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Influence of Work-Related Musculoskeletal Disorders on Cognitive Performance of SDL Machine Operators in Underground Mines – A Statistical Inference Approach

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Abstract

Musculoskeletal disorders (MSDs) are found among humans performing work, physical activities, and sports. The presence of MSDs is often associated with health burdens and significantly affects the ability to work. MSD discomfort, such as lower back pain, is considered more prevalent than pain in the neck, shoulders, and knees. The objective of this study was to evaluate the prevalence of MSDs and their effect on cognitive performance among machine operators working in underground mines. Fifty-five male machine operators participated in this study, with MSDs evaluated using the Nordic Musculoskeletal Questionnaire (NMQ) and cognitive performance assessed with the Psychomotor Vigilance Test (PVT). The results suggested that lower back pain was the highest reported pain with 43.6%, followed by upper back (29.1%), and neck (23.6%). Statistically significant effects of shoulder (B = 90.487, p = 0.033) and lower back (B = 60.755, p = 0.021) were obtained from the multivariate regression analysis. Long-term sedentary work has resulted in the prevalence of MSDs among machine operators. Moreover, the impairment of cognitive performance is a serious concern in one of the safety-critical jobs of machine operations in the production face of the underground mines. Management and prevention of MSDs, cognitive performance decline, and the implementation of health improvement plans by mine management are necessary for safe machine operations.

Major Findings: *In this study, the role of MSDs in cognitive performance among machine operators was identified, which is a critical observation for establishing safe machine operations in underground mines.*

Keywords: *Alertness, Lower Back Pain, Psychomotor Vigilance Test, Sustained Attention*

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1. Introduction

Musculoskeletal disorders (MSDs) are found among humans performing work, physical activities, and sports. The presence of MSDs is often associated with health burdens and significantly affects the ability to work[1]. An association between adverse health effects and sedentary work behaviour has been observed in the literature[2]. Conventional studies focused on the impact of sedentary work on health complications such as obesity, diabetes, cancer, and premature mortality. Static postures and constrained sitting have been identified and documented in recent studies as risk factors for MSDs in seated work environments[3]. Nonetheless, the role of sedentary work and associated MSDs in cognitive function has not been studied extensively to have a clear picture[4].

Lower back pain associated with sedentary work has been extensively studied in both industrial settings and laboratory environments to determine its causal relationship with task-related risk factors. Several studies have reported factors such as continuous pressure on the buttocks and working discomfort as reasons for the occurrence of lower back pain[5,6]. Furthermore, other findings suggest that the reason for back pain and discomfort is due to sustained low-intensity stimulation of passive tissues[7]. Sitting time has also been related to

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lower back discomfort due to long sitting hours, resulting in flattening of the spinal curve[8]. A prolonged period of low muscle loading in the lower back region is identified as another cause of such discomfort[7].

The discomfort in the neck, shoulders, and upper limbs has been widely reported among sedentary workers in various industries[9]. Studies on the effect of work-related sedentary work on MSDs affecting the lower limbs have reported mixed evidence. Some studies among them have shown association of prolonged sitting during work and prevalence of MSDs in the lower limb region[10]. Certain studies on prolonged sitting conditions have shown discomfort in the lower limb, which sometimes manifests as swelling[11,12]. Compared with active working styles like walking or cycling, prolonged periods of sitting with poor work posture result in comparatively less muscle activity in the lower limbs[6]. The presence of passive load in the thigh and buttock regions, which affects the tissues, has also been observed in sedentary work studies[13].

