Physiological Strain of Warehouse Staff in Bangkok and Suburban Areas

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ABSTRACT

Introduction: Musculoskeletal disorders (MSDs) are an increasing concern that affects individuals across diverse professions, diminishing their quality of life. This study evaluates biomechanical risks faced by manual material handling workers in Thai small and medium-sized firms (SMEs) specializing in warehousing services. Approaches: Forty male volunteers, aged 26 to 33, were classified based on the weight of goods managed. Three categories were delineated: low-weight; LH (6-15 kg), medium-weight; MH (16-25 kg), and extra-heavy-weight; EH (>25 kg). During a 30-minute work interval, participants' physical state, cardiovascular load (%CVL), and muscle condition (%MVC) were assessed objectively. Results: The findings indicated a significant risk of musculoskeletal disorders (MSDs), especially in the extra-heavy-weight category (P= 0.001), with the lower back being notably impacted. The cardiovascular strain attained alarming levels, exacerbated by a Wet Bulb Globe Temperature (WBGT) of 28.14 °C. The perceived work strain was moderately distressing. The study advocates for the implementation of mechanical assistive devices and alternate work-rest schedules to alleviate these dangers, highlighting the necessity of managing physical workload, particularly in hot-humid environments. The study emphasizes the particular strain levels seen by operators and stresses the necessity for stakeholders to adopt steps to alleviate physical effort, particularly under heightened WBGT situations.

Keywords: Warehouse staff, EMG, %MVC, %CVL, WBGT, SWI, Manual material handling

1. Introduction

Musculoskeletal disorders (MSDs) represent a substantial health issue, impacting 60% of the workforce in the European Union and Asian nations. Biomechanical elements, including substantial lifting and inadequate posture, significantly contribute to musculoskeletal disorders in physical work settings (EU-OSHA, 2019; Kamarudzaman et al., 2023). Approximately 100 million individuals in Europe are afflicted by musculoskeletal disorders (MSDs), with 40 million instances directly associated with occupational factors, negatively affecting health, work efficiency, and production (Veale, Woolf, and Carr, 2008). The economic impact is significant, with losses of 240 billion euros, or 2% of GDP, in Europe by 2015 (Bevan, 2015). These numbers underscore the pressing necessity for workplace treatments to mitigate biomechanical stress and the incidence of musculoskeletal disorders (MSDs).In Thailand, work-related musculoskeletal disorders (MSDs) have markedly escalated, attaining a rate of 259.78 cases per 100,000 individuals in 2019 (Annual report, 2020). Warehouse workers, a substantial portion of the labor force, encounter diverse postural stresses and physical requirements in material handling activities, leading to cumulative trauma disorders. Although several companies utilize mechanical aids, financial limitations impede their widespread implementation. This underscores the need for customized interventions, such as ergonomic solutions, to reduce MSD risks among warehouse workers in Thailand. Yoopat et al. (2017) conducted a study of 500 blue-collar workers in Bangkok and its suburbs to evaluate work-related musculoskeletal risks associated with lifting, employing NIOSH lifting factors (NIOSH, 1994). Recent surveys reveal an increased prevalence of musculoskeletal disorders across many occupations (Bláfoss, Aagaard, and Andersen, 2019; Bevan, 2015). Kamarudzaman et al. (2023) indicated that the predominant musculoskeletal disorders among mechanics at a tire service center in Malaysia include low back pain, shoulder discomfort, and elbow pain.

To strengthen the study's rigor, real-time physiological metrics such as muscle activity and heart rate should be incorporated, offering a solid foundation for comprehending the effects of lifting techniques on the musculoskeletal system. This study seeks to evaluate the physiological reactions of warehouse personnel across various material handling weight classifications, focusing on essential inquiries regarding biomechanical hazards and vulnerability factors: Does warehouse item handling involve biomechanical hazards? 2) If so, which anatomical regions and environmental variables are most vulnerable?

2. Methods

2.1 Study design

This cross-sectional quasi-study employed purposive sampling to select 40 warehouse operators from 500 small and medium-sized enterprises in Bangkok and its suburban areas.

