

The Impact of Ergonomic Risks on Musculoskeletal Disorders and Quality of Working Life: The Case of The Health Sector

Ergonomik Risklerin, Kas-İskelet Sistemi Sorunlarına ve Çalışma Yaşam Kalitesine Etkisi: Sağlık Sektörü Örneği

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Abstract

Background: To examine the direct and pain mediated indirect effects of ergonomic exposures on the quality of working life (QWL) among laboratory employees in a university hospital.

Materials and Methods: This cross-sectional analytical was conducted in a single center across 13 laboratory units (N=150). Data were collected via researcher observations and face-to-face Questionnaire. The Quick Exposure Check the Nordic Musculoskeletal Questionnaire and the QWL Scale were used as data collection tools. Findings were summarized with descriptive statistics, group mean comparisons, and correlation analyses. Subsequently, bootstrap based mediation analysis was performed while controlling for potential confounders. A p-value <0.05 was considered statistically significant.

Results: Negative indirect effects on QWL via the number of painful body regions in the last 7 days were identified for shoulder/arm (B=-0.28; p<0.01), low back (B=-0.43; p<0.01), and stress (B=-0.21; p=0.02) exposures. Similar indirect effects were observed for predominantly standing work (B=-0.28; p=0.04) and mechanically demanding work (B=-0.36; p=0.03). Regarding direct effects, low back (B=-0.64; p=0.04), stress (B=-0.59; p=0.02), and work pace (B=-1.04; p=0.04) reduced quality of working life; predominantly desk-based (B=-0.90; p=0.04) and standing work (B=-1.13; p=0.02) also showed direct negative effects. Total effects were negative for shoulder/arm (B=-0.64; p<0.01), low back (B=-1.07; p<0.01), stress (B=-0.80; p<0.01), work pace (B=-0.83; p=0.04), and for desk-based/standing work (R²≈0.22-0.29).

Conclusions: Among laboratory personnel, both biomechanical (particularly low back and upper limb) and psychosocial (stress, pace) exposures may adversely affect QWL through short-term pain burden as well as through direct pathways. The findings support integrated ergonomics programs combining workstation redesign, posture duration management, microbreaks, and workload/pace management.

Keywords: Ergonomics, Musculoskeletal pain, Quality of Work Life, Occupational exposure, Health personnel

Öz

Amaç: Bir üniversite hastanesinde görev yapan laboratuvar çalışanlarında ergonomik maruziyetlerin çalışma yaşam kalitesi (ÇYK) üzerindeki doğrudan ve ağrı aracılı dolaylı etkilerini incelemek.

Materyal ve metod: Tanımlayıcı tipte bu araştırma, tek merkezde 13 laboratuvar biriminde yürütüldü (N=150). Veriler araştırmacı gözlemleri ve yüz yüze anketle toplandı. Hızlı Maruziyet Değerlendirme Ölçeği, İskandinav Kas İskelet Sistemi Anketi ve ÇYK Ölçeği veri toplama aracı olarak kullanıldı. Bulgular tanımlayıcı istatistikler, grup ortalaması karşılaştırmaları ve korelasyon analizi ile özetlendi. Ardından kafa karıştırıcılar kontrol altına alınarak bootstrap temelli aracılık analizi uygulandı. 0,05'in altındaki p değeri anlamlı kabul edildi.

Bulgular: Omuz/kol (B= 0,28; p<0,01), bel (B= 0,43; p<0,01) ve stres (B= 0,21; p=0,02) maruziyetlerinin son 7 gündeki ağrılı bölge sayısı üzerinden çalışma yaşam kalitesini azaltan negatif dolaylı etkileri saptandı. Çalışma şekline göre “çoğunlukla ayakta” (B= 0,28; p=0,04) ve “mekanik zorlanma” (B= 0,36; p=0,03) için de benzer dolaylı etkiler izlendi. Doğrudan etkilerde bel (B= 0,64; p=0,04), stres (B= 0,59; p=0,02) ve iş temposu (B= 1,04; p=0,04) ÇYK puanını düşürdü; çoğunlukla masa başı (B= 0,90; p=0,04) ve ayakta çalışma (B= 1,13; p=0,02) da doğrudan negatif etkiye sahipti. Toplam etkiler omuz/kol (B= 0,64; p<0,01), bel (B= 1,07; p<0,01), stres (B= 0,80; p<0,01), iş temposu (B= 0,83; p=0,04) ve masa başı/ayakta çalışma için negatif bulundu (R²≈0,22-0,29).