In industrial settings, where operators assume a sitting posture, besides MSDs affecting various body parts, researchers have also highlighted the issue of deterioration of cognitive health[4]. Several pieces of evidence indicate that light and moderate physical activity is associated with improvement in cognitive health[14]. On the contrary, workers performing sedentary work, where sitting posture is maintained for a prolonged time, have experienced deterioration of cognitive capabilities[15]. A study on the elderly working population found that prolonged sedentary work led to the development of MSDs and discomfort throughout the body, which in turn resulted in a decline in cognitive performance, including attention and response[4]. Several studies also suggested that cognitive functions, including attention, working memory, and processing, are linked to muscle characteristics in terms of the quality and efficiency of their functioning[16,17]. A recent study of fatigue among face machinery operators showed the impact of workload on cognitive fatigue operators working in underground coal mines[18]. Other risk factors, such as BMI and age-related muscle loss, are found to be critical assessment of MSDs and cognitive performance among the working population[19].

It is evident that several studies pertaining to the public health domain, with a focus on MSDs in the general population and a certain number of studies on office workers, are predominant in the literature[4,20]. Field-based evaluations of workers involved in various industrial jobs are required to ascertain the risk to safety and occupational health. To address this gap, this study aimed to evaluate musculoskeletal disorders and their effect on the cognitive performance of SDL machine operators in underground coal mines. Moreover, it was an attempt to explore the relationship between various MSDs affecting different body regions and their impact on the cognitive performance of the operators.

2. Materials and Methods

The study was conducted among machine operators working in underground coal mines located in the eastern part of India, and all the standard ethical guidelines were followed throughout. The Institutional Ethics Committee of the Indian Institute of Technology Kharagpur approved this study. Before the commencement of all the assessments related to the study, a briefing on the objectives of the study and the procedures to be followed was performed. All the participants associated with this study provided informed consent for participating in the study. 55 mobile machine operators, in healthy condition based on their medical history, volunteered to participate in the current study. The participants were between the ages of 18 and 60 years. The machine operators working in the production face of the underground mine were all male. Figure 1 shows an operator handling an SDL machine in an underground coal mine.

2.1 Personal and Demographic Factors

Certain personal and demographic factors of the machine operators working in the underground mines were included in the data collection process. The personal factors include height (cm), weight (kg), BMI (kg/m^2), BSA (m), and the demographic factor considered was age. The BSA was computed from the Mosteller formula. The percentage-wise distribution of operators among different age groups and BMI categories was also determined.

2.2 MSDs Evaluation

The symptoms of MSDs experienced by the machine operators engaged in this study were examined using the

Nordic musculoskeletal questionnaire (NMQ). In this evaluation method, the MSD symptoms associated with the body, starting from the neck to the feet, were examined. Those specific body parts were the neck, shoulders, arms, wrists, hands, upper back, lower back, hips, thighs, knees, and feet. The symptoms associated with MSDs were pain and discomfort in the affected regions of the body. The pain due to MSDs experienced by the participants was self-reported for each body part mentioned in NMQ.

2.3 Cognitive Performance Test

The machine operators performed the sustained attention test using a standard Psychomotor Vigilance Test (PVT) procedure for evaluating their cognitive performance. The equipment used was a portable and convenient piece of equipment used for field conducted studies, namely, the PVT-192 monitor (Ambulatory monitoring, Inc., Ardsley, NY), as shown in Figure 2. The operators performed the sustained attention test for a time period of 10 minutes. The test was based on observing a visual stimulus and performing a reaction, which encompasses a psychomotor interaction between the subject and the device. PVT-192 monitor consists of a visual stimulus display area in red colour, and a main display in blue colour. The main display showed the settings available with the device, initiation, and end of the test. The visual stimulus was a red-Light Emitting Diode (LED) display of a running number in the form of milliseconds, starting from 0 ms. The operators responded by pressing the reaction button upon observing the visual stimulus. When the first reaction was performed, the visual stimulus disappeared. The next visual stimulus appeared randomly between a time interval of 2 sec. and 10 sec. This cycle of the display of a visual stimulus and the delivery of a reaction continued for a period of 10 minutes. Reaction time, which is defined as the time elapsed from the display of the visual stimulus to the execution of the reaction, was saved in the memory of the device. Similarly, all the reaction times obtained for a single operator throughout the experiment were saved in the device memory. Finally, an average reaction time was computed and conveyed by the device. At the end of the experiment, an average reaction time, which is referred to as the reaction time associated with an individual, was obtained for all the participants.