2.2 Ethical consideration

The research protocol, informed consent form, data collection form, and schedule plan received approval from the advisory board and medical committee ethics review board of the Social Security Office of the Compensation Fund, Ministry of Labor, Thailand. The study was conducted following the principles of the Declaration of Helsinki, with approval from the Rangsit University Ethical Committee (approval number RSEC 21/2557).

2.3 Participants

Forty male, healthy adults under 41 years from small and medium-sized enterprises (SME) voluntarily participated in the project, categorized into three groups based on material-handling weights: LH (6-15 kg, n = 13), MH (16-25 kg, n = 14), and EH (over 25 kg, n = 13).

2.4 Inclusion and exclusion criteria

All participants underwent a preliminary physical and musculoskeletal examination conducted by an experienced orthopedist and were found free of any musculoskeletal problems in the spine and in the upper and lower extremities.

2.5 Experiment procedure

Subjects were classified into three groups according to their average weight handling category. Biometric measurements included body weight, height, (BMI), systolic and diastolic blood pressure, resting heart rate, and handgrip strength.

2.5.1 Subject preparation

The standard physiological responses were assessed post-registration, including heart rate monitored with chest pre-cordial sensors transmitting frequency pulses to a wrist datalogger. Muscular reactions were measured using a surface electromyography (EMG) recorder, with electrodes on the upper back (M. Trapezius) and lower back (M. Erector Spinae) on both the left and right sides. Subjects adhered to the standard uniform protocol of the enterprise.

2.5.2 Measurement and assessment

The measurements were conducted in authentic working conditions at workplaces located in Bangkok and the suburban areas of Thailand.

2.5.3 Pre-and post-material handling work

Muscle Capacity Assessment: Pre- and post-material handling, a Maximal Voluntary Contraction (MVC) test was conducted to evaluate the upper back muscle (M. Trapezius; TZ) and lower back muscle (M. Erector Spinae; ER) on both the left (lt.) and right (rt.) sides. Power (MVC) was quantified utilizing three disposable electrodes placed on each muscle. Recordings were obtained with a portable electromyography (EMG) device (ME6000, Mega Electronics, Finland) operating at a frequency of 1000 Hz and a one-second sampling rate.

MVC Test Procedures: M. Trapezius Test: Subjects elevated their shoulders vertically as high as possible against manual resistance provided by an experienced researcher. M. Erector Spinae Test: Subjects, lying prone on a bench with hands clasped at the back of the neck and feet secured by an experienced researcher, lifted their trunk as high as possible, maintaining the posture for 3 seconds.

Perceived Work Strain Assessment*:* Perceived work strain was assessed using the Subjective Workload Index (SWI) questionnaire (Yoopat, Pitakwong, and Vanwonterghem, 2020). Participants rated feelings about work and the work environment on a 10-point scale, indicating personal discomfort. SWI integrates 6 load factors and 2 compensating factors. Scores are averaged for interpretations: SWI ≤ 2, very light to light work; SWI 2 to ≤ 3, moderate work; SWI 3 to ≤ 4, heavy to tough work; and SWI ≥ 5, estimated limit for personal manual work intensity. When SWI exceeds 2.0, participants specify perceived discomfort (rating level 0-5) for 11 specific conditional factors related to working conditions.

2.5.4 Physiological responses during performed work

Muscle-Intensity Assessment: EMG registration (microvolts) and the percentage of Maximal Voluntary Contractions (MVCs) were calculated using Megawin software. Levels exceeding 10-12% warrant attention, while values between > 15% and < 30% MVC indicate a need for adjustments. Levels surpassing 30% MVC are considered critical and require almost immediate action.

Heart Rate: Heart rate (beats per minute; bpm) registration is transformed into a calculated cardiovascular load (percentage of CVL). Values exceeding 30% CVL should be given priority (Yoopat et al., 2020).

Environment: Environmental registration during work included light luminance (cd/m2) measured by a Minolta luminance meter LS-110 (Japan), light illuminance (lux) measured by a light meter - Digicon LX-70, noise level (dB(A)) measured by a Sound level meter (Japan), and climatic conditions measured by WBGT Quest-temp (USA).

2.6 Statistical analysis

All variable data, encompassing means, standard deviations, and standard errors for measured variables, were computed using SPSS (Version 21). Pairwise t-tests were applied to assess differences between pre-and post-treatment MVC variables. ANOVA was employed to compare variable means among the three warehouse groups. Statistical significance was established at a P-value < 0.05, with a confidence interval of 0.95.

