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Original Article

Evaluation of time spent in high strain postures among nurses and laboratory technicians: implications for ergonomic interventions

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Abstract

***Background & Aims*:** Musculoskeletal problems can develop due to the work conditions of nurses and laboratory technicians. The purpose of this study was to evaluate how much time nurses and laboratory technicians spent on high strain postures.

***Materials & Methods*:** This cross-sectional study was performed on 32 nurses (from internal medicine and general surgery wards) and 20 laboratory technicians in a hospital located in Tabriz, northwestern Iran. The Nordic questionnaire and the rapid entire body assessment (REBA) method, with a new scoring algorithm, were used for ergonomic assessment. The 90th percentile was calculated for REBA components to determine the time spent by participants working in stressful postures in the upper extremity, upper quadrant, and trunk/lower extremity. One-way analysis of variance was used for statistical analysis.

***Results*:** Musculoskeletal symptoms of the neck (63.5%) and back (55.8%) were the most common. The time spent in high strain postures of upper extremity and trunk/lower extremity was statistically different between nurses and laboratory technicians. Internal medicine nurses and laboratory technicians were observed in high strain postures for 11% and 8% of their work hours, respectively.

***Conclusion*:** Internal medicine nurses are subjected to more biomechanical stress than general surgery nurses, particularly in the upper body. On the other hand, laboratory technicians work with biomechanical stress on their trunk and lower extremities. Ergonomic interventions are proposed to correct nurses' upper body postures and laboratory technicians' lower body postures.

***Keywords*:** Ergonomic assessment, Hospital, Laboratory technician, Nurse, REBA

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Introduction

Musculoskeletal disorders (MSDs) are common throughout the world and are regarded as major occupational injuries in both developed and developing countries. MSDs are the leading cause of disability in muscles, tendons, ligaments, joints, blood vessels, and peripheral nerves, causing pain or discomfort (1). Work-related Musculoskeletal Disorders (WMSDs) are

conditions in which “the work environment and performance of work contribute significantly to the condition and/or the condition is made worse or persists longer due to work conditions” (2).

In the United States of America from, 1992 to 2010, WMSDs accounted for 29–35 % of occupational injuries and illnesses requiring days away from work. In 2007, the overall cost, direct and indirect, was estimated to be $2.6 billion (3). Workplace activities such as heavy lifting, long work-shifts, a lack of work-rest schedules, repetitive movements, poor postures, vibrations, extreme static hand and arm postures are known to be risk factors of WMSDs. Demographic characteristics and psychological factors are also known to be significant predictors (4, 5).

Nursing is a physically demanding profession and in terms of physical workload is second only to industrial jobs. Nurses are particularly vulnerable to MSDs due to the nature of their job (6). Nursing requires frequent bending and twisting, rapid movements in non-neutral positions, and patient handling (4). Therefore, nursing is one of the occupations with a high prevalence of WMSDs, especially in the neck, shoulder, arm, wrist, and lower back, with lower-back pain being the most prominent (7-9). For example, 70.8 %of Korean university hospital nurses reported having musculoskeletal symptoms (10). About 85% of the Iranian nurses reported MSD symptoms in the last 12 months. The most common issue was lower back pain (4). According to a study by Karki et al., the prevalence of MSDs among nurses affecting the upper limbs and spine was 86.1%, while the occurrence rate of MSDs affecting the lower limbs was 66.1% (6). Alam et al. found a high prevalence of MSDs among female nurses in Indian hospitals, with the highest occurrence reported in the lower back (79%), followed by the right shoulder and neck (67%), and knee pain (63%) in the past 12 months (11).

Medical laboratory technicians are skilled medical professionals who face occupational health hazards that can lead to various health issues. They are exposed to biological, physical, chemical, and ergonomic risks due to their profession. Most research on laboratory workers has focused on biological, physical, and chemical hazards, with little attention paid to ergonomic hazards (12-14). The routine work activities of laboratory technicians include using pipets and a microtome, opening, closing, and filling test tubes, manipulating samples, and working with a computer screen (15). Working in a biological safety cabinet or fume hood increases the risk of laboratory personnel's upper limb, neck, and back disorders (16). These tasks could lead to the development of MSDs in laboratory technicians. For example, a study in India found that 69.9% of laboratory technicians had musculoskeletal pain in the last year, with the back being the most common area (44 %) (17). Another study found that 73.3 % of medical laboratory workers suffer from MSDs (13).