Sonuç: Laboratuvar çalışanlarında hem biyomekanik (özellikle bel ve üst ekstremiteler) hem de psikososyal (stres, tempo) maruziyetler, kısa dönem ağrı yükü üzerinden ve doğrudan yollarla çalışma yaşam kalitesini olumsuz etkileyebilir. Bulgular, iş istasyonu düzenlemeleri, postür süre yönetimi, mikro-mola ve iş yükü/tempo yönetimini birleştiren bütüncül ergonomi programlarını desteklemektedir.

Anahtar Kelimeler: Ergonomi, Kas iskelet ağrıları, Çalışma yaşam kalitesi, Mesleki maruziyet, Sağlık personeli

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Introduction

Ergonomics is a discipline that aims to align work with human physical and mental capacities, thereby increasing productivity and reducing job stress (1). Preventing ergonomic risks in the workplace reduces occupational accidents and diseases while also and improves workers' productivity and safety (2). Therefore, identifying ergonomic risks and developing preventive strategies are critical for occupational health and safety (3).

Ergonomic risk factors are commonly grouped into six categories: physical, cognitive, organizational, environmental, personal, and psychosocial (4). Multiple approaches such as surveys, observational methods, and direct measurement tools, are used to assess these risks accurately (5,6). Among healthcare workers, poor posture, repetitive movements, and prolonged static postures are leading contributors to musculoskeletal (MSK) complaints (7,8).

MSK complaints lead to lost work time, absenteeism, and increased costs; ergonomic modifications mitigate these problems and positively affect employee health and performance (9,10). The concept of quality of working life (QWL) reflects the degree to which employees' physical, psychological, and social needs are met in the workplace and is directly related to organizational commitment and service quality (11,12). Among healthcare personnel, higher QWL is associated with greater staff satisfaction and improved patient care (13).

Accordingly, the aim of this study is to identify ergonomic risks among laboratory employees in a university hospital and to examine the effects of these risks on QWL via MSK problems.

This study contributes to the existing literature by simultaneously examining both the direct and pain-mediated indirect effects of multidimensional ergonomic exposures on QWL within a single analytical model. By integrating observational ergonomic risk assessment, task-based job classification, and short-term MSK pain as a mediator, the study offers a comprehensive perspective that is rarely addressed in laboratory settings. In this respect, the findings provide practical evidence to inform integrated ergonomic and organizational interventions in healthcare laboratories.

Materials and Methods

Study Design, Setting, and Period

This cross-sectional analytical study was conducted in December 2024 at Harran University Faculty of Medicine Hospital across 13 laboratory units.

Population and Participant Selection

The study population comprised all staff working in the specified laboratory units during the study period (n=165). No sampling was performed; instead, we aimed to reach all actively employed staff listed by hospital administration. The study was completed with 150 participants who agreed to take part (participation rate 90.9%).

Inclusion criteria: All laboratory personnel without communication barriers who voluntarily consented to participate.

Exclusion criteria: Communication barriers; a history of orthopedic surgery restricting MSK movements; refusal to participate; and holding a faculty position in the relevant units (owing to limited routine presence in the work environment).

Data Collection Instruments and Procedures

Data were collected through researcher's observations/field notes and a structured questionnaire.

Observations were conducted in the designated laboratories in three different time slots, each lasting at least one hour, in accordance with unit workflows. Field notes were recorded digitally by the same researcher and organized by unit on the same day.

The questionnaire was administered face-to-face by appointment and comprised four sections: (i) a 48-item form developed by the researchers to assess sociodemographic characteristics, work life, work status, work postures, and work environment conditions; (ii) the Quick Exposure Check (QEC); (iii) the Nordic MSK Questionnaire (NMQ); and (iv) the Health Personnel Quality of Work Life (QWL) Scale.

1. Quick Exposure Check (QEC): To assess ergonomic exposure, we used the observational risk assessment method QEC, originally developed by Li and Buckle in 1998 and last updated in 2005 (14,15). The Turkish adaptation was performed by Özcan et al (16).

The method involves active participation of the worker and comprises two sections: "Observation" and "Report." In the observation section, the researcher evaluates posture- and movement-related risks in the low back, shoulder/arm, wrist/hand, and neck. In the report section, the worker provides information on factors such as the maximum weight lifted or carried, task duration, hand force, visual demand, vehicle use, vibration, work pace, and stress. Exposure scores for each body region are computed by combining observer-identified risk

factors with worker responses and represent a hypothetical mapping of increasing risk levels to potential health outcomes (17).