3. Results

Physical characteristics: Table 1 outlines study participant biometric data. The mean age for the LH groups was 28 (4) years and for the EH group was 33 (7) years. The MH group showed a higher mean age compared to both the LH and EH groups. Consistent biometric outcomes were observed across all three groups for parameters such as body mass index (BMI), systolic and diastolic blood pressure, and grip strength for both the left and right hand.

Table 1.

Physical characteristics of warehouse workers according to weight handling categories (Mean, SD)

N	LH Group 6-15 kg. (n=13)	MH Group 16-25 kg. (n=14)	EH Group >25 kg. (n=13)	F	*P*-value	95%CI
Age (year)	28	33 ± 7*	26 ± 6	4.943	0.013	27, 30
BMI (kg/m2)	23.0 ± 5.6	22.7 ± 2.3	22.8 ± 4.7	0.020	0.978	19.9, 26.4
SP (mm. Hg)	125 ± 10	135 ± 20	120 ± 10	2.534	0.094	120, 130
DP (mm. Hg)	80 ± 5	85 ± 20	80 ±10	0.353	0.705	70, 95
Handgrip R (kg. BW)	0.65 ± 0.18	0.64 ± 0.11	0.70 ± 0.10	0.601	0.553	0.55, 0.76
Handgrip L (kg. BW)	0.65 ± 0.17	0.64 ± 0.12	0.67 ± 0.12	0.239	0.789	0.54, 0.76

* Bonferroni multiple comparisons indicate significant differences with EH at $P < 0.05$, SD: standard deviation

Tasks, organization, and environment: Tasks; Thai warehouse workers perform diverse activities, such as loading orders, organizing stock, and manual material handling (MMH) tasks, ensuring efficient logistics from receiving to dispatching goods.Organization; The LH group, affiliated with grocery and electricity enterprises, achieves a daily productivity of 150-300 parcels, with peak rates of 30 parcels per minute. The MH group handles 150 parcels daily, while the EH group, working in teams of 8-10, manages about 500 sacks per day, weighing 25-45 kg. Environment; Physical work environments, including noise, lighting, and climate, are detailed in Table 2.

Table 2.

Environmental factors at work (Mean ± SD)

	LH	MH	EH

		6-15 kg.	16-25 kg.	>25 kg.
Noise dB (A)		75 ± 2	61 ± 3	60 ± 5
Light Illuminance (lux)		443 ± 48	315 ± 56	261 ± 116
Light luminance (cd/m^2)				
	Hand	35 ± 12	117 ± 80	639 ± 331
	Forward sight 1m	43 ± 14	555 ± 47	458 ± 88
	Forward sight 3m	75 ± 33	60 ± 33	140 ± 68
	Forward sight 10m	90 ± 50	344 ± 206	189 ± 96
	Luminance ratio	1:1:2:2	2:9:1:6	5:3:1:1
Climate				
	Td (C°)	33.12 ± 0.70	31.82 ± 0.86	32.02 ± 0.49
	Tg (C°)	33.41 ± 0.36	32.63 ± 0.83	32.58 ± 0.42
	Tw (C°)	26.42 ± 0.29	27.44 ± 0.57	26.37 ± 0.04
	WBGT (i)	28.40 ± 0.26	28.96 ± 0.58	28.16 ± 0.14
	WBGT (o)	28.40 ± 0.27	28.90 ± 0.58	28.14 ± 0.15

Table 3 encompasses comprehensive physiological outcomes. Notably, the heart rate during the effort, and cardiovascular load (CVL) were highest in the EH group. Meanwhile, the Subjective Workload Index (SWI) perceived discomfort score from work exceeded 2.5 in all groups, with the highest value observed in the LH group.

Table 3.