The REBA (Rapid Entire Body Assessment) method is one of the ergonomic assessment methodologies developed primarily for healthcare environments. This method has been applied in the ergonomic evaluation of medical personnel, including hospital nurses and home nurses (18), dentists (19), and radiologists (20). Janowitz et al. modified the REBA method by incorporating some ergonomic risk factors found in hospital settings. Furthermore, the upper and lower extremity scores are not combined and are shown separately using the new coding system, allowing for better targeting of the ergonomic recommendations (21). There are a limited number of published studies evaluating nurses' and technicians' ergonomics using the modified REBA. Therefore, our study aims to determine and compare the ergonomic conditions of nurses and laboratory technicians working in a hospital in Tabriz, northwestern Iran using the modified REBA.

Materials & Methods

This study was conducted in one of the main hospitals in Tabriz, Iran. The study population consisted of 32 nurses and 20 laboratory technicians. Nurses were enrolled from two wards; 16 nurses were working in general surgery (as a low-workload ward) and 16 from an internal medicine ward (as a high-

workload ward). The sample size was based on census, and all nurses of the two departments or laboratory technicians were studied.

Before data collection, the participants were informed about the study's goal and methodology, and their satisfaction was ascertained. The ethics committee of Urmia University of Medical Sciences approved the current study's ethical considerations under the code IR.UMSU.REC.1395.278. Based on observations of work cycles and discussions with the hospital's head nurse and occupational health specialist, low and high workload nursing wards were determined. Thus, it was determined through interviews with head nurses that patients admitted to the internal medicine ward typically have chronic conditions and require long-term hospitalization to control disease symptoms and receive supportive therapy. In addition to doing standard nursing responsibilities, the nurses on this ward conduct tasks such as regularly repositioning patients to prevent bedsores, bathing patients in bed, and suctioning patients to prevent and cure pulmonary problems. In comparison, patients admitted to the general surgery ward typically stay for a short period and require routine nursing care.

In the present study, the modified REBA method was used for ergonomic assessment. The REBA method was introduced in 2000 for the ergonomic evaluation of healthcare workers and has been used for ergonomic assessments of hospital nurses and home nurses (15), dentists (16), and radiologists (17). When assessing using REBA, the coder determines the scores for different body parts and then combines the scores to produce a final REBA score, accompanying risk and action levels. The action levels ranging from 0-4 provide a basis for ergonomic interventions (18). In 2006, Janowitz et al. (21) modified the REBA method to ergonomically evaluate the different hospital occupations. The modifications include 1) using a sampling approach (repeated and multiple observations) instead of analyzing stressful work conditions, 2) adding items from the University of California computer use checklist, and 3) creating a new algorithm for scoring the upper and lower limbs separately. They believed that by combining upper and lower body scores in the original REBA approach, the final score might be reduced to a level that the risk stayed below the threshold. As a result, the separate evaluation of upper and lower body parts can assist in directing ergonomic interventions to the stressed body region.

In the modified REBA, the upper extremity score (-4 to 57) is the sum of the scores obtained for the postures of the shoulder, elbow, and wrist; coupling; and arm support. Adding the neck, small range of motion (ROM), and mouse to upper extremity yields the upper quadrant score between -4 to 67. Trunk/lower extremity scores yield from the sum of the trunk, legs, knees, sitting position, foot support, static position, and large postural changes with an unstable base between -4 to 103. Scoring is made according to the condition of each part of the body. For example, four basic positions are considered for the shoulder, and the score of each position is affected by factors such as the presence of arm support, arms distance from the body, shoulder raising, and the weight of the load carried. Accordingly, the minimum and maximum scores for the shoulder could range -1 (neutral posture, no-load, with arm support) and 28 (shoulder flexion > 90 degrees, shoulder abduction/rotation, load heavier than 22 lbs, shoulders raised, no arm support), respectively. The scoring algorithm is detailed in Janowitz et al. (21).