2. Nordic quality of working life Questionnaire (NMQ): The Turkish linguistic and cultural adaptation of the NMQ was conducted by Kahraman et al. (18). The instrument assesses MSK complaints across nine anatomical regions. Three questions per region capture whether pain was experienced in the last 12 months, whether usual activities were limited due to symptoms, and whether pain was present in the past 7 days. Responses can be summarized by region-specific percentages and/or as the total number of painful regions for the last 7 days and/or last 12 months.

3. Health Personnel Quality of Work Life (QWL) Scale: Developed by Aydın et al., this 27-item scale comprises six subdimensions: risk of occupational accidents/diseases and physical working conditions (6 items), workplace discrimination (5), continuous development and improvement opportunities (5), social integration in the organization (5), job stress and time pressure (3), and organizational regulations (3). Items are rated from 1 (strongly disagree) to 5 (strongly agree), with reverse scoring for negatively worded items. Total scores range from 27 to 135, with higher scores indicating better QWL. The overall Cronbach’s alpha is 0.88, with item-total correlations between 0.20 and 0.57 (19).

Outcome Variable and Analytic Model

Based on combined evaluation of questionnaire findings

and field observations, the primary outcome was defined as the total QWL score. Several variables were categorized for analysis as follows:

1. Body mass index (BMI): Calculated as weight/height² (kg/m²) based on self-reported weight and height, and classified as underweight, normal weight, overweight, and obese (20).

2. Physical activity level: Frequency and duration of activities lasting ≥30 minutes and moderately increasing heart or respiratory rate (e.g., brisk walking, running, cycling, gardening, resistance training, cardio). Participants were classified as “sufficient” (≥5 times/week), “moderate” (1-4 times/week), or “low” (<1 time/week or none) (21).

3. Work pattern classification: To identify comparable exposures, laboratory tasks were grouped into four categories based on observations and unit information: 0) patient treatment/care tasks; A) predominantly desk-based sitting tasks; B) predominantly standing tasks with prolonged same/ varied postures; C) mechanically demanding tasks (e.g., lifting, pushing, pulling).

Model specification: Table 1 presents independent variables, the mediator, and the outcome along with coding details. To minimize recall bias, the number of painful body regions in the last 7 days was selected as the mediator. Figure 1 depicts the conceptual model in which ergonomic exposure scores and work pattern exert direct effects on QWL and indirect effects through the mediator.

Table 1. Definitions and coding of independent, mediator, and dependent variables in the research model
Independent variables (X)
X1: Neck exposure score
X2: Wrist/hand exposure score
X3: Shoulder/arm exposure score
X4: Low back exposure score
X5: Stress exposure score
X6: Work pace exposure score
X7: Job classification by work pattern:
0: Patient care/treatment tasks (dummy variable)
A: Mostly desk-based seated tasks
B: Mostly standing tasks for long periods in the same/different positions
C: Tasks involving mechanical strain

Table 1. Continued
Mediator variable (M)
M: Number of painful body regions in the last 7 days
Dependent variable (Y)

Ethical Approval and Administrative Permissions

Ethical approval was obtained from the Clinical Research Ethics Committee of Harran University Faculty of Medicine (approval number: HRU/24.18.10, date: November 18, 2024). Written permission was granted by the hospital administration, and written informed consent was obtained from all participants. Permissions were also secured from the scale owners. All procedures complied with the Declaration of Helsinki and institutional ethical standards.

Statistical Analysis

Analyses were performed using IBM SPSS Statistics (Version 26.0; IBM Corp., Armonk, NY, USA) and jamovi (Version 2.3.28; The jamovi Project, 2023). Categorical variables were summarized as n (%), and continuous variables as mean ± standard deviation (SD). Normality was assessed using the Kolmogorov–Smirnov

test, distribution plots, and skewness/kurtosis indices. Between-group differences for continuous variables were tested with independent-samples t test or one-way ANOVA; for ANOVA with $p < 0.05$, Tukey’s post-hoc test was applied. Associations between continuous variables were examined with correlation analysis. To evaluate direct and indirect effects between independent variables and the outcome, we conducted mediation analyses using jamovi’s medmod module. The model shown in Figure 1 served to test the study hypotheses, with age, sex, BMI, having children, employment status, and total years worked entered as covariates. The significance and precision of mediation effects were estimated via nonparametric bootstrapping with 5000 resamples, yielding 95% confidence intervals. We report unstandardized coefficients (B), standard errors (SE), confidence intervals (CI), t statistics, p-values, and the proportion mediated (% mediation). Two-tailed $p < 0.05$ was considered statistically significant.