Physiological responses of warehouse workers at work (Mean ± SD**)**

Weight Handling categories	LH (n=13)	MH (n=14)	EH (n=13)	F	*P*-value	95%CI
Working heart rate (bpm)	96 ± 10***	103 ± 12***	136 ± 22	24.111	0.000	90,149
Cardiovascular load (%)	33.1 ± 13.8***	43.1 ± 16.9***	83.3 ± 27.4	22.184	0.000	24.8,100.7
SWI	3.6 ± 0.7	2.8 ± 0.9*	2.7 ± 0.6*	4.657	0.016	2.1, 4.1

******* Bonferroni indicate significant different with EH at $P < 0.05$ and $P < 0.001$; * Significant different with LH at $P < 0.05$, SD: Standard deviation

Muscle strain: All subjects worked with an EMG intensity exceeding 20% MVC (see Figure 1). The low back muscle strain on the left and sides of the EH group was significantly higher than that of the LH group at $P < 0.01$. In contrast, the upper back muscles (M. Trapezius) of all three groups exhibited an EMG intensity higher than 20% MVC, with no significant differences observed among the three groups.

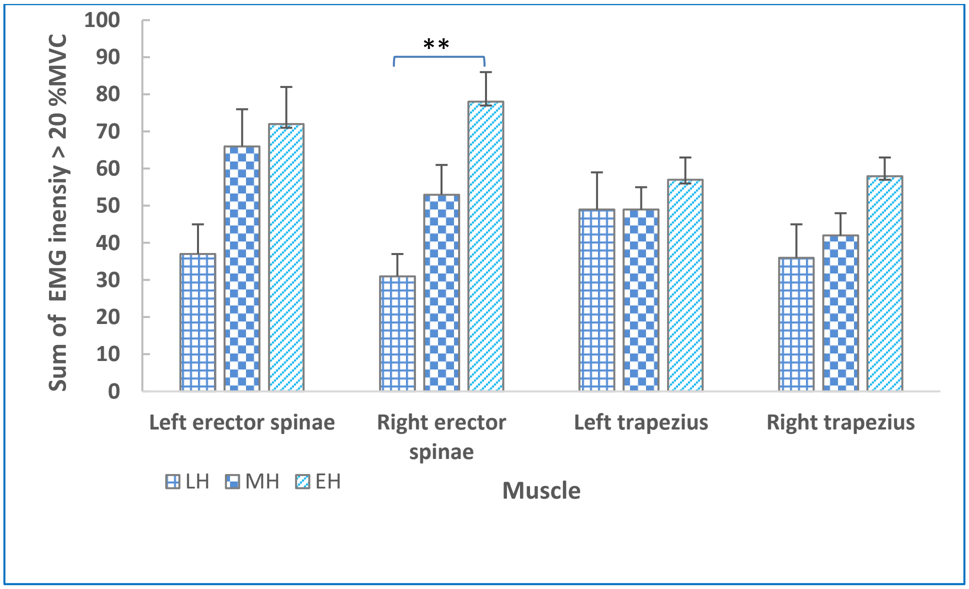

Fig. 1. Muscle strain at work of M. trapezius and M. erector spinae both left and right sides of warehouse workers (Mean± SE)

** Bonferroni multiple comparisons indicate significant differences between groups (*P* 0.018), SE: Standard error

Muscle capacity before and after work among three groups: (Table 4) Before work, the lower back muscles on both the left and right sides of group EH exceeded those of group MH. However, after work, no significant difference was observed in the muscle capacity of the upper and lower back among the three groups.

Table 4.

Muscle capacity test (MVC) in microvolts before and after work of warehouse workers, (Mean ± SE)

Muscle capacity test (MVC)	LH 6-15 kg.	MH 16-25 kg	EH >25 kg.	F	*P*-value	95%CI
Left M. ER before	234 ± 23	199 ± 33*	333 ± 37	4.452	0.023	107,416
Right M. ER before	238 ± 24*	208 ± 20*	360 ± 38	7.971	0.001	163,446
Left M. TZ before	587 ± 70	537 ± 53	542 ± 60	0.201	0.819	412,740
Right M. TZ before	800 ± 73	566 ± 51	711 ± 98	2.472	0.099	457,961

Left M. ER after	207 ±14	199 ± 17	264 ± 34	1.731	0.201	143,342
Right M. ER after	215 ± 25	195 ±19	284 ± 29	3.245	0.053	151,349
Left M. TZ after	472 ± 58	449 ± 63	501 ± 57	0.195	0.824	308,626
Right M. TZ after	722 ± 74	518 ± 55	551 ± 70	2.640	0.086	399,702

*,** Bonferroni multiple comparisons indicate significant different with EH at $P < 0.05$, SD: standard error

Muscle capacity before and after work in each group: The capacity of M. Erector Spinae (Figure 2) on both the left and right sides of group EH exhibited a significant decrease after work ($P = 0.013$, $P = 0.001$).