Job observation was utilized to collect data using a job sampling technique. In other words, participants' body postures were observed at 2-minute intervals, and data were recorded on a data collecting sheet. As a result, 30 observations were made for each participant during a one hour period. The nurses and laboratory technicians were observed in the morning (3 days), evening (2 days), and night (2 nights) shifts to account for a variety of possible working conditions. There were 1,560 observations, including 960 observations of nurses and 600 observations of laboratory technicians. The selection of individuals to observe and record information was random.

The Nordic musculoskeletal questionnaire was used to determine the prevalence of MSDs in the neck, shoulders, back, waist, elbows, wrists, shoulders, legs, and knees over the previous 12 months. Additionally, the Nordic questionnaire collected demographic data on the individuals. Prior to data collection, a pilot study was conducted to determine the observer's reliability. Photographs from the working conditions of participants were coded twice, and the agreement was determined. The percentage of agreement for the majority of REBA method components was greater than 85 %, indicating the high reliability of observations.

The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 19.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to calculate the prevalence of MSDs and the score of REBA components. For each REBA component, the 90th percentile was calculated using the data of all observations. The observations with scores above the 90th percentile were used to calculate the time spent in "high strain" postures. We only calculated the high strain postures for three main components of REBA, including upper extremity, upper quadrant, and trunk/lower extremity, and compared them statistically between nurses and laboratory technicians using ANOVA test.

Results

The participants' demographic data were evaluated by age, sex, marital status, work experience, body mass index, and shift work. Twenty of the participants (38.5%) were male, while 32 were female (61.5%). Eight (15.4%) were single, while 44 (84.6%) were married. The participants ranged in age from 27 to 45 years, with a mean of 35.92 years. Half of the participants were considered to have a normal body mass. The majority of participants (69.2%) worked in rotating shifts.

The prevalence of MSDs in different body parts during the past year was shown in Table 1. MSDs were prevalent in the neck (63.5%), low back (55.8%), and upper back (51.9%) of subjects. The intensity of pain was greater in the neck (1.96), lower back (1.84), knees (1.56), and upper back (1.46) of participants.

Table 1. Prevalence and severity of musculoskeletal disorders in nurses and laboratory technicians

Body part	Prevalence of MSDs, N(%)	The mean of pain severity (0-5)
Neck	32 (63.5)	1.96
Shoulders	21 (40.4)	1.19
Upper back	27 (51.9)	1.46
Elbows	9 (17.3)	0.53
Wrist and hands	14 (26.9)	0.86
Lower back	29 (55.8)	1.84
Thighs	9 (17.3)	0.50
Knees	24 (46.2)	1.51
Legs	25 (48.1)	1.55

Table 2 summarizes the upper extremity, upper quadrant, and trunk/lower extremity scores, as well as the individual item scores for each body part. The upper extremity, upper quadrant, and trunk/lower extremity had a mean score of 8.16, 11.01, and 9.59, respectively. The observed and possible scores for elbow posture, arm support, neck posture, small range of motion, foot support, prolonged static position, and

large rapid changes were equal, indicating a broader degree of ergonomic exposure for these items.

Table 2. The mean, 90th percentile, and observed scores for each REBA method component (N = 52, Observations = 1,560)