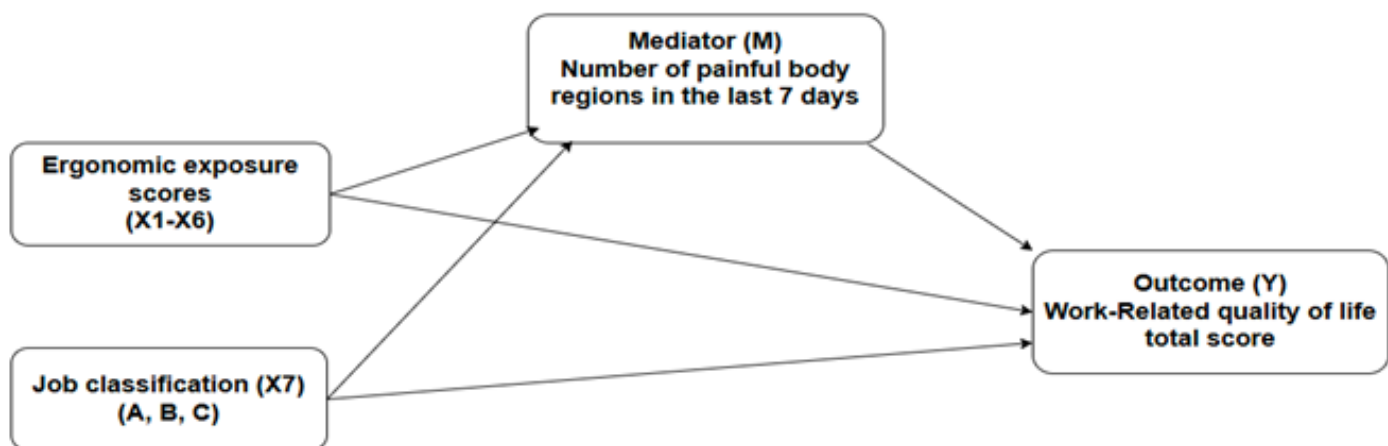


Figure 1. Conceptual model showing the effects of ergonomic exposure scores (X1-X6) and job classification (X7: A, B, C) on the Work-Related Quality of Life (Y) through the mediating role of the number of painful body regions in the last 7 days (M). Arrow direction indicates direction of effect

Results

Of the participants, 56.7% were male (n=85), and the mean age was 34.7±8.2 years. Regarding education, 64.0% (n=96) were university graduates, whereas only 2.0% (n=3) had primary/

secondary education. Overall, 64.7% (n=97) were married and 56.0% (n=84) had at least one child. Only 14.0% (n=22) were judged by the investigator to have an adequate level of physical activity. A chronic disease was reported by 14.0% (n=22). The mean BMI was 25.4±3.8 kg/m² (Table 2).

Table 2. Descriptive characteristics of the study group			
Characteristic (categorical variables)		n	%
Gender	Female	65	43.3
	Male	85	56.7
Education level	Primary/secondary school graduate	3	2.0
	High school graduate	22	14.7
	University graduate	96	64.0
	Master's/Doctorate	29	19.3
Marital status	Single/Divorced	53	35.3
	Married	97	64.7
Having children	No	66	44.0
	Yes	84	56.0
Physical activity level	Insufficient	63	42.0
	Moderately sufficient	66	44.0
	Sufficient	21	14.0
Presence of chronic disease	No	129	86.0
	Yes	21	14.0
Characteristic (continuous variables)		Mean ± SD (min-max), median	
Age (years)		34.7±8.2 (21-57), 33	
Height (m)		1.7±0.1 (1.5-1.9), 1.69	
Body weight (kg)		72.9±13.4 (48-110), 72	
BMI (kg/m ²)		25.4±3.8 (34.9-25.4), 25.39	
Number of children		2.3±1.2 (1-6), 1	
BMI: Body mass index; n: Number; %: Percent; Mean ± SD (Min-Max): Mean ± standard deviation (minimum–maximum)			

By job title, laboratory technicians/technologists constituted the largest group (66.7%, n=100), followed by physicians (14.0%, n=21), nurses/midwives (5.3%, n=8), and biologists (4.7%, n=7). A total of 69.3% (n=104) worked permanent day shifts, and 74.0% (n=111) held permanent staff positions. By work pattern

classification, 11.3% (n=17) were engaged in patient treatment/care, 48.0% (n=72) in predominantly desk-based sitting tasks, 37.3% (n=56) in predominantly standing tasks with prolonged same/varied postures, and 3.3% (n=5) in mechanically demanding tasks (e.g., lifting, pushing, pulling). Mean tenure in the current

unit was 7.7±7.6 years, and mean total work experience was 11.2±8.3 years. Based on combined observation and self-report,

mean daily working time and time spent standing were 9.0±3.4 hours and 4.8±2.5 hours, respectively (Table 3).