2.4 Statistical Analysis

All the statistical analyses used in this study were performed in IBM-SPSS (version 29.0). All the data collected during the process of this study were systematically gathered and organised to aid the analysis. The descriptive statistics of the personal and demographic factors, MSDs, and reaction time were evaluated first. Pearson correlation analysis was performed to examine the association of all the personal factors involved in this study, namely, age, BMI, and BSA, with the reaction time. Additionally, a Point – Biserial correlation analysis was performed to assess the correlation between pain



Figure 1. An operator sitting in an underground mining machine.



Figure 2. PVT-192 reaction time measuring device.

Table 1. Descriptive statistics of personal and demographic factors (n = 55)

Factor	Mean	SD	Min.	Max.
Height (cm)	165.71	6.08	152.20	183.10
Weight (kg)	67.76	7.44	54.20	89.60
Age (year)	40.38	7.21	28	57
BSA (m)	1.76	0.11	1.55	2.09
Age group				
20–29	5.5%			
30–39	40.0%			
40–49	43.6%			
50–60	10.9%			
BMI (kg/m²)	24.67	2.38	21.15	32.59
BMI class				
≥23kg/m²	83.6%			
<23 kg/m²	16.4%			

in various body regions and the reaction time. Finally, multivariate regression analysis was employed to assess the association of MSD pains observed from NMQ among the operators. In this analysis, the dependent variable was the reaction time obtained from the PVT assessment of cognitive performance. The independent variables were the individual pains in different body regions. The presence of pain was considered as a binary outcome coded as yes = 1, and no = 0.

3. Results

The descriptive statistics of the personal and demographic factors of the machine operators (n = 55) are shown in Table 1. The mean (SD) and range of height and weight were: height = 165.71 (6.08), and range = 152.20 to 183.10 cm, and weight = 67.76 (7.44), range = 54.20 to 89.60 kg. The percentage of operators in the age group in the range 20 – 29 was 5.5%, 30 – 39 was 40%, 40 – 49 was 43.6%, and 50 – 60 was 10.9%. mean (SD) of age = 40.38(7.21). The average BSA was 1.76 (SD = 0.11) m, with a range = 1.55 to 2.09 m. The percentage of operators with a Body Mass Index (BMI) ≥23kg/m² was 83.6%, and those with a BMI <23 kg/m² was 16.4%. Mean (SD) of BMI was 24.67(2.38) kg/m².

Table 2. Various MSDs and their percentage among operators (n = 55)

MSD	Operators (%)
Neck	23.6
Shoulder	1.8
Elbows	18.2
Hand	10.9
Upper Back	29.1
Lower Back	43.6
Hip/Thigh	7.3
Knee	23.6
Ankle/Feet	10.95

The MSDs related to pain in various body regions, according to the NMQ scheme of evaluation, are shown in Table 2. The percentage of operators who experienced pain in the neck was 23.6%, the shoulder was 1.8%, the elbows was 18.2%, the hands was 10.9%, the upper back was 29.1%, the lower back was 43.6%, the hip/thigh was 7.3%, the knee was 23.6%, and the ankle/feet was 10.95%.

The reaction time and its distribution obtained from the sustained attention test using the PVT 192 portable device are shown in Table 3. The reaction time ranged

from 224.89 ms to 530.98 ms. The 25th percentile was 286.63 ms, the 50th percentile (median) reaction time was 401.25 ms, and the 75th percentile was 426.59 ms.

