Research Paper

Assessing Musculoskeletal Disorder Risk and Discomfort in Auto Parts Manufacturing: A Comparative Analysis of CRAMUD, REBA, and the Cornell Musculoskeletal Discomfort Questionnaire

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ABSTRACT

Purpose: Musculoskeletal disorders (MSDs) are one of the main causes of disability and reduced workplace productivity. Given their high prevalence and negative health and economic impacts, there is an urgent need to identify MSD-related hazards and their contributing factors. The comprehensive risk assessment of MSDs (CRAMUD) technique was used in this study to evaluate the risk of acquiring MSDs and ascertain the point prevalence of these illnesses among workers in Tehran Province who manufacture automobile components.

Methods: This cross-sectional analytical investigation was conducted in 2024 in an automotive parts manufacturing industry in Tehran Province, Iran. A total of 340 workers were selected from 360 available workers based on the inclusion criteria. The instruments used included the CRAMUD questionnaire, the rapid entire body assessment (REBA) method, and the Cornell musculoskeletal discomfort questionnaire (CMDQ) to measure musculoskeletal discomfort. Data were analyzed using SPSS software (version 27). The Shapiro-Wilk test was used to assess the data's normality. The relationships between all variables were examined using Pearson correlation tests and linear regression analyses. The chi-square test was also used to examine group differences.

Results: The mean CRAMUD MSD risk score was 11.12±3.53, and the point prevalence of MSDs was 44.8%. Additionally, 18.5% of the participants were highly risky, and 26.3% were risky. There was a high positive correlation between CRAMUD, REBA (r=0.755, P<0.001), and CMDQ (r=0.776, P<0.001) scores. Linear regression analysis also showed that physical, personal, and psychosocial items had significant (P<0.05) effects on the CMDQ score.

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Conclusion: The **results of this study confirm the** significant prevalence of MSDs in the automotive parts manufacturing industry and the high validity of the CRAMUD method in assessing associated risks. The incidence and severity of MSDs can be prevented by implementing preventive interventions and improving ergonomic conditions.

Highlights

● This study found a high prevalence of MSDs in the automotive parts manufacturing industry and the high validity of the CRAMUD method in assessing associated risks.

● A considerable proportion of workers were at high or very high risk of MSDs. The CRAMUD method showed a strong correlation with REBA and CMDQ, confirming its validity as a tool for assessing the risk of MSDs.

Plain Language Summary

Musculoskeletal disorders (MSDs) are one of the main causes of disability and reduced workplace productivity. Given their high prevalence and the significant health and economic impacts they cause, accurately identifying the risks and contributing factors is critically important. This study aimed to assess the risk of developing MSDs using the comprehensive risk assessment of MSDs (CRAMUD) method to determine the point prevalence of these disorders among auto parts manufacturing workers in Tehran Province, Iran. The results showed that the risk of MSDs was significant. The CRAMUD method showed a strong correlation with the rapid entire body assessment (REBA) and Cornell musculoskeletal discomfort questionnaire (CMDQ), confirming its validity as a tool for assessing the risk of MSDs. The findings also showed that the rate of musculoskeletal problems can be affected by three factors: physical, individual, and psychological, and the physical factor is more effective. Such outcomes illustrate the potential of CRAMUD as an extensive tool to identify MSDs risks in the workplace environment, remembering the multifactorial causality of MSDs and the necessity for combined protective measures. Automated auxiliary equipment and devices should be adopted for material carriage in other procedures. Special emphasis needs to be paid to reducing psychosocial and individual factors in the work environment that affect the prevalence of MSDs.

Introduction

The diversity of equipment in industrial contexts frequently results in unexpected occupational injuries. The complexity of resources and varying work environments can all impact workers' health [1]. Since the mid-20th century, with the rapid growth of industry, diseases and conditions associated with industrial life have increased at an alarming rate [2]. Musculoskeletal disorders (MSDs) are among the most common occupational injury and disability causes [3, 4]. MSDs are inflammatory or degenerative MSDs caused by occupational activities that impair muscles, tendons, ligaments, and other associated support structures [5]. They may develop gradually over prolonged exposure to occupational hazards or abruptly as a result of sudden trauma [6]. MSDs are viewed as being amongst the most frequent occupational diseases within Europe and involve over 33% of workers in various sectors [7]. According to the U.S. Department of Labor, the prevalence of MSDs among the U.S. workforce is 29.7-32.6% [8]. A meta-analysis in Iran reported a high prevalence of work-related MSDs among Iranian workers, 50% for lower back pain and 42.1% for knee disorders [9].