Table 3. Distribution of participants’ work-related characteristics

Characteristic (categorical variables)		n	%
Job title	Laboratory technician/technologist	100	66.7
	Physician	21	14.0
	Nurse/Midwife	8	5.3
	Biologist	7	4.7
	IT/Secretarial staff	7	4.7
	Cleaning staff	5	3.3
Work schedule in unit	Audiologist	2	1.3
	Daytime only	104	69.3
Employment status	Shift work	34	22.7
	Night shift only	12	8.0
	Permanent (civil servant)	111	74.0
Job classification by work performed	Temporary employment (via company)	22	14.7
	Contracted	17	11.3
	Patient care/treatment tasks	17	11.3
	Mostly desk-based sedentary tasks	72	48.0
	Mostly standing tasks	56	37.3
	Tasks involving mechanical strain	5	3.3
Characteristic (continuous variables)		Mean ± SD (min-max), median	
Years worked in current unit (years)		7.7±7.6 (1-35). 5	
Total years worked (years)		11.2±8.3 (1-35). 10	
Daily working hours in unit (h)		9.0±3.4 (5-24). 8	
Daily hours spent standing (h)		4.8±2.5 (1-16). 5	
n: Number; %: Percent; Mean ± SD (min-max): Mean ± Standard deviation (minimum-maximum)			

QWL subscales and total scores were as follows: Physical working conditions (Subscale 1), 14.5±5.4; workplace discrimination (Subscale 2), 17.1±5.1; opportunities for continuous development and improvement (Subscale 3), 18.4±3.9; social integration in the organization (Subscale 4), 16.4±4.5; Job stress and time pressure (Subscale 5), 9.5±3.3; regulations in the organization (Subscale 6), 9.8±2.6; and total QWL score, 85.7±13.3.

When QWL scores were compared by the work-pattern classification, there were significant between-group differences for social integration in the organization (Subscale 4) and the total QWL score (p<0.01 and p=0.04, respectively). Post-hoc analyses indicated that the difference was driven by those working predominantly in prolonged standing positions (Table 4).

Table 4. Comparison of work-related quality of life scale means by job classification

Subscale/total	Patient care/ treatment tasks Mean ± SD	Mostly desk-based seated tasks Mean ± SD	Mostly standing for long periods (same/ different positions) Mean ± SD	Tasks involving mechanical strain Mean ± SD	F/p
Subscale-1	14.2±6.9	14.5±4.7	14.5±6.0	16.4±2.9	0.21/0.88
Subscale-2	16.4±5.6	16.6±4.7	18.0±5.5	15.8±2.5	1.05/0.37
Subscale-3	17.2±4.3	18.2±4.1	18.9±3.8	18.0±2.7	0.90/0.43
Subscale-4	16.5±5.5	15.1±4.8*	18.0±3.5*	17.0±2.3	4.58/<0.01
Subscale-5	8.6±3.0	9.2±3.3	10.2±3.3	9.2±3.1	1.42/0.23
Subscale-6	9.6±2.0	9.6±2.5	10.1±3.0	10.0±2.7	0.32/0.81
Total scale	82.6±15.3	83.3±13.6	89.6±12.0*	86.4±5.9	2.84/0.04
Subscale-1: Physical working conditions					
Subscale-2: Workplace discrimination					
Subscale-3: Continuous improvement and development opportunities					
Subscale-4: Social integration within the organization					
Subscale-5: Job stress and time pressure					
Subscale-6: Laws/regulations within the organization					
*Groups driving the difference were identified with Tukey post-hoc test. F: One-way ANOVA; Mean ± SD (min-max): Mean ± Standard deviation (minimum-maximum)					

Significant positive correlations were observed between the total number of painful body regions over the past 12 months and stress ($r=0.20$), low back ($r=0.32$), and wrist/hand exposure scores ($r=0.20$); and between the total number of painful body regions over the past 7 days and stress ($r=0.29$), low back ($r=0.17$), and wrist/hand exposure scores ($r=0.19$). In addition, the following significant associations were noted: Subscale 1 (Physical working conditions) with stress ($r=-0.20$), shoulder/arm ($r=-0.18$), and wrist/hand ($r=0.19$); subscale 2 (Workplace discrimination) with work pace ($r=-0.29$), stress ($r=-0.35$), low back ($r=-0.20$), shoulder/arm ($r=-0.17$), wrist/hand ($r=-0.19$), total painful regions in the last 7 days ($r=-0.33$) and in the last 12 months ($r=-0.37$); subscale 3 (Opportunities for continuous development and improvement) with work pace ($r=-0.18$) and stress ($r=-0.16$); subscale 4 (Social integration) with the total number of painful regions in the last 12 months ($r=-0.18$); subscale 5 (Job stress and time pressure) with work pace ($r=-0.20$), stress ($r=-0.31$), total painful regions in the last 7 days ($r=-0.22$) and in the last 12 months ($r=-0.32$); and the total QWL

