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Effort-Reward Imbalance and Low Back Pain Among Industrial Workers: A Cross-sectional Study

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Abstract

Background: Low back pain (LBP) in workers is a leading cause of disability and loss of work time, adversely affecting job performance and overall well-being. The primary objective of this study was to evaluate the potential role of effort-reward imbalance (ERI) as a risk factor for the development of LBP among workers.

Methods: This analytical cross-sectional study was conducted among industrial workers (n = 1127) in Tehran province. Data were collected using 3 different questionnaires—an occupational-sociodemographic questionnaire, the van Vegchel version of the ERI questionnaire, and the Dutch Musculoskeletal Questionnaire (DMQ). Workers who reported experiencing pain in the past 12 months and the past 7 days were classified as having LBP. To assess the relationship between ERI and other independent factors with LBP, univariate logistic regression was employed. Subsequently, to adjust for the effects of influential factors on the dependent variable, a multiple logistic regression model with backward elimination was utilized.

Results: Out of 1127 participants, 1015 (90.06%) were men. The prevalence of ERI among the participants was 60.69%. The results of the multivariate logistic regression model indicated that having ERI (adjusted odds ratio [AOR], 2.985 [95% CI, 1.994-4.470]; $P < 0.001$), having accident experience (AOR, 3.338 [95% CI, 2.378-4.685]; $P < 0.001$), and being married (AOR, 1.602 [95% CI, 1.028-2.498]; $P = 0.037$) were associated with an increased risk of LBP among industrial workers.

Conclusion: Similar to findings in other countries and various occupational studies, ERI was prevalent among industrial workers in Iran. Additionally, we found that ERI is a significant risk factor for LBP.

Keywords: Job Demands, Work-related Stress, Risk Factors, Iran

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Introduction

Low back pain (LBP) encompasses discomfort experienced between the lower edge of the ribs and the buttocks, manifesting in acute, subacute, or chronic forms. This condition can impact individuals of all ages and significantly impair mobility, thus diminishing quality of life and mental well-being. LBP may hinder professional responsibilities and reduce social interactions. According to a World Health Organization report, in 2020 approximately 619 million people were affected by LBP globally, with projections suggesting an increase to 843 million by 2050 due to population growth and aging (1). Lower back pain (LBP) represents a significant challenge for healthcare systems worldwide, characterized by substantial economic implications (1, 2). A comprehensive study focusing on adults with

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↑What is "already known" in this topic:
LBP is recognized as the most prevalent musculoskeletal disorder, shaped by various risk factors—including demographic, behavioral, anthropometric, health, and occupational elements. Several hypotheses, notably suggesting that psychosocial elements such as ERI may significantly contribute to the onset of musculoskeletal disorders, further complicating the multifactorial nature of LBP.

→What this article adds:
Like in many other countries especially Western nations, ERI was prevalent among industrial workers in Iran, and our findings underscore its role as a significant risk factor for LBP.

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newly diagnosed LBP in the United States illustrated this burden, revealing that the overall care costs for patients who did not receive surgical intervention reached an astonishing 1.8 billion dollars (3).

Workers represent a significant risk group for this type of pain, with the majority experiencing symptoms of LBP at some point during their professional careers (4-8). LBP in workers is a leading cause of disability and loss of work time, adversely affecting job performance and overall well-being (9). In light of the prevailing concerns surrounding LBP, numerous researchers across Iran and various other nations have diligently sought to elucidate the risk factors contributing to this widespread condition (4). They have demonstrated that certain demographic, behavioral, anthropometric, health, and occupational factors have significant effects on the occurrence of LBP (10, 11). A review study conducted by Mazloumi et al identified 9 distinct groups of risk factors associated with LBP among Iranian workers. These groups include biomechanical factors, workplace design, tools and equipment, environmental influences, temporal aspects of job design, job content, organizational elements, personal characteristics, and training (12). A study conducted by Gaffari et al revealed that several risk factors contributed to the prevalence of LBP among Iranian industrial workers over the previous 12 months. Specifically, increasing age, lack of regular exercise, heavy lifting, repetitive tasks, and monotonous work were identified as significant determinants (13). However, in recent years, attention has increasingly focused on other types of risk factors for LBP—such as psychosocial factors (4, 14). Numerous studies conducted across various nations have shown that factors such as social support (15, 16), job satisfaction (16), supervisor support, job freedom, and mandatory overtime work (17, 18) could play an important role in the occurrence of LBP.

In recent years, several hypotheses have emerged proposing that factors such as effort-reward imbalance (ERI) may contribute significantly to the development of musculoskeletal disorders. The efforts-rewards imbalance (5) in work can be measured using the ERI model. The ERI model serves as a critical framework for understanding the detrimental health effects associated with stressful psychosocial work environments in both developed and rapidly developing nations. This model posits that those who consistently experience a disparity between high levels of effort and low levels of reward—characterized as "high cost/low gain" scenarios—are at an elevated risk for developing stress-related disorders—including depression and coronary heart disease (19). Efforts in this context denote job demands or commitments imposed on the worker, while rewards encompass financial compensation, esteem, and job security or career advancement opportunities (20). Recent research has examined the correlation between ERI and musculoskeletal disorders, emphasizing the increased vulnerability of certain occupational groups. For example, Yokoyama et al found that eldercare workers with high ERI face a significantly elevated risk of lower back pain compared with their low ERI counterparts (21). Furthermore, additional investigations have established a link between high job strain and ERI, revealing associations with symptoms affecting the neck, shoulders, and wrists (22). Moreover, a study involving San Francisco transit operators corroborated these findings, demonstrating a notable connection between ERI and injuries to the lower back and neck (23).