These conditions lead to many issues, including disability, impairment in performing activities of daily living, physical and emotional distress, and vocational issues, all of which have direct and indirect costs [10]. In the United States, MSDs are estimated to cost 45–54 billion USD annually through compensation and loss of productivity, while in European countries, they account for approximately 2% of gross domestic product [11, 12].

Many conditions trigger the causation of MSDs in the workplace—almost entirely individual, physical, and psychosocial factors [13]. Individual factors are predominant. Research has reported that MSDs are linked to a higher frequency of physical activities, such as lifting, tugging, pushing, standing, bending, and performing hard or repetitive tasks [14]. The auto parts manufacturing industry has a high prevalence of MSDs due to common physical hazards such as manual handling of heavy parts, highly repetitive work cycles, poor posture, and the use of high-speed machines or hazardous power tools [15, 16]. Most workers in this sector work standing and often report shoulder, leg, and lower back pain due to repetitive and heavy work [17].

In addition to physical risks, personal and psychosocial elements may exacerbate MSDs. For instance, Karwan et al. discovered a significant relationship between the occurrence of MSDs and individual factors, including age, work experience, body mass index (BMI), smoking status, and physical activity [18]. Darvishi et al. provided evidence that working conditions, such as hours of work, mental workload, and the intensity of ergonomic risks, play an important role in the creation of MSDs [19]. Similarly, Rintala et al. reported that workers who had higher levels of physical fitness incurred fewer job-related injuries than less fit co-workers [20]. Studies also show that psychosocial factors influence MSD development across varied working conditions. A systematic review identified psychosocial stressors as causative agents for MSD development [21]. Bugajska et al. reported that excessive work demands, lack of control, and poor social support were the primary psychosocial risk factors [22]. In addition, an epidemiological study demonstrated that employees exposed to high psychosocial and physical risks developed more MSD symptoms, suggesting a powerful interaction among them [23].

Given these findings, preventing MSDs in industrial settings is essential. Traditional MSD assessment methods primarily focus on physical risks. Therefore, this study utilizes the comprehensive risk assessment of MSDs (CRAMUD) method, which evaluates MSD risk across three domains: personal, physical, and psychosocial. It also compares CRAMUD with two commonly used methods (rapid entire body assessment [REBA] and Cornell musculoskeletal discomfort questionnaire [CMDQ]) within an auto parts manufacturing setting. Since limited research has been conducted on MSDs in this industry and no studies have yet used the CRAMUD method in this context, the present study was designed to fill this gap.

Materials and Methods

This descriptive-analytical cross-sectional study was conducted in 2024. The objective was to use the CRAMUD approach to assess the risk and identify the prevalence of MSDs in one of the auto parts manufacturing factories in Tehran Province.

The study participants were male workers from the auto parts division of a car manufacturing company in Tehran Province, Iran. Participants were selected randomly, provided they met the inclusion criteria and did not meet any exclusion criteria. All participants' general health status was assessed using the general health questionnaire (GHQ-28).

Inclusion and exclusion criteria

The inclusion criteria were the conscious willingness to participate in the study, completion of the informed consent form, being an official employee of the company, having over a year of work experience, not working two jobs, and engaging in many activities during their free time.

The exclusion criteria were the unwillingness to continue the study, occurrence of an occupational or non-occupational accident for the individual during the study, having structural musculoskeletal abnormalities, a history of severe trauma, and not having a neurological or psychiatric disease.