Component		Mean	90th percentile	Observed range	Possible range
Shoulder	Right	1.12	4	-1 to 9	-1 to 28
	Left	0.92	4	-1 to 10	-1 to 28
Elbow	Right	0.79	2	0 to 4	0 to 4
	Left	0.76	2	0 to 4	0 to 4
Wrist	Right	0.90	2	0 to 5	0 to 7
	Left	1.04	2	0 to 6	0 to 7
Coupling	Right	2.28	5	0 to 5	0 to 7
	Left	3.52	5	0 to 5	0 to 7
Arm support	Right	-0.13	0	-3 to 3	-3 to 3
	Left	-0.05	0	-3 to 3	-3 to 3
Upper extremity score	Max. right or left	8.16	13	-2 to 21	- 4 to 57
Mouse		0.08	0	0 to 2	0 to 2
Small ROM		1.37	3	0 to 3	0 to 3
Neck		1.31	5	0 to 5	0 to 5
Upper quadrant score		11.01	17	-1 to 25	-4 to 67
Trunk		1.16	3	-2 to 12	-4 to 72
Legs	Right	0.31	1	-2 to 1	-2 to 3
	Left	0.31	1	1- to 1	-2 to 3
Knees, if standing	Right	0.13	0	0 to 5	0 to 15
	Left	0.10	0	0 to 5	0 to 15
Foot support	Right	0.49	3	0 to 5	0 to 5
	Left	0.51	3	0 to 5	0 to 5
Sitting position of legs	Right	0.26	1	0 to 2	0 to 2
	Left	0.28	1	0 to 2	0 to 2
Static position for >1 minute		1.79	5	0 to 5	0 to 5
Large postural changes with an unstable base		5.09	8	0 to 8	0 to 8
Trunk/lower extremity score		9.59	14	3 to 26	-4 to 103

The time spent in "high strain" postures in the upper extremity, upper quadrant, and trunk/lower by subjects in each occupation is summarized in Table 3. The time spent in "high strain" postures of the upper extremity and trunk/lower extremity differs significantly across the three occupations (p value < 0.05). Internal medicine ward nurses face ergonomic stress primarily in their upper extremities, whereas laboratory technicians experience ergonomic stress in their trunk and lower extremities.

Table 3. The amount of time spent in high-strain postures of the upper extremities, upper quadrant, and trunk/lower extremity by nurses and laboratory technicians

Job category	Upper extremity	Upper quadrant	Trunk/lower extremity
Surgery nurses	4.37 (3.98)	6.87 (4.45)	4.58 (4.99)
Internal medicine nurses	10.83 (7.04)	8.59 (6.94)	3.53 (3.93)
Laboratory technicians	6.83 (6.25)	6.99 (6.74)	8.3 (7.9)
F- value	4.08	0.04	3.17
P value	0.01	0.63	0.05

Discussion

This investigation aimed to study and compare the ergonomics of laboratory technicians and nurses from two internal medicine and general surgery wards in Tabriz, Iran. Musculoskeletal symptoms were prevalent in the neck (63.5%) and lower back (55.8%). Evaluation of work postures by the modified REBA method showed that the level of risk factors in the upper quadrant of nurses and laboratory technicians are similar, while in the upper and lower extremities, they experienced statistically different ergonomic stress. Nurses working in internal medicine ward spend about 11% of their time in high strain postures of the upper extremity, whereas laboratory technicians spend 8% of their work time in high strain postures of the lower extremity.

In this study, we did not study the prevalence of MSDs in a larger sample of nurses and laboratory technicians, and only subjects who participated in the REBA assessment were examined for MSDs. As a result, the neck (63.5%) and lower back (55.8%) were identified as the body parts with the highest prevalence and degree of pain. In some previous research, the MSDs of Laboratory technicians have been studied. A study in Iran found that pain in the lower back (42.7%) and neck (33.3%) of laboratory technicians was the most common (16). Maulik et al. identified the lower back (32.5%), knees (20.7%), and neck (18.4%) as the body parts with the highest MSDs prevalence among Indian laboratory technicians (17). Another Indian study found the highest prevalence of MSDs in the trunk (including the lower back), knees, and neck of laboratory technicians (13). The higher prevalence of MSDs in laboratory technicians could be attributed to common risk factors such as static work postures, prolonged standing, and a lack of back support (13, 17).

Observational methods such as RULA have been used in prior research to analyze laboratory technicians' working conditions and workstations. For example, Maulik et al., using the RULA method, categorized the work postures of laboratory technicians in action levels of greater than 1, which indicates non-acceptable working conditions. They suggested providing proper training on appropriate work postures, administrative measures to establish a work-rest cycle, and the use of ergonomically built workstations to prevent MSDs in laboratory personnel (13). In a similar study, it is discovered that 70% of analyzed situations by the RULA gained scores greater than 5, indicating the need for significant adjustments to the work environment of pathology laboratory technicians (22). Carvalho et al. using RULA data, found that the risk of developing MSDs exists in all work activities of pathological anatomy service, indicating the need for evaluation and adjustment of work circumstances (23).