score with work pace ($r=-0.33$), stress ($r=-0.36$), wrist/hand exposure ($r=-0.16$), total painful regions in the last 7 days ($r=-0.29$), and in the last 12 months ($r=-0.32$) (Table 5).

Using multiple mediation analysis, we examined the effects of ergonomic exposure scores, the work-pattern classification, and the mediator number of painful body regions in the past 7 days on the total QWL score (Table 6). Significant negative indirect effects via the mediator were observed for shoulder/arm ($B=-0.28$; $p<0.01$), low back ($B=-0.43$; $p<0.01$), and stress exposures ($B=-0.21$; $p=0.02$). Within the work-pattern classification, predominantly standing work ($B=-0.28$; $p=0.04$) and mechanically demanding work ($B=-0.36$; $p=0.03$) also showed significant negative indirect effects on QWL via the mediator.

Regarding direct effects on QWL, low back ($B=-0.64$; $p=0.04$), stress ($B=-0.59$; $p=0.02$), and work pace ($B=-1.04$; $p=0.04$) exposure scores significantly reduced the QWL total score. For the work-pattern classification, predominantly desk-based work ($B=-0.90$; $p=0.04$) and predominantly standing work ($B=-1.13$; $p=0.02$) were associated with significantly lower QWL, whereas

mechanically demanding work was associated with higher QWL (B=1.11; p=0.01).

For total effects on QWL, significant negative associations were found for shoulder/arm (B=-0.64; p<0.01), low back (B=-1.07; p<0.01), stress (B=-0.80; p<0.01), and work pace (B=-0.83; p=0.04) exposure scores, as well as for predominantly desk-based (B=-7.13; p<0.01) and predominantly standing work

(B=-1.41; p<0.01). Across the models, explained variance (R²) was 0.29 for indirect effects, 0.22 for direct effects, and 0.23 for total effects (all p<0.05). Within total effects, the proportion mediated was 43.0% for shoulder/arm exposure, 40.3% for low back exposure, 26.0% for stress, 19.8% for standing work, and 48.4% for mechanically demanding work.

Table 5. Correlation analysis among exposure scores, number of painful body regions, and work-related quality of life scores

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Work pace	1														
2. Stress	0.53*	1													
3. Low back	0.14	-0.03	1												
4. Shoulder/arm	0.04	-0.05	0.78*	1											
5. Wrist/hand	0.12	0.10	0.47*	0.53*	1										
6. Neck	-0.02	0.03	0.20*	0.14	0.33*	1									
7. painful regions (12 months)	0.09	0.20*	0.32*	0.14	0.20*	-0.04	1								
8. painful regions (7 days)	0.13	0.29*	0.17*	0.02	0.19*	0.05	0.69*	1							
9. Sub-scale-1	-0.13	-0.20*	-0.08	-0.18*	-0.19*	0.03	-0.10	-0.08	1						
10. Sub-scale-2	-0.29*	-0.35*	-0.20*	-0.17*	-0.19*	-0.07	-0.33*	-0.37*	0.08	1					
11. Sub-scale-3	-0.18*	-0.16*	0.02	0.06	0.01	-0.10	-0.11	-0.09	-0.23*	0.18*	1				
12. Sub-scale-4	-0.13	-0.08	-0.01	0.03	0.04	0.06	-0.18*	-0.15	-0.04	0.41*	0.43*	1			
13. Sub-scale-5	-0.20*	-0.31*	-0.01	0.01	-0.08	-0.04	-0.22*	-0.32*	0.36*	0.38*	-0.01	0.27*	1		
14. Sub-scale-6	-0.12	0.03	0.03	0.09	-0.06	0.10	0.11	0.02	-0.26*	0.06	0.24*	0.22*	-0.11	1	
15. Total scale	-0.33*	-0.36*	-0.10	-0.09	-0.16*	-0.01	-0.29*	-0.32*	0.39*	0.71*	0.46*	0.72*	0.60*	0.23*	1
Subscale-1: Physical working conditions															
Subscale-2: Workplace discrimination															
Subscale-3: Continuous improvement and development opportunities															
Subscale-4: Social integration within the organization															