The outcome from the Pearson correlation analysis considering the demographic and personal factors included in the study, namely, age, BMI, and BSA, is shown in Table 4. Age had a statistically significant correlation of r = 0.383 (95% CI = 0.131 to 0.588, p = 0.004), with BMI r = -0.240 (95% CI = -0.287 to 0.243, p = 0.864), with BSA r = -0.210 (95% CI = -0.450 to 0.059, p = 0.124),

Point–Biserial correlation between various body part pains and the reaction time is shown in Table 5. Neck pain correlated r_{pb} = 0.083 (95% CI = -0.186 to 0.341, p = 0.545), with shoulder a statistically significant, r_{pb} = 0.380 (95% CI = 0.127 to 0.586, p = 0.004), with elbows, r_{pb} = 0.266 (95% CI = 0.000 to 0.496, p = 0.050), with hand, r_{pb} = 0.249 (95% CI = -0.017 to 0.483, p = 0.067), with upper back, r_{pb} = 0.248 (95% CI = -0.019 to 0.481, p = 0.068), with lower back a statistically significant, r_{pb} = 0.435 (95% CI = 0.192 to 0.628, p <0.001), with hip/thigh, r_{pb} = 0.146 (95% CI = -0.124 to 0.396, p = 0.288), with

Table 3. Distribution of the reaction time (n = 55)

	Reaction Time (ms)
Minimum	224.89
25th percentile	286.63
50th percentile	401.25
75th percentile	426.59
Maximum	530.98

Table 4. Pearson correlation of the reaction time with all the factors (n = 55)

Factor	Corr.(r)	95% CI		p-value
		Lower Bound	Upper Bound	
Age	0.383*	0.131	0.588	0.004
BMI	-0.240	-0.287	0.243	0.864
BSA	-0.210	-0.450	0.059	0.124

**correlation is significant with p ≤ 0.001, *correlation is significant with p ≤ 0.05.

Table 5. Point – Biserial correlation of the reaction time with all the factors (n = 55)

Factor	Corr.(r_{pb})	95% CI		p-value
		Lower Bound	Upper Bound	
Neck	0.083	-0.186	0.341	0.545
Shoulder	0.380*	0.127	0.586	0.004
Elbows	0.266*	0.000	0.496	0.050
Hand	0.249	-0.017	0.483	0.067
Upper Back	0.248	-0.019	0.481	0.068
Lower Back	0.435**	0.192	0.628	<0.001
Hip/Thigh	0.146	-0.124	0.396	0.288
Knee	0.193	-0.076	0.436	0.157
Ankle/Feet	0.155	-0.115	0.404	0.258

**correlation is significant with p ≤ 0.001, *correlation is significant with p ≤ 0.05.

Table 6. Association of various MSDs with the reaction time (n = 55) using multivariate regression analysis

MSD	Estimate (B)[a]	95%CI		p-value
		Lower Bound	Upper Bound	
Neck	-32.87	-121.61	55.87	0.459
Shoulder	88.88*	4.84	172.91	0.039
Elbows	150.58	-15.44	316.61	0.074
Hand	34.10	-92.32	160.53	0.589
Upper Back	-0.95	-81.85	79.96	0.981
Lower Back	58.42*	6.01	110.83	0.030
Hip/Thigh	-126.90	-309.94	56.13	0.169
Knee	-50.89	-151.28	49.50	0.313
Ankle/Feet	50.58	-69.39	172.55	0.395

[a]Age-adjusted estimates are shown, *p< 0.05

knee, r_{pb} = 0.193 (95% CI = -0.076 to 0.436, p = 0.157), and with ankle/feet, r_{pb} = 0.155 (95% CI = -0.115 to 0.404, p = 0.258).

The impact of pain in various body parts due to the prevalence of MSDs among the machine operators was analysed by multivariate regression analysis. The age-adjusted estimate (B) for each body part is shown with its 95% CI and the significance in Table 6. The value of estimate obtained were: for neck pain, B = -32.87 (95% CI = -121.61 to 55.87, p = 0.459), shoulder, B = 88.88 (95% CI = 4.84 to 172.91, p = 0.039), elbows, B = 150.58 (95% CI = -15.44 to 316.61, p = 0.074), hand, B = 34.10 (95% CI = -92.32 to 160.53, p = 0.589), upper back, B = -0.95 (95% CI = -81.85 to 79.96, p = 0.981), lower back, B = 58.42 (95% CI = 6.01 to 110.83, p = 0.030), hip/thigh, B = -126.90 (95% CI = -309.94 to 56.13, p = 0.169), knee, B = -50.89 (95% CI = -151.28 to 49.50, p = 0.313), and ankle/feet, B = 50.58 (95% CI = -69.39 to 172.55, p = 0.395).