Sample size

Based on a cohort study that estimated the prevalence of MSDs among Iranian men at 53%, the sample size was calculated using a 95% confidence level and 90% test power. The exact calculation formula follows (Equation 1):

$$1.\ n=\frac{P(P-1)z^2}{d^2}=340$$

In the sample size formula, p refers to the estimated prevalence of 0.53, z refers to the 95% confidence level (1.96), and d refers to the margin of error. We used an estimate of 53% based on a national cohort of Iranian men [24], which, although not specific to auto parts workers, reflects the general prevalence of MSDs in the working male population. Given the absence of prior studies in this specific industrial context using the CRAMUD method, this was deemed an appropriate and conservative estimate. Based on the calculation using this formula, the minimum sample size was estimated at 340 participants. Of the 360 male workers employed in the selected industry, 343 were considered. However, three employees declined to respond. Moreover, five participants were disqualified due to incomplete responses or poorly completed questionnaires, leaving 335 participants who enrolled at the last minute and whose data were included in statistical analysis [24].

Data collection tools

CRAMUD questionnaire

Through observation, this questionnaire was used to evaluate physical, psychological, and individual items. A total of 38 questions in two portions of the tool were designed. The worker completed explanations, and observational questions were completed by the expert(s). The REBA method was used to determine the worst and most frequent physical condition for each limb in group A (back, neck, and legs) and group B (arm, forearm, and wrist). The scores for this questionnaire ranged from 0 to 25.5, with the highest score indicating the level of MSDs in the individual (Table 1).

According to Yazdanirad et al. (2022), the questionnaire's content validity and reliability were extremely good. Cronbach's α coefficient was computed and reported as 0.94, while the average content validity ratio and content validity index were 0.77 and 0.934, respectively [25].

REBA questionnaire

Since the activities of auto parts workers involved a combination of dynamic and static body positions, the risk of poor posture and repetitive motions was identified and evaluated using the REBA approach. Hignett and McAtamney developed this technique to examine the working positions. The methods involves examining the neck, trunk, upper limbs (arms, forearms, and wrists), and lower limbs (legs). In this method, each working position is scored by observing the head, trunk, and lower and upper limbs for their angles. Also, factors such as force, grip type, and muscle activity are added to the limb scores. A final score is obtained from the total scores, which determines the degree of risk to the individual's musculoskeletal system. Ultimately, this method determines whether to modify that work situation, based on the level of risk identified [26, 27]. Table 2 presents the score and risk levels for muscularskeletal diseases using the REBA approach.

CMDQ

The three phases of this questionnaire, which includes a body map, are: frequency of discomfort (never, 1-2 times in the past week, 3-4 times in the past week, once a day, and multiple times a day); intensity of discomfort (slightly, moderately, and very uncomfortable); and interference

Table 1. Score and risk level of MSDs using the CRAMUD method

Risk Level	Score
Low	<8.5
Medium	8.51-11.02
High	11.03-15.31
Very high	>15.31

Table 2. Score and risk level of MSDs using the REBA method

Risk Level	Score
Negligible	1
Low	2-3
Medium	4-7
High	8-10
Very high	11-15

with workability during the previous week (not at all, slightly uncomfortable, and significantly uncomfortable), and analyzes 12 body parts, which are a total of 20 body parts, based on the degree of organ damage in a self-reported manner. The CMDQ questionnaire is currently used in the United States and other countries worldwide and is well-known as a valuable tool for assessing the degree of musculoskeletal discomfort. To calculate the total score of discomfort due to MSDs, the scores of frequency (0, 1.5, 3.5, 5, and 10), severity (1, 2, and 3), and interference (1, 2, and 3) in each body region were multiplied together, and then the obtained values were added together [28, 29]. In the study by Afifehzadeh-Kashani et al. (2010), which examined the validity and reliability of the Persian version of this questionnaire, they found the results to be desirable. The Cronbach's α coefficient for this questionnaire was calculated and reported as 0.986 [30].