Table 5. Continued
Subscale-5: Job stress and time pressure
Subscale-6: Laws/regulations within the organization

Table 6. Multiple mediation analysis results for direct, indirect, and total effects of exposure scores and job classification on work-related quality of life

Effect type	Effect direction	Coefficient (B)	SE	%95 CI		t	p	% Mediation
				Lower	Upper			
Indirect effects	X1 → M → Y (Neck exposure score)	0.56	0.31	-0.05	1.17	1.81	0.07	91.8
	X2 → M → Y (Wrist/hand exposure score)	-0.09	0.06	-0.21	0.03	-1.50	0.14	31.0
	X3 → M → Y (Shoulder/arm exposure score)	-0.28	0.08	-0.43	-0.13	-3.58	<0.01	43.0
	X4 → M → Y (Low back exposure score)	-0.43	0.15	-0.74	-0.13	-2.77	<0.01	40.3
	X5 → M → Y (Stress exposure score)	-0.21	0.09	-0.39	-0.03	-2.24	0.02	26.0
	X6 → M → Y (Work pace exposure score)	0.21	0.15	-0.09	0.52	1.35	0.17	25.5
	A → M → Y (Desk-based tasks)	0.16	0.12	-0.06	0.39	1.45	0.15	22.5
	B → M → Y (Standing tasks)	-0.28	0.14	-0.56	-0.01	-1.99	0.04	19.8
	C → M → Y (Mechanical strain tasks)	-0.36	0.17	-0.69	-0.03	-2.12	0.03	48.4
	M → Y	-1.24	0.37	-1.96	-0.51	-3.37	<0.01	
R², F (df1; df2), p: 0.29, 5.61(10;139), <0.001								
Direct effects	X1 → Y (Neck exposure score)	0.05	0.97	-1.85	1.97	0.05	0.95	9.2
	X2 → Y (Wrist/hand exposure score)	-0.20	0.20	-0.60	0.19	-1.02	0.30	69.7

	X3 → Y (Shoulder/arm exposure score)	-0.36	0.21	-0.78	0.05	-1.72	0.08	57.0
	X4 → Y (Low back exposure score)	-0.64	0.34	-1.32	0.04	-1.84	0.04	59.7
	X5 → Y (Stress exposure score)	-0.59	0.26	-1.10	-0.08	-2.29	0.02	74.0
	X6 → Y (Work pace exposure score)	-1.04	0.52	-2.08	-0.01	-1.98	0.04	74.5
	A → Y (Desk-based tasks)	-0.90	0.44	-1.76	-0.04	-2.06	0.04	77.5
	B → Y (Standing tasks)	-1.13	0.49	-2.08	-0.18	-2.33	0.02	80.2
	C → Y (Mechanical strain tasks)	1.11	0.43	-0.27	1.95	2.58	0.01	51.7
R2, F (df1; df2), p: 0.22, 4.33(9;140), <0.001								
Total effects	X1 → Y (Neck exposure score)	0.61	1.00	-1.34	2.58	0.61	0.53	
	X2 → Y (Wrist/hand exposure score)	-0.29	0.21	-0.71	0.11	-1.38	0.17	
	X3 → Y (Shoulder/arm exposure score)	-0.64	0.23	-1.09	-0.19	-2.79	<0.01	
	X4 → Y (Low back exposure score)	-1.07	0.33	-1.74	-0.40	-3.16	<0.01	
	X5 → Y (Stress exposure score)	-0.80	0.26	-1.32	-0.29	-3.07	<0.01	
	X6 → Y (Work pace exposure score)	-0.83	0.45	-1.72	0.05	-1.86	0.04	
	A → Y (Desk-based tasks)	-0.73	0.28	-1.29	-0.19	-2.64	<0.01	
	B → Y (Standing tasks)	-1.41	0.42	-2.24	-0.59	-3.36	<0.01	
	C → Y (Mechanical strain tasks)	0.74	4.40	-0.09	1.59	1.74	0.86	
R2, F (df1; df2), p: 0.23, 4.47(10;139), <0.001								
Control variables: Age, Sex, BMI, Having children, Employment status, and Total years worked. X: Independent variable, M: Mediator, Y: Dependent variable								

Discussion

This study tested, within a single analytical model, both the indirect effects of ergonomic exposures on QWL via the “number

of painful body regions in the past 7 days,” and the direct effects of exposures. In multiple mediation analysis, shoulder/arm, low back, and stress exposures exerted significant negative indirect effects on QWL; in addition, stress and work pace showed

significant direct negative effects after controlling for the mediator. By work-pattern classification, predominantly standing tasks and mechanically demanding tasks exhibited significant indirect effects operating through pain; For mechanical demands, the observed pattern of a negative indirect effect coupled with a positive direct effect may suggest the possibility of competitive mediation. However, given the small number of participants classified under mechanically demanding tasks, this interpretation should be approached with caution. The model's explanatory power was moderate ($R^2 \approx 0.22-0.29$). Taken together, the pattern suggests that both individual pain burden and the biomechanical/psychosocial facets of the job jointly shape QWL.