4. Discussion

4.1 Prevalence of MSDs among Operators

The operators performing machine operations were found to experience MSD discomfort while performing their operations. The sedentary nature of the job was one of the major characteristics that was observed to affect musculoskeletal health. These results are consistent with past studies that have observed that operators are affected by working in a seated posture, such as in locomotives and trucks[21,22]. The prevalence of MSDs in such studies also indicated the influence of workplace factors, such as whole-body vibration and awkward posture. In this study, the body region with the highest percentage of affected operators was the lower back (43.6%). The second highest reported discomfort was in the upper back (29.1%), followed by the neck and knee (23.6%). Similar results were obtained in studies that focused on evaluating MSDs among the working population, including occupationally seated workers[23-25]. Previous studies in India have reported that work-related MSDs in the lower back region of workers' bodies are the most commonly reported discomfort[21,23]. Similarly, a combination of pain in the neck, shoulder, and lower back has been reported among workers in seated postures[26]. In the current study, it was observed that the design of the operator cabin seat was inadequate to provide the required comfort and support to the operator's body parts. Such inequalities in the anthropometric requirements of operators have been identified as a risk factor in the causation of MSDs[27,28]. The operators involved in this study performed driving and load-handling activities during their machine operations in underground coal mines. The hip, thigh, and leg portions were observed to be in a static loading condition throughout the working time. In such situations, research has shown that the muscles experience cramping, fatigue,

and lowered blood flow[29]. Such biomechanical stress due to static loading has been shown to result in chronic strain in the critical body segments, such as the lower spine[30]. In this study, the upper body regions, namely, neck and upper back, were also reported as highly affected body parts, followed by elbows and hands, indicating the presence of MSDs. It was also observed that workers assumed awkward postures while performing task-related to machine operations. These findings are in agreement with studies that reported awkward posture and its impact on MSDs[29,31].

4.2 Impact of MSDs on Cognitive Performance

In this study, the vigilance evaluation using the standard PVT indicated that the MSDs experienced by the operators affected their cognitive performance. From the statistical analysis, it was clear that certain body regions suffering from MSD-related pain were significantly associated with cognitive performance. Among them, lower back pain showed the most significant association, followed by pain in the shoulder and elbows. These results are consistent with a study that has shown the detrimental effect of pain on cognitive performance and the tendency to commit errors[32]. It is also found that chronic pain has adversely influenced cognitive functions, affecting various aspects of cognitive function, such as memory, response, and flexibility[33]. Driving tasks are generally considered complex and often involve numerous subtasks[34], whereas operating mobile machines in the underground mines is a more complicated job. Chronic sitting and the related MSDs problems faced by the machine operators and their successive impact on cognitive performance, according to previous studies, have been associated with inaccuracies in driving, vigilance, and workplace safety[35,36]. Studies have also shown that older adults exhibited a steep increase in cognitive performance decline and a significantly increased probability of dementia[37,38]. According to Baker[4], the sedentary work had resulted in discomfort related to MSDs and cognitive performance, and recommended a practice of breaking prolonged sitting to improve the performance of workers. Machine operators' prolonged sitting may also affect their visuospatial capability to understand the workplace features, which is critical in mobile machine operations, as evidenced by the deteriorating cognitive performance. A review by Chandrasekaran[15] has pointed out such negative effects of chronic sedentary work on cognitive function and, as an intervention, recommended breaking up continuous occupational sitting to improve safety and productivity.