Data collection

Following the acquisition of the required authorization from the Vice President for Research, the Ethics Committee of Shahid Beheshti University of Medical Sciences, and the representatives of the auto parts manufacturer, the researchers visited the relevant industry, explained the research objectives, and obtained informed consent from the industry employees. Demographic data, such as age, height, weight, and work experience, were collected in the first step. Then, the participants were asked to complete the CMDQ and questions regarding the individual and psychological elements of the CRAMUD questionnaire. They were then permitted to go back to work and carry out their regular tasks. The researchers observed the participants' duties and spoke with them, as well as with the company's safety and health manager, to obtain information about the questionnaire's physical items. Using the REBA approach, the worst and most common conditions associated with each body part during working hours were assessed.

Statistical analysis

SPSS software, version 27 was used to analyze the data. The Shapiro-Wilk test was used to verify the normality of the data distribution. Depending on the normality of the data, the Pearson or Spearman correlation coefficient was used to evaluate the relationship between quantitative variables. Qualitative variables between groups were compared using the chi-square test. Linear regression was used to examine the relationship between independent variables and the dependent variable. Before performing regression analysis, we examined the standard assumptions, including linearity, normality of the residuals, homoscedasticity, and independence of errors. Multicollinearity was assessed using the variance inflation factor (VIF), and all VIF values were below 2. The significance level for all tests was set at P<0.05. In addition, the point prevalence of the variable in question was also calculated.

Results

A total of 335 participants were included in this study, with a mean work experience of 11.63±7.51 years; all were male. The mean age of the participants was 36.99±7.58 years. The mean BMI of the participants was 26.20±4.22 kg/m^2. Table 3 presents the Mean±SD of the demographic factors.

Mean and standard deviation of MSD risk scores

The CRAMUD score consists of three items: personal, psychological, and physical. The mean estimated MSD risk score using the CRAMUD method was 11.11±3.53. This score was estimated to be 6.13 for the REBA questionnaire and 604.63 for the CMDQ (Table 4, Figure 1).

MSDs risk classification

Based on CRAMUD scores, 18.5% of participants were at very high risk, 26.3% at high risk, 23.6% at moderate risk, and 31.6% at low risk. REBA scores also showed that 11.9% were at very high risk, 10.7% at high risk, 48.7% at moderate risk, and 28.7% at low risk.

Comparison of MSD risk assessment tools

The relationship between the CRAMUD tool and the REBA and CMDQ scores was investigated to assess the risk of MSDs. The results showed that the scores from CRAMUD were highly correlated with those from both tools, indicating the method's strong ability to identify people at risk. The CRAMUD score had a substantial positive association with the CMDQ (r=0.776, P<0.001) and REBA (r=0.755, P<0.001) in the correlation analysis of MSD diagnostic instrument scores. Additionally, there was a strong association (r=0.8, P<0.001) between the REBA and CMDQ scores. The physical items had the strongest connection (r=0.952, P<0.001) with the overall CRAMUD score among all the CRAMUD components (Table 5, Figure 2).

Linear regression analysis

Physical, personal, and psychosocial item scores significantly impacted the CMDQ score (P<0.05) in multivariate regression analysis. Age and BMI did not significantly affect the CMDQ (P>0.05) in the regression model analysis of demographic factors (Table 6).

Table 3. Demographic characteristics of participants (n=335)

Variables	Mean±SD
Age (y)	36.99±7.58
Height (m)	176.03±8.5
Weight (kg)	81.87±13.81
BMI (Kg/m²)	26.2±4.22
Work experience (y)	11.63±7.51

Abbreviations: BMI: Body mass index.

Table 4. Mean and standard deviation of MSD risk questionnaires

Variables	Mean±SD
Physical items	7.76±3.38
Personal items	2.15±0.66
Psychological items	1.18±0.51
CRAMUD score	11.12±3.53
REBA score	6.13±2.99
CMDQ score	604.63±184.3

Abbreviations: CRAMUD: Comprehensive risk assessment of musculoskeletal disorders; REBA: Rapid entire body assessment; CMDQ: Cornell musculoskeletal discomfort questionnaire.