The current study discovered that laboratory technicians spend 8.3% of their time working in high strain trunk/lower extremity postures. This time is roughly twice as long as nurses spend. Although laboratory technicians spend 6.8 % of their work time in high strain upper extremity postures, they mainly work in sitting positions, and their trunks and legs are highly strained. As a result, ergonomic interventions are recommended first for the trunk/lower extremities and then for the upper extremities. It has been discovered that laboratory technicians typically work in a standing position (55 % of the time), whereas non-

neutral postures occur typically in sitting positions (45% of the time) during work activities such as working with safety cabinets, microscopes, and microtomes (15). According to Penkala et al., 51% of work positions in university medical laboratories were sitting positions, with the majority of the chairs being non-adjustable stool type which may intensify users' musculoskeletal problems. Participants expressed concerns about the need for better height-adjustable seats and back support to avoid hunching during laboratory activities (24). It might be concluded that, in order to alleviate ergonomic stress on laboratory technicians' trunks and lower extremities, work adjustments and redesign should focus mainly on sitting positions.

Throughout nursing tasks, nurses' upper and lower limbs are subjected to biomechanical pressures and physical strain. The most frequently reported MSDs symptoms included low back pain, knee pain, ankle/foot pain, and neck pain. The REBA method has been used to analyze biomechanically stressful tasks of nurses. Analysis of nursing activities by REBA in a physical rehabilitation unit revealed a medium to high risk of developing work-related MSDs. The physical positioning of patients, transportation and manual handling of patients and equipment, and reaching and supporting weight away from the body were all activities that contributed to the development of MSDs (25). In a study on operating room (OR) nurses, the overall mean REBA score of 7.7 indicated that most OR nurses need immediate assessment and modifications to their work habits and workstations to minimize their risk level (26). The percentage of time spent in high-stress situations was measured in the current study by applying REBA in an observational mode. Internal medicine nurses worked while spending around 11% of their work time with upper extremities under physical stress. Surgery nurses, on the other hand, experienced less biomechanical stress on their upper extremities. These variations could be attributable to the nursing tasks done in the internal medicine and surgical wards. In other words, care for chronically-ill patients in the internal medicine ward necessitates handling, repositioning, and other supporting acts that may place nurses' hands and shoulders in awkward positions. Internal medicine nurses spent a similar amount of time in high-strain scenarios as surgery nurses in the trunk and lower extremities. It could be concluded that ergonomic improvements should be implemented to reduce physical strain on nurses' shoulders, hands, and necks, particularly those who work in the internal medicine ward.

This study had its limitations. The main limitation of this study was its relatively small sample size. Therefore, a similar study is proposed to be conducted on nurses and laboratory technicians from several hospitals. One observer recorded the observations, which some work conditions might not have included in the survey. Multiple observers could assist in accurately capturing participants' work conditions.

Conclusion

Nurses and laboratory technicians reported more musculoskeletal pain in the neck and lower-back over the past year. The modified REBA method was easily adopted in hospital jobs such as nurses and laboratory technicians using the new scoring system. According to observations made on nursing wards and in the medical diagnostic laboratory, nurses' upper extremities and laboratory technicians' trunk/lower extremities are mostly subjected to biomechanical stress. Given that reducing stressful work postures can help prevent MSDs in nurses and laboratory technicians, it is suggested that ergonomic interventions be concentrated on the upper extremities of nurses and the lower extremities of laboratory technicians.

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Authors' Contributions

Mohammad Hajaghazadeh and Abolfazl Ghahramani designed the study. Fatemeh Farrokhi collected data. Mohammad Hajaghazadeh, Samira

Orujlu and Abolfazl Ghahramani analyzed the data. All of the authors revised and approved the paper.

Data Availability

The data supporting these findings are available from the corresponding author upon reasonable request.

Conflict of Interest

Authors declare there is no conflict of interest.

Ethical Statement

This study was approved by the Ethics Committee of Urmia University of Medical Sciences (code IR.UMSU.REC.1395.278) in accordance with ethical principles.

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