4.3 Limitations of This Study

The present study was conducted among machine operators, constituting a smaller sample size. Further, the MSDs-related data were collected using a subjective assessment method such as NMQ, which possesses reporting bias. Additional research in this area, which evaluates the relationship of MSDs on attention tasks, is necessary to establish conclusive outcomes.

5. Conclusion

The objective of this study was to evaluate the prevalence of musculoskeletal disorders (MSDs) among underground mine machine operators and to examine their impact on cognitive performance, measured through reaction time in a sustained attention task. The results showed that lower back pain was the most prevalent MSD (43.6%), followed by upper back pain (29.1%) and neck pain (23.6%). Statistical analyses revealed significant associations between shoulder and lower back pain and increased reaction times, indicating impaired cognitive performance. These findings highlight that long-term sedentary work and the presence of other risk factors are consequential in leading to such disorders and cognitive health effects. Prolonged sedentary work and awkward postures in machine cabins contribute not only to MSDs but also to reduced vigilance in safety-critical tasks. Therefore, ergonomic interventions such as improved seat design, scheduled breaks to reduce continuous sitting, and management of vibration and repetitive motion are essential to mitigate MSDs and safeguard cognitive performance. Mine management should prioritise health improvement plans and ergonomic redesigns to enhance operator safety and productivity.

6. References

1. Fulton J, Wright K, Kelly M, Zebrosky B, Zanis M, Drvol C, *et al.* Injury risk is altered by previous injury: a

systematic review of the literature and presentation of causative neuromuscular factors. Int J Sports Phys Ther. 2014 Oct; 9(5):583-95.

2. Straker L, Dunstan D, Gilson N, Healy G. Sedentary work. Evidence on an emergent work health and safety issue. 2016;

3. Marshall S, Gyi D. Evidence of health risks from occupational sitting: where do we stand? Am J Prev Med [Internet]. 2010 Oct 1; 39(4):389-91. https://doi.org/10.1016/j.amepre.2010.07.001

4. Baker R, Coenen P, Howie E, Williamson A, Straker L. The short-term musculoskeletal and cognitive effects of prolonged sitting during office computer work. Vol. 15, International Journal of Environmental Research and Public Health. 2018; 15:1678. https://doi.org/10.3390/ijerph15081678

5. De Looze MP, Kuijt-evers LFM, Van Dieën J. Sitting comfort and discomfort and the relationships with objective measures. Ergonomics [Internet]. 2003 Aug 1; 46(10):985-97. https://doi.org/10.1080/0014013031000121977

6. Reid CR, McCauley Bush P, Karwowski W, Durrani SK. Occupational postural activity and lower extremity discomfort: A review. Int J Ind Ergon [Internet]. 2010; 40(3):247-56. https://doi.org/10.1016/j.ergon.2010.01.003

7. Mörl F, Bradl I. Lumbar posture and muscular activity while sitting during office work. J Electromyogr Kinesiol [Internet]. 2013; 23(2):362-8. https://doi.org/10.1016/j.jelekin.2012.10.002

8. Le P, Marras WS. Evaluating the low back biomechanics of three different office workstations: Seated, standing, and perching. Appl Ergon [Internet]. 2016; 56:170-8. https://doi.org/10.1016/j.apergo.2016.04.001

9. Wærsted M, Hanvold TN, Veiersted KB. Computer work and musculoskeletal disorders of the neck and upper extremity: A systematic review. BMC Musculoskelet Disord [Internet]. 2010; 11(1):79. https://doi.org/10.1186/1471-2474-11-79

10. Da Costa BR, Vieira ER. Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. Am J Ind Med [Internet]. 2010 Mar 1; 53(3):285-323. https://doi.org/10.1002/ajim.20750

11. Søndergaard KHE, Olesen CG, Søndergaard EK, de Zee M, Madeleine P. The variability and complexity of sitting postural control are associated with discomfort. J Biomech [Internet]. 2010; 43(10):1997-2001. https://doi.org/10.1016/j.jbiomech.2010.03.009