Prevalence of MSDs

According to the CRAMUD score, the point prevalence of MSDs was 44.8%. The age distribution study revealed that the 20–29 age group had the lowest incidence rate (24.6%), while the 40–49 age group had the highest (58.3%) (P<0.001). Also, the study of BMI showed that 41.5% and 51.9% of overweight and obese individuals

Table 5. Correlation analysis

Variables		R	P
CRAMUD	Reba	0.755	<0.001
	CMDQ	0.776	<0.001
CMDQ	Physical items	0.743	<0.001
	Personal items	0.281	<0.001
	Psychological items	0.113	0.039
CRAMUD	Physical items	0.952	<0.001
	Personal items	0.313	<0.001
	Psychological items	0.077	0.162
CMDQ	Reba	0.80	<0.001

Abbreviations: CRAMUD: Comprehensive risk assessment of musculoskeletal disorders; REBA: Rapid entire body assessment; CMDQ: Cornell musculoskeletal discomfort questionnaire.

Table 6. Linear regression analysis

Model	B	SE	P	CI 95%	
				Lower	Upper
Physical items	39.725	1.95	0.001	35.88	43.57
Personal items	58.184	14.43	0.001	29.8	86.58
Psychological items	23.511	13.4	0.080	-2.85	49.87
Age	-1.177	1.18	0.319	-3.5	1.14
BMI	-0.927	1.64	0.573	-4.15	2.3
Constant	211.331	53.85	0.001	105.381	317.281

Abbreviations: BMI: Body mass index; CI: Confidence interval; SE: Standard error.

PHYSICAL TREATMENTS

had MSDs, respectively. However, the statistical significance of this link was not established (P=0.557). However, a statistically significant correlation (P=0.001) was found between work experience and the presence of musculoskeletal conditions (Table 7).

Discussion

This study aimed to assess the risk of MSDs among male workers in an automotive parts manufacturing plant using the CRAMUD method and to determine its effectiveness against commonly used tools, such as the REBA and CMDQ. We hypothesized that CRAMUD

Table 7. Association of MSDs with variables

Variables	Levels	No. (%)		Total	P
		MSDs			
		No	Yes		
Age (y)	20-29	46(75.4)	15(24.6)	61	0.001
	30-39	82(59)	57(41)	139	
	40-49	48(41.7)	67(58.3)	115	
	>49	9(45)	11(55)	20	
BMI (kg/m²)	Underweight	4(66.7)	2(33.3)	6	0.557
	Normal weight	72(54.1)	61(45.9)	133	
	Overweight	83(58.5)	59(41.5)	142	
	Obese	26(48.1)	28(51.9)	54	
Experience (y)	1-5	57(66.3)	29(33.7)	86	0.001
	6-10	44(69.8)	19(30.2)	63	
	11-15	33(41.8)	46(58.2)	79	
	16-20	26(37.1)	44(62.9)	70	
	>20	25(67.6)	12(32.4)	37	
Total	-	185(55.2)	150(44.8)	335 (100)	-

BMI: Body mass index.

PHYSICAL TREATMENTS

Figure 1. Classification of MSDs risk

PHYSICAL TREATMENTS

accurately identifies workers at risk of MSDs and that physical, individual, and psychosocial factors significantly influence this risk. The results provide strong support for this hypothesis. This study found that the prevalence of MSDs among automotive assembly workers in Iran, with a mean work experience of 11.63±7.51 years, was 44.8%, indicating long-term exposure to risk factors. This finding necessitates preventive and ergonomic interventions in the work and production environments [31, 32]. Automotive parts manufacturing tasks often involve repetitive motions, awkward postures, high force, and sustained muscle strain. For example, workers are frequently involved in overhead work, prolonged standing, or moving heavy parts, all of which contribute to strain on the upper limbs and back [33]. The industry's focus on mass production and efficiency often results in minimal variation in work cycles, high repetition rates, and inadequate rest periods. These conditions contribute to fatigue accumulation and make workers more vulnerable to MSDs over time [34]. This prevalence is similar