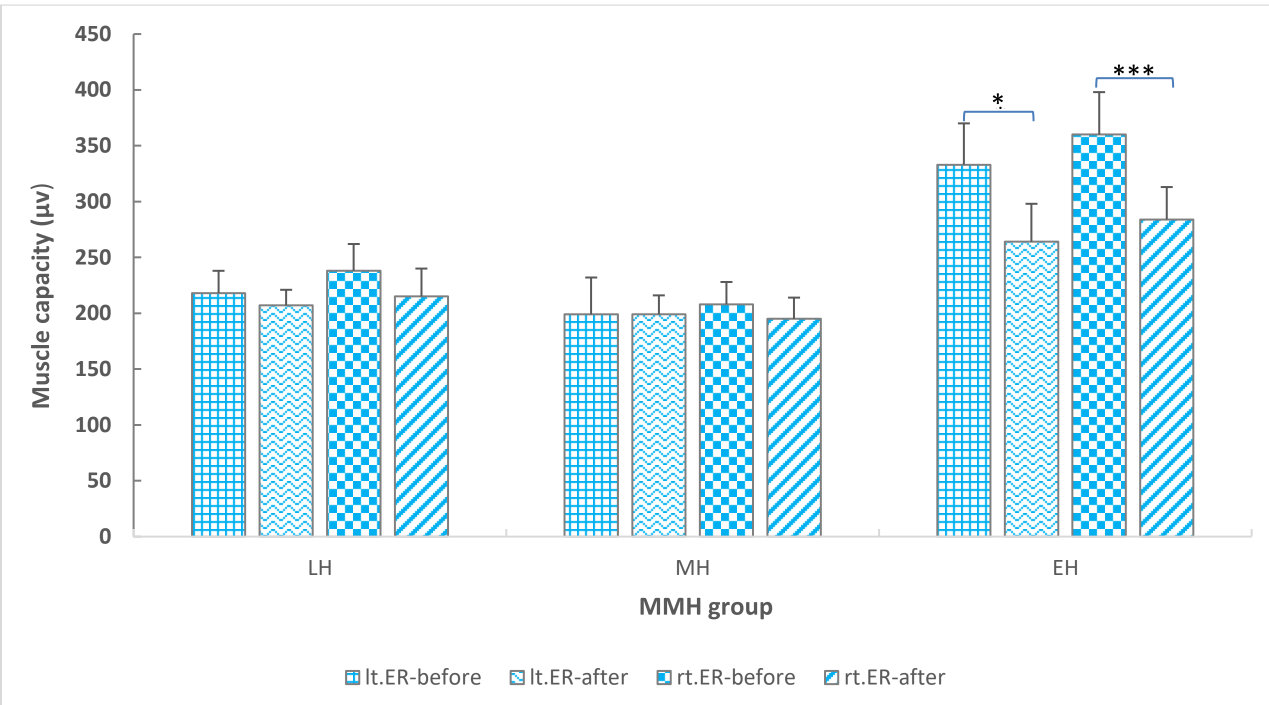

Fig. 2. Muscle capacity test (MVC) of the lower back muscles in microvolts before and after work of warehouse worker, (Mean ±SE)

* Pair *t*-test indicates a significant difference between before and after in each group (P= 0.013).

*** Pair *t*-test indicates a significant difference between before and after work (P= 0.001)., SE: Standard error, lt.ER: left M. erector spinae, rt.ER: right M. erector spinae, lt.TZ: left M.Trapezius, rt.TZ: right M.Trapezius

In Figure 3, the capacity of M. Trapezius on both the left and right sides of group LH significantly decreased after work ($P < 0.01$). In group MH, the capacity of M. Trapezius on the left side decreased significantly after work ($P < 0.05$). Similarly, the capacity of M. Trapezius on the right side in the EH group decreased significantly after work ($P < 0.01$).