The present findings are broadly consistent with the literature: in health care, work-related MSK complaints are common; the exposure profile is characterized by repetitive upper-extremity motions, awkward or prolonged static postures, and high work demands; and these factors are linked with worker well-being and performance outcomes, as shown in systematic reviews (14,22,23).

Field-friendly observational tools such as the QEC facilitate the identification of multidimensional ergonomic exposures and help prioritize interventions in practice (14). In laboratory settings, the adverse total and pain-mediated effects of upper-extremity and low-back exposures on QWL are consistent with tasks involving repetitive movements and prolonged static postures, with evidence supporting the benefits of microbreaks during microscopic work and the association between prolonged standing and low-back symptoms (24,25).

For psychosocial exposures, the coexistence of direct effects of stress and work pace on QWL and indirect effects mediated by pain aligns with evidence linking work organization and job demands to MSK complaints (23,26).

At the subscale level, consistent patterns were observed. Declines in Physical Working Conditions scores with increasing biomechanical exposures and stress highlight the close link between perceived physical load and ergonomic risk factors, supporting the value of interventions such as microbreaks and posture-duration management (24,25). Inverse associations of the Discrimination at Work and Opportunities for Continuous Development subscales with stress and work pace are consistent with evidence that workload and perceived injustice adversely affect well-being and QWL (27-29). The inverse relationship between Social Integration and longer-term pain may indicate a role for social support in the pain experience, while weaker associations for organizational regulations likely reflect the influence of broader institutional factors rather than immediate task-level exposures.

Using the "number of painful regions in the past 7 days" as the mediator yielded the expected negative relation with QWL, consistent with short-term pain burden coinciding with decrements in functioning, job satisfaction, and social integration; the 7-day horizon also helps reduce recall bias relative to 12-month reporting (14,18). The model's moderate explanatory power is compatible with the multi-determinant nature of QWL; for some predictors (e.g., mechanical demands), a competitive-mediation pattern may also contribute.

From an implementation standpoint, our results support prioritizing workstation/equipment ergonomics, task cycling and microbreak scheduling, work pace and workload management, and participatory ergonomics. Participatory programs have been shown to provide benefit for MSK complaints, absenteeism, and work outcomes in systematic reviews (30), while microbreaks represent a practical, low-cost option in microscopy-intensive work (24). Integrated deployment especially targeting low-back and upper-extremity loads alongside psychosocial demand management appears likely to yield meaningful gains in QWL.

Study Limitations

Key strengths include the joint modeling of multi-dimensional ergonomic exposures and task classification, and the use of bootstrap-based mediation testing. Limitations include the descriptive, cross-sectional design that precludes causal inference; the potential for measurement bias as some exposures relied on self-report; and the single-center sample that may constrain generalizability. Future studies employing longitudinal, multi-level, and latent-variable approaches (particularly for mechanical demands and psychosocial domains) could more precisely interrogate competitive mediation patterns. Another limitation of this study is the relatively small number of participants in the mechanically demanding work group, which may affect the stability and generalizability of estimates related to this subgroup. Accordingly, findings concerning mechanical demands should be interpreted with caution and warrant confirmation in studies with larger and more balanced samples.

Conclusion

This study indicates that, among laboratory personnel, ergonomic exposures influence QWL through both direct and pain-mediated indirect pathways. In particular, shoulder/arm, low-back, and stress exposures adversely affect QWL; Work pace and mechanical demands may display distinct combinations of direct and indirect effects; however, findings related to mechanical demands should be interpreted cautiously in light of

the limited number of participants in this subgroup. The pattern suggests that concurrent biomechanical loads (e.g., prolonged standing, repetitive actions) and psychosocial pressures (stress and workload) may increase pain burden and depress QWL, reinforcing the view that QWL is inherently multi-factorial. These results argue for ergonomic and organizational interventions in health-care laboratories specifically, workstation redesign and equipment optimization, task rotation, microbreak implementation, and active workload/pace management. Interventions that simultaneously mitigate low-back and upper-extremity loads and address psychosocial demands are likely to offer the greatest potential for improving QWL in this workforce.

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