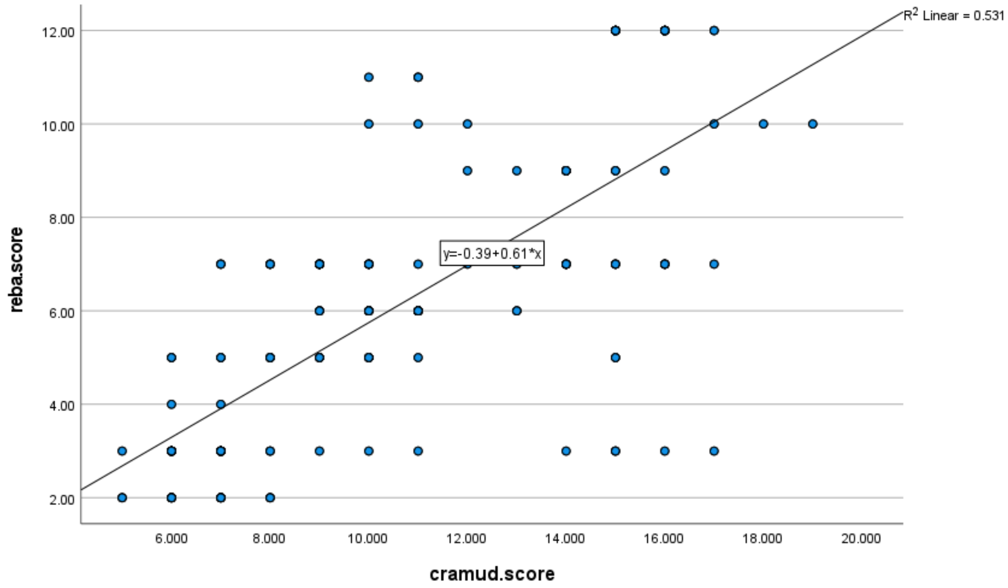

Figure 2. Correlation chart of CRAMUD and REBA scores

PHYSICAL TREATMENTS

to that of the comparable working environment but varies somewhat with recent studies. According to a 2023 cross-sectional study by Chen et al. on logistics workers in the automotive manufacturing industry in Guangzhou, China, the total prevalence of work-related MSDs was 42.9% [35]. According to research by Yang et al. 40.6% of workers in the industrial sector had MSDs [36]. These consistent findings and near-consensus may indicate stability in MSD prevalence across different parts of the motor vehicle sector and imply that MSDs continue to represent a significant occupational health concern within manufacturing sectors.

Compared to the instruments used to assess the prevalence of MSDs, the REBA instrument reported a lower prevalence, which may be due to the CRAMUD instruments' more comprehensive nature.

The results of this study showed that the highest incidence of MSDs was in the age group of 40–49 years (58.3%), which confirms the findings of previous studies that middle-aged workers are at risk of developing MSDs due to cumulative physical strain [37]. This could be due to limitations in mobility, posture, and work-related stress among this group of individuals [38]. The results also showed that despite the trend of higher prevalence of MSDs among obese individuals (51.9% vs 45.9% in normal weight), there was no statistically significant association between BMI and MSDs. This finding is consistent with the studies of Tantawy et al. [39] and Thamrin et al. [40]. These results indicate that occupational factors in automotive and auto parts manufacturing may overshadow demographic effects, as Da Costa and Vieira emphasized the greater influence of workplace conditions and factors on the etiology of MSDs [13]. Additionally, the study's findings revealed a substantial correlation between age and the CRAMUD MSD score across MSD distribution, indicating that younger individuals had a lower likelihood of developing MSDs than middle-aged individuals. This finding is consistent with the results of some studies [23, 41]. Also, a study on healthcare workers showed that the prevalence of skeletal disorders increases with age, and younger workers report a lower rate of these disorders [42]. However, a statistically significant relationship was observed between work experience and MSDs, consistent with the results of Hosseini's study in the tile industry [43]. Therefore, according to the results obtained, it is recommended to transfer or reassign older workers with longer work histories to low-risk jobs.