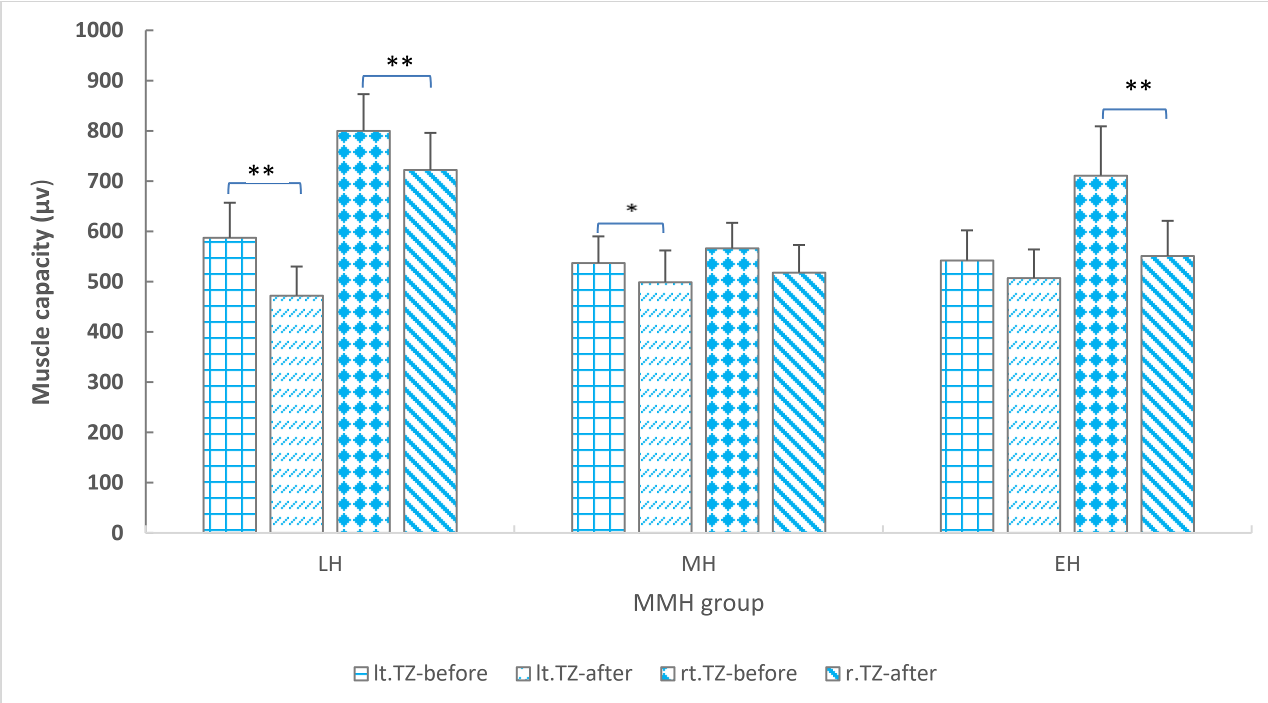

Fig. 3. Muscle capacity test (MVC) of the upper back in microvolts before and after work of warehouse worker, (Mean± SE).

* Pair -t-test test indicates a significant difference between before and after in each group (*P* < 0.05).

** Pair -t-test indicates a significant difference between before and after work (*P* <0.01). SD: Standard deviation

Table 5.

Perceive work stress factors and SWI scores of warehouse workers (Mean ± SD)

Work factors	LH	MH	EH	F	*P-value*	95 %CI
Fatigue	6.1 ± 2.5	5.3 ± 1.4	5.2 ± 2.5	0.653	0.527	3.6,7.6
Risk	9.1 ± 1.4	7.6 ± 1.8	7.3 ± 3.4	2.12	0.135	5.3,9.9
Concentration	7.0 ±1.7	4.6 ± 1.8**	5.6 ± 2.6	4.298	0.021	3.5,8.0
Complexity	6.5 ± 1.3	5.4 ± 0.6	4.3 ± 1.9***	7.696	0.002	3.1,7.2
Work rhythm	7.1 ± 1.8	5.8 ± 1.1	5.8 ± 1.8	2.600	0.088	4.7,8.2
Responsibility	9.2 ± 1.0	8.1 ± 1.9	8.5 ± 1.9	1.608	0.214	6.9,9.8
Job interest	8.2 ± 1.9	7.5 ± 2.0	7.2 ± 2.1	0.978	0.386	5.9,9.4
Autonomy	7.3 ± 1.7	6.9 ± 2.8	7.6 ± 1.8	0.346	0.710	5.3,8.7
SWI score	3.7 ± 0.7	2.8 ± 0.9*	2.7 ± 1.0*	4.657	0.016	2.1,4.1