12. Winkel J, Jørgensen K. Evaluation of foot swelling and lower-limb temperatures in relation to leg activity during long-term seated office work. Ergonomics [Internet]. 1986 Feb 1; 29(2):313-28. https://doi.org/10.1080/00140138608968267

13. Makhsous M, Lin F, Bankard J, Hendrix RW, Hepler M, Press J. Biomechanical effects of sitting with adjustable ischial and lumbar support on occupational low back pain: evaluation of sitting load and back muscle activity. BMC Musculoskelet Disord [Internet]. 2009; 10(1):17. https://doi.org/10.1186/1471-2474-10-17

14. Sui SX, Balanta-Melo J, Pasco JA, Plotkin LI. Musculoskeletal deficits and cognitive impairment: epidemiological evidence and biological mechanisms. Curr Osteoporos Rep [Internet]. 2022; 20(5):260-72. https://doi.org/10.1007/s11914-022-00736-9

15. Chandrasekaran B, Pesola AJ, Rao CR, Arumugam A. Does breaking up prolonged sitting improve cognitive functions in sedentary adults? A mapping review and hypothesis formulation on the potential physiological mechanisms. BMC Musculoskelet Disord [Internet]. 2021; 22(1):274. https://doi.org/10.1186/s12891-021-04136-5

16. Sui SX, Williams LJ, Holloway-Kew KL, Hyde NK, Leach S, Pasco JA. Associations between muscle quality and cognitive function in older men: cross-sectional data from the Geelong osteoporosis study. J Clin Densitom [Internet]. 2022; 25(2):133-40. Available from: https://doi.org/10.1016/j.jocd.2021.03.007

17. Sui SX, Holloway-Kew KL, Hyde NK, Williams LJ, Leach S, Pasco JA. Muscle strength and gait speed, rather than lean mass, are better indicators of poor cognitive function in older men. Sci Rep [Internet]. 2020; 10(1):10367. https://doi.org/10.1038/s41598-020-67251-8

18. A K A, Samanta B, Bhattacherjee A. Evaluation of the impact of subjective workload on cognitive fatigue among face machinery operators in underground coal mines. Mining, Metall Explor [Internet]. 2026; **43**:971–984 https://doi.org/10.1007/s42461-025-01450-7

19. de Lucena Alves CP, de Almeida SB, Lima DP, Neto PB, Miranda AL, Manini T, *et al*. Muscle quality in older adults: a scoping review. J Am Med Dir Assoc [Internet]. 2023; 24(4):462-467.e12. https://doi.org/10.1016/j.jamda.2023.02.012

20. Pronk NP, Katz AS, Lowry M, Payfer JR. Reducing occupational sitting time and improving worker health:

the Take-a-Stand Project, 2011. Prev Chronic Dis. 2012; 9:E154. https://doi.org/10.5888/pcd9.110323

