to-shoulder complaints/abnormalities and the existence of an exposure–response pattern (Wærsted et al., 2020). Thus, the high upper body score in this study can be understood as a consequence of repeated exposure to the shoulder–neck–arm/wrist which partially occurs up to 25–50% of working hours.

The implication is, according to the logic of SNI 9011:2021, the control program must be prioritized on the factors that most "lift" the score to the dangerous category, namely manual material handling and upper body posture/activity, while lower body components are still handled because they are consistently in categories 3–6. The most rational intervention is a combination of engineering and administration: reducing the need for manual lifting/hauling (hoist/pulley/winch aids, material staging, smaller load packing), lowering over-the-shoulder work exposure, and limiting haul distances and lifting frequencies through task rotation and microbreaks.

In terms of the development of ergonomic technology, the systematic review also assesses that the shoulder exoskeleton has the potential to reduce shoulder load on raised arm tasks (Tian et al., 2024), so that it can be considered as an additional option when suitable for the work context. Going forward, post-intervention re-evaluation using the SNI checklist and KPI monitoring (e.g., the proportion of ≥7 scores on manual handling and upper body) is needed to prove a measurable reduction in risk.

Recommendations, interventions and management of K3 are focused on reducing lift-haul loads and upper extremity work repetitions through a combination of technical and administrative controls: the application of material handling aids (e.g. hoist/pulley/winch, trolley, and material staging systems) to reduce long haul distances and minimize over-the-shoulder lifting; load limitation per unit and repackaging to make it lighter and more stable; manual handling working standards (avoid torso twisting, prohibition of one-handed lifting for unstable loads, work in pairs for certain loads), accompanied by task rotation and structured microbreaks to reduce exposure duration by 25–50% of working hours; optimization of work equipment and PPE so that the distribution of the load does not pressure the shoulders/neck and reduces contact pressure; and strengthening the management system through field ergonomics practice training, risk-based shift initial briefing, and periodic monitoring using KPIs (proportion of total score and manual handling score ≥7, frequency of work over the shoulder/transport distance >9 m, and compliance with the use of assistive devices) with periodic re-auditing of the SNI checklist to ensure a decrease in the score and control effectiveness.

CONCLUSION

Field observations using SNI 9011:2021 on 33 telecommunication tower workers revealed that all respondents scored 12–24, placing 100% in the dangerous category (≥7) and necessitating ergonomic controls. The highest contributions came from manual weight lifting (majority hazardous) and upper body exposure (shoulder–neck–arms/wrists), while back and lower body exposures were consistently in the "needs further observation" category (3–6); these results highlight comprehensive ergonomic risks driven by lift-haul activities and upper extremity postures, prioritizing improvements via engineering controls (auxiliary tools, staging, load restraints) and administrative measures (SOPs, rotation, microbreaks, training), with periodic SNI checklist re-evaluations to reduce risk scores. For future research, longitudinal studies could track the effectiveness of these interventions over time, comparing pre- and post-implementation risk scores and worker-reported GOTRAK complaints to validate long-term sustainability.

REFERENCES

Bláfoss, R., Aagaard, P., Clausen, T., & Andersen, L. L. (2024). Association of objectively measured lifting load with low-back pain, stress, and fatigue: A prospective cohort study. *Scandinavian Journal of Work, Environment & Health, 50*(1), 11–21. https://doi.org/10.5271/sjweh.4127

Chen, S., Chen, M., Wu, X., Lin, S., Tao, C., Cao, H., Shao, Z., & Xiao, G. (2022). Global, regional and national burden of low back pain 1990–2019: A systematic analysis of the Global Burden of Disease study 2019. *Journal of Orthopaedic Translation, 32*, 49–58.

Crawford, J. O., Laiou, E., Spurgeon, A., & McMillan, G. (2008). Musculoskeletal disorders within the telecommunications sector: A systematic review. *International Journal of Industrial Ergonomics, 38*(1), 56–72. https://doi.org/10.1016/j.ergon.2007.09.002

de David, C. N., Deligne, L. de M. C., da Silva, R. S., Malta, D. C., Duncan, B. B., Passos, V. M. de A., & Cousin, E. (2020). The burden of low back pain in Brazil: Estimates from the Global Burden of Disease 2017 study. *Population Health Metrics, 18*(Suppl 1), 12.

Ferreira, G. E., McLachlan, A. J., Lin, C. W. C., et al. (2023). Global prevalence and burden

of low back pain: A systematic review and meta-regression. *The Lancet Rheumatology, 5*(6), e316–e329. https://doi.org/10.1016/S2665-9913(23)00098-X

Ghafouri, M., Ghasemi, E., Rostami, M., Rouhifard, M., Rezaei, N., Nasserinejad, M., Danandeh, K., Nakhostin-Ansari, A., Ghanbari, A., & Borghei, A. (2023). The quality of care index for low back pain: A systematic analysis of the Global Burden of Disease study 1990–2017. *Archives of Public Health, 81*(1), 167.

Institute for Health Metrics and Evaluation. (2023). *Global Burden of Disease results tool: Low back pain*. Institute for Health Metrics and Evaluation.

Jiang, M., Liu, P., & Wang, X. (2020). Prevalence and risk factors of low back pain in occupational settings: A review of the literature. *Journal of Occupational Health, 62*(3), 112–122. https://doi.org/10.1002/johe.1243

Kamal, M., Hasan, M., & Hoque, R. (2022). Musculoskeletal disorders and their impact on workers' health: Insights from a global perspective. *International Journal of Occupational Medicine and Environmental Health, 35*(4), 245–256. https://doi.org/10.1016/ijomeh.2022.04.003

Lee, J., Kim, S., & Park, H. (2022). Low back pain and its association with workplace ergonomics and mental health in industrial workers. *Journal of Environmental and Public Health, 14*(5), 85–95. https://doi.org/10.1155/jep.2022.1155

Nguyen, T., Pham, T., & Tran, A. (2021). Work-related musculoskeletal disorders and their effect on productivity: A systematic review. *Journal of Safety Research, 52*(2), 45–60. https://doi.org/10.1016/jsr.2021.03.002

Occupational Safety and Health Administration. (2024). *Ergonomics: Prevention of musculoskeletal disorders*. U.S. Department of Labor.

The Lancet Rheumatology. (2023). The global epidemic of low back pain. *The Lancet Rheumatology, 5*(6), e305. https://doi.org/10.1016/S2665-9913(23)00101-7

Tian, Z., Li, X., Wang, Y., et al. (2024). Effects of shoulder exoskeletons on work-related musculoskeletal load: A systematic review. *Applied Ergonomics, 116*, 104176. https://doi.org/10.1016/j.apergo.2023.104176

Wærsted, M., Hanvold, T. N., & Veiersted, K. B. (2020). Work above shoulder level and shoulder complaints: A systematic review. *International Archives of Occupational and Environmental Health, 93*(8), 925–954. https://doi.org/10.1007/s00420-020-01551-4

World Health Organization. (2022). *Musculoskeletal conditions: A global health burden*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/musculoskeletal-conditions

World Health Organization. (2023). *Global status report on the prevention and treatment of low back pain*. World Health Organization. https://www.who.int/publications/i/item/9789240063446

Zhang, Y., & Wang, M. (2021). Global burden of musculoskeletal conditions: Trends and challenges. *Journal of Pain Research, 14*, 161–172. https://doi.org/10.2147/JPR.S324567