*,**,*** Bonferroni Multiple comparisions with Significant different with LH at P < 0.05, 0.01 and P < 0.001

SWI perceived workload: Table 5 displays the perceived workload of the three working groups. The three highest negative work factors rated by the groups are responsibility, concentration, and work rhythm. Detailed perceived discomfort is shown in Table 6, indicating high discomfort scores in heat, dust, and movement for all three groups

Table 6.

Perceived environmental stress factor scores (Mean ± SE)

Environmental factors	LH	MH	EH	F	*P-value*	95 %CI
Posture	1.1 ± 0.3	1.3 ± 0.3	2.4 ± 1.3	3.199	0.054	0.5,3.3
Movement	1.3 ± 0.3	1.9 ± 0.3	2.4 ± 0.4	2.110	0.137	0.6,3.3
Hot	2.0 ± 0.4	2.3 ± 0.3	3.3 ± 0.4	3.153	0.056	1.2,4.1
cold	1.0 ± 0.4	0.1 ± 0.1*	0.0 ± 0.0 *	6.019	0.006	0.0,1.8
Noise	2.2 ± 0.4	0.5 ± 0.2**	1.1 ± 0.5	5.868	0.007	0.0,3.2
Vibration	1.2 ± 0.4	0.3 ± 0.2	0.0 ± 0.0*	4.367	0.021	0.0,2.2
Light	0.6 ± 0.2	0.3 ± 0.2	0.5 ± 0.2	0.563	0.575	0.0,1.0
Air quality	1.4 ± 0.3	0.5 ± 0.2**	2.3 ± 0.5	6.838	0.003	0.1,3.5
Dust	2.2 ± 0.2	2.2 ± 0.3	3.0 ± 0.3	2.305	0.116	1.6,3.7
Organization	1.2 ± 0.2	0.7 ± 0.2	0.2 ± 0.1*	4.245	0.023	0.0,1.7
Others	0.1 ± 0.1	0.8 ± 0.5	0.0 ± 0.0	2.426	0.104	0.0,1.9

*,** Bonferroni Multiple comparisons with Significant differences with LH at $P < 0.05$ and $P < 0.01$

*,** Bonferroni Multiple comparisons with Significant differences with EH at $P < 0.01$, SE: Standard error

4. Discussion

Participants, as shown by biometric data (Table 1), are in normal physical health with BMI within the normal range and no musculoskeletal issues confirmed by an orthopedist. This supports findings linking BMI and musculoskeletal symptoms in the working population (Cost and Vieira, 2013), highlighting an inappropriate BMI as a major risk factor for work-related MSDs (Dianat et al., 2016).

Due to continuous work planning, measurement sessions were restricted to 30 to 45 minutes per subject, ensuring a comprehensive assessment of task performance effectiveness.

The physical environment, outlined in Table 2, significantly influences bodily functions and behavior. Noise affects auditory system function and communication, lighting is crucial for visual perception and event detection during work, and climate, especially heat, impacts body temperature, requiring effective thermoregulation through sweating and blood circulation for cooling.

While lighting may not directly impact physiological responses, its qualitative and quantitative aspects are crucial, influencing body posture and contributing to fatigue. Light levels, measured in cd/m2 or Lux, are essential for perceiving details in the visual field. Maintaining a contrast ratio of 1:3:10 between the work area and the environment is critical for safety, as insufficient or excessive contrast can pose risks. Excessive contrast may cause glare and temporary blindness during transitions between well-lit and dark areas. Lux, indicating illuminance, is a key factor for light intensity, with recommended levels between 50 to 100 cd/m2 for manual work and 20 to 70 cd/m2 for material handling. In this study, warehouse operators engaged in manual material handling maintained light levels within the acceptable safe range.