21. Upadhyay Rahul, Bhattacherjee Ashis, Patra Aditya Kumar, Chau Nearkasen. Association between whole-body vibration exposure and musculoskeletal disorders among dumper operators: a case-control study in indian iron ore mines. WORK [Internet]. 2021 Dec 15; 71(1):235-47. https://doi.org/10.3233/WOR-205140
22. Johanning E, Landsbergis P, Fischer S, Christ E, Göres B, Luhrman R. Whole-body vibration and ergonomic study of US railroad locomotives. J Sound Vib [Internet]. 2006; 298(3):594-600. https://doi.org/10.1016/j.jsv.2006.06.030
23. Pradeepkumar H., Sakthivel G., Shankar S. Prevalence of work-related musculoskeletal disorders among occupational bus drivers of Karnataka, South India. WORK [Internet]. 2020 May 12; 66(1):73-84. https://doi.org/10.3233/WOR-203152
24. Urwin M, Symmons D, Allison T, Brammah T, Busby H, Roxby M, *et al*. Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. Ann Rheum Dis [Internet]. 1998; 57(11):649-55. https://doi.org/10.1136/ard.57.11.649
25. Netterstrøm B, Juel K. Low back trouble among urban bus drivers in Denmark. Scand J Soc Med. 1989; 17(2):203-6. https://doi.org/10.1177/140349488901700211
26. Valachi B, Valachi K. Preventing musculoskeletal disorders in clinical dentistry: Strategies to address the mechanisms leading to musculoskeletal disorders. J Am Dent Assoc [Internet]. 2003; 134(12):1604-12. Available from: https://doi.org/10.14219/jada.archive.2003.0106
27. Ismaila OS, Odunlami SA, Kuye SI, Olayanju TMA, Musa AI, Adekunle NO, et al. Anthropometric seat design for bus drivers in southwestern Nigeria. Mindanao J Sci Technol. 2022; 20(1). https://doi.org/10.61310/mndjsteect.1021.22
28. Khademi Javad, Charkazi Ailin, Rajabi Abdolhalim, Rahimifard Hoda, Sohrabi Masumeh, Heidari Hamidreza. Musculoskeletal symptoms related to workstation design, an ergonomic mismatch between office furniture, and anthropometric measures among office staff. WORK [Internet]. 2025 Jul 13; 82(4):994-1007. https://doi.org/10.1177/10519815251327317
29. Leder Horina J, Blašković Zavada J, Slavulj M, Budimir D. Ergonomics study of musculoskeletal disorders among tram drivers. Vol. 15, Applied Sciences. 2025; 15:8348. https://doi.org/10.3390/app15158348
30. Lis AM, Black KM, Korn H, Nordin M. Association between sitting and occupational LBP. Eur Spine J [Internet]. 2007; 16(2):283-98. https://doi.org/10.1007/s00586-006-0143-7
31. Westgaard RH, Winkel J. Ergonomic intervention research for improved musculoskeletal health: A critical review. Int J Ind Ergon [Internet]. 1997; 20(6):463-500. https://doi.org/10.1016/S0169-8141(96)00076-5
32. Veldhuijzen DS, Kenemans JL, Wijck AJM van, Olivier B, Kalkman CJ, Volkerts ER. Processing capacity in chronic pain patients: A visual event-related potentials study. Pain [Internet]. 2006; 121(1):60-8. https://doi.org/10.1016/j.pain.2005.12.004
33. Bunk S, Preis L, Zuidema S, Lautenbacher S, Kunz M. Executive functions and pain. Zeitschrift für Neuropsychol. [Internet]. 2019 Sep 1; 30(3):169-96. https://doi.org/10.1024/1016-264X/a000264
34. Aasman J, Michon JA. Multitasking in Driving BT - Soar: A cognitive architecture in perspective: a tribute to Allen Newell. In: Michon JA, Akyürek A, editors. Dordrecht: Springer Netherlands; 1992; 169-98. https://doi.org/10.1007/978-94-011-2426-3_6
35. Gresham B, McManus B, Mrug S, Visscher K, Anthony T, Stavrinos D. Validation of the attention-related driving errors scale in novice adolescent drivers. Accid Anal Prev [Internet]. 2021; 159:106249. https://doi.org/10.1016/j.aap.2021.106249
36. Wickens CM, Toplak ME, Wiesenthal DL. Cognitive failures as predictors of driving errors, lapses, and violations. Accid Anal Prev [Internet]. 2008; 40(3):1223-33. https://doi.org/10.1016/j.aap.2008.01.006
37. Ezzati A, Wang C, Katz MJ, Derby CA, Zammit AR, Zimmerman ME, *et al*. The temporal relationship between pain intensity, pain interference and incident dementia. Curr Alzheimer Res [Internet]. 2019; 16(2):109-15. https://doi.org/10.2174/1567205016666181212162424
38. Murata S, Sawa R, Nakatsu N, Saito T, Sugimoto T, Nakamura R, *et al.* Association between chronic musculoskeletal pain and executive function in community-dwelling older adults. Eur J Pain [Internet]. 2017 Nov 1; 21(10):1717-22. https://doi.org/10.1002/ejp.1083