Multivariate regression analysis results indicated that the risk of MSDs was significantly influenced by physical ($B=39.725$, $P<0.001$), personal ($B=58.184$, $P<0.001$), and psychosocial ($B=23.511$, $P=0.080$) components. Physical variables exert a strong influence ($r=0.952$ with CRAMUD, $P<0.001$), which is in line with findings from some research indicating that manual handling and repetitive jobs are the main causes of MSDs in manufacturing [44]. The findings of Park et al.'s study also demonstrate that physical elements have a higher coefficient of influence than both cognitive and personal components [45]. This could be because musculoskeletal problems are directly caused by workplace physical conditions, whereas an individual is predisposed to MSDs by personal and psychosocial factors. The marginal importance of psychosocial factors ($P=0.080$) is consistent with the results of some studies that support addressing workplace stress and social dynamics in MSDs prevention [21, 46], although the weaker effect in this study could be attributed to the overwhelming influence of the high-intensity physical demands inherent in the work environment. Studies suggest that physical exposures are direct, immediate, and measurable causes of MSDs, often overriding the more subtle contributions of individual characteristics or social context. Studies confirm that in environments such as assembly lines, physical factors have the strongest association with reported pain and disability [47, 48]. The results of the correlation study between the scores of the common MSD assessment tools REBA and CMDQ with CRAMUD showed a strong positive correlation. This result is consistent with the findings of Yazdanirad et al. who reported a strong correlation between CRAMUD and CMDQ scores [25]. The stronger correlation between REBA and CMDQ also reinforces their common focus on physical ergonomics, although the broader scope of CRAMUD positions it as a preferred integrated tool for assessing the risk of MSDs. This result is consistent with the results of Yılmaz and Ünve [49]. Given the relatively high mean risk scores for MSDs in all three methods, ergonomic interventions are essential in the automotive parts manufacturing industry to prevent injuries, improve worker health, and improve productivity and operational efficiency. The effectiveness of these interventions depends not only on technical design but also on organizational integration and worker participation [50]. A participatory research approach in an automotive metal parts factory showed that a focused intervention program resulted in a reduction in injuries, largely attributable to the implementation of ergonomic improvement programs, which included worker training and equipment modifications [51]. Similarly, a randomized study in an Iranian automotive factory showed that ergonomic training alone significantly reduced neck and shoulder pain. This suggests that even non-technical interventions – such as workshops and coaching – can have a meaningful impact [52].

Conclusion

The results showed that the risk of MSDs is significant. The CRAMUD method showed a strong correlation with REBA and CMDQ, confirming its validity as a tool for assessing the risk of MSDs. The results also showed that all three physical, individual, and psychosocial factors affect the rate of MSDs, with the physical factor being the most effective. Such results demonstrate the potential of CRAMUD as a broad tool for identifying the risks of MSDs in the workplace, bearing in mind their multifactorial causation and the need for combined protective measures. Special emphasis should also be placed on reducing psychosocial and individual factors in the workplace that influence the prevalence of MSDs. However, multi-layered, participatory interventions, including training workshops, participatory ergonomics, and workstation redesign, offer a dynamic approach to significantly reducing MSDs by increasing worker participation in ergonomic assessments and solutions. Management measures such as establishing work-rest cycles and adequate rest periods, timely reporting, and managing early signs of MSDs can significantly reduce the incidence of these disorders.

Limitations and recommendations

Given the cross-sectional design of the study and the reliance on self-report, the findings should be interpreted with caution. Therefore, the results may not be generalizable to other occupational groups. Furthermore, this study was conducted using a relatively small sample size. Hence, a larger sample size is needed to obtain more robust results.

Although the high correlations among CRAMUD, REBA, and CMDQ support the convergent validity of the CRAMUD instrument, its predictive validity cannot be assessed due to the cross-sectional design of the present study. Therefore, future longitudinal studies are recommended to assess CRAMUD's ability to predict the development of MSDs over time.

The researchers recommend conducting longitudinal studies, especially in workplaces with different genders, further investigating the role of individual and psychosocial factors in MSDs, and examining the impact of ergonomic interventions on the rate of disorders before and after the intervention.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Research Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (Code: IR.SBMU.RETECH.REC.1402.751). Written informed consent was obtained from all participants, and all data were kept confidential.

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Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interception of the results and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

Conflict of interest

The authors declared no conflict of interest.

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