The noise levels consistently remained within safe limits, ensuring that the auditory system was not exposed to intensities considered risky for an 8-hour permanent exposure (set at 85 dB(A)).

In tropical regions, climatic conditions present a significant risk of heat stress, particularly for physical work and material handling in non-climatized settings where direct exposure to sunlight cannot be mitigated by air conditioning. A thorough understanding of environmental conditions in specific work settings can greatly influence productivity and enhance workers' quality of life (Parson, 2014).

Occupational exposures are often assessed using Wet Bulb Globe Temperature (WBGT), as per ISO Standard 7243 (Francesca et al., 2014; Parson, 2014), for evaluating hot environments. This index considers air temperature, humidity, and radiation, particularly in tropical conditions. The duration of exposure is determined by the intensity of human work-related heat production: light, moderate, and heavy. For example, at 28 degrees WBGT, moderate work (group LH) allows for 45 minutes of work followed by 15 minutes of rest. The work/rest ratio adjusts for more intensive work (groups MH, EH) as WBGT increases. Physiological measurements, including body temperature, heart rate, and weight loss (sweating), are recommended for work periods exceeding 4 hours. While the WBGT index holds ISO-standard validity, our research team supplemented it with physiological criteria, incorporating working heart rate as an indicator of cardiovascular strain (Yoopat et al., 2002).

Material handling (Figure 1) involves not only the muscular load from lifting and pushing-pulling materials but also the maintenance of body posture strength. The upper limbs, arms, and shoulders, heavily engaged in material handling, experience significant strain. The shoulder region, typically strong enough to maintain posture, and the lower back muscles, in conjunction with the abdominal muscles, stabilize the lumbar region—the skeleton's weakest point. Increased abdominal pressure during lifting supports the trunk, forming a robust system for correctly lifting heavy weights. The decline in MVC after work (Table 4, Figures 2 and 3), particularly in the upper and lower back muscles, is a normal phenomenon resulting from muscle fatigue (Al-Mulla, Sepulveda, and Colley, 2011).

Post-work muscle capacity in the three groups reflects the workload during work, posing a risk of Musculoskeletal Disorders (MSDs), particularly low back pain (LBP) (Figure 2). This aligns with a study linking physical, psychological, and environmental factors at work to LBP in Danish warehouse workers (Bláfoss, Aagaard, and Andersen, 2019). Another study recommends tailored mechanical lifting devices for Manual Material Handling (MMH) and emphasizes collaborative teamwork to mitigate tardiness and benefit both workers and enterprises (Jamili, Berg, and Koster, 2022).

Perceived strain, measured by the SWI score (Table 5) and environmental load factors (Table 6), accurately reflects the actual work situation, with average SWI scores indicating a moderate level of discomfort across the three groups. SWI represents work-related problems as perceived by active operators, aiding in prioritizing improvements. Participants identified responsibility, risk, and work rhythm as top-priority factors. Further analysis highlighted heat, dust, and movement as sources of discomfort, aligning with objective measurements of EMG and cardiovascular strain (Yoopat et al., 2020; Dianat et al., 2016).

5. Conclusions

Manual material handling activities pose biomechanical risks of musculoskeletal disorders (MSDs). Physiological variations in cardiac risk ranged from moderate to high in groups LH, MH, and EH. Muscular load exceeded the 20%-MVC limit for safe work in all groups, with the highest MSD risk identified in the MMH group EH, particularly in the lower back on the right side. Muscle capacity decreased after duties, indicating potential fatigue, notably in the lower back muscles on both sides in the EH group. Objectively measured results aligned with subjective data, suggesting that improving the quality of life for operational staff benefits stakeholders at various organizational levels.

6. Limitations

Conducted in real working conditions, this study has minor limitations related to the duration of subject preparation and the influence of standardized job performance on normal daily work efficiency. Communication, organization, materials, equipment, workplace, and protocols required permission from enterprise owners and managers, potentially biasing workload activity selection. Participants were aware of being part of a standardized project, excluding mental pressure from customer-client relations and unpredictable delivery issues—variables that could impact scientific study standards. Additionally, the authors lacked direct experience with production stressors, potentially introducing a bias in the outcomes.

Declaration of competing interest

There is no conflict of interest

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