Most existing research on the correlation between LBP and ERI is derived from Western or developed nations, raising questions about the applicability of these findings to developing countries such as Iran. This study is distinguished as the first inquiry into this relationship within the Iranian context. Consequently, understanding the status of ERI and its implications for LBP among industrial workers is of paramount importance. Thus, the principal aim of this investigation was to determine whether ERI constitutes a significant risk factor for LBP in this population.

Methods

Design and Data Collection Questionnaires

This analytical cross-sectional study was conducted in 2018 among industrial workers in Tehran province. Data collection employed 3 distinct questionnaires—a validated occupational-sociodemographic questionnaire designed to gather comprehensive occupational and socio-demographic data (24), the van Vegchel version of the ERI questionnaire (25), and the Dutch Musculoskeletal Questionnaire (DMQ).

The study examined a range of factors through the occupational-sociodemographic questionnaire—including sex, age, education level, marital status, body mass index, tenure in current job, history of injury or accident (including instances of leaving work due to work-related accidents), shift work, smoking status (current smoker), and exercise habits. The evaluation of ERI status among the workers was conducted using the ERI questionnaire. Pain experienced in various parts of the body was recorded using the DMQ for 2 main periods: the past 12 months and the past 7 days.

Population and Sample Size of the Study

In this research, the target population consisted of industrial workers aged ≥18 years within Tehran province. The inclusion criteria were meticulously defined to ensure the integrity of the study. Participants were required to provide informed consent, have a minimum of 1 year of employment in their respective industries, and exhibit no congenital or acquired disabilities. Furthermore, those with specific illnesses or preexisting heart diseases were excluded from participation, thereby refining the sample to represent healthy workers in the industrial sector.

The industrial landscape was categorized into 11 distinct sectors, as delineated by the Ministry of Industry, Mine, and Trade of Iran. These sectors included the food industry, pharmaceutical industry, health industry, machine manufacturing industry, electrical industry, automotive industry, chemical industry, cellulosic industry, textile industry, metal industry, and household appliances industry. To ensure a representative sample, a multistage cluster sampling method was employed. Through this methodology, a total of 1127 workers were successfully enrolled in the study,

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providing a robust dataset that supports the research objectives.

Data Analysis

In the descriptive statistics section, numbers and percentages were reported for qualitative factors. For analytical purposes, LBP was considered as the dependent variable, treated as a dichotomous variable where 1 represented worker who reported pain in the past 12 months and the past 7 days, and 0 represented other conditions.

The ERI factor was also treated as a dichotomous variable, where 1 indicated workers experiencing ERI (effort/reward ratio >1), and 0 indicated those who did not (effort/reward ratio ≤ 1).

To explore the relationship between ERI and other independent factors with LBP, univariate logistic regression was initially employed. Subsequently, to adjust for the effects of influential factors on the dependent variable, a multiple logistic regression model using backward elimination was utilized. Variables were eliminated from the model if their P value exceeded 0.05 ($P > 0.05$). However, to avoid missing potentially important factors due to confounding effects, variables with $P \leq 0.2$ in univariate analysis were included in the model.

Statistical significance was determined at $P < 0.05$. All statistical analyses were performed using Stata 15.1 software (Stata Corp).

Results

Out of the 1127 workers enrolled in the study, 1015 (90.06%) were men. The mean (±SD) age of the participants was 33.22 ± 7.63 years. Additionally, the mean (±SD) tenure in their current job was 7.24 ± 6.19 years (Table 1). The prevalence of ERI among the workers was 61.70% (Figure 1).

Several factors exhibited statistically significant associations with LBP—including marital status, tenure in current job, accident experience, smoking status, exercise habits, and ERI (Table 2). According to the findings from the multivariate logistic regression model (Table 3), experiencing ERI (adjusted odds ratio [AOR], 2.985 [95% CI, 1.994-4.470]; $P < 0.001$), having a history of work-related accidents or illnesses (AOR, 3.338 [95% CI, 2.378-4.685]; $P < 0.001$), and being married (AOR, 1.602 [95% CI, 1.028-

Table 1. Prevalence of measured factors by LBP, Tehran, Iran, 2017

Factors	LBP				All n=1127(%)
	No		Yes		
	N	%	N	%	
Sex					
Male	853	84.04	162	15.96	1015 (90.06)
Female	96	85.71	16	14.29	112 (9.94)
Age					
18-30	401	86.24	64	13.76	465 (41.26)
31-40	384	82.58	81	17.42	465 (41.26)
41-60	163	82.74	34	17.26	197 (17.48)
Education level					
Elementary	208	86.31	33	13.69	241 (21.38)
High school & Diploma	484	80.94	114	19.06	598 (53.06)
University	257	89.24	31	10.76	288 (25.55)
Marital status					
Single	244	89.71	28	10.29	272 (24.13)
Married	705	82.46	150	17.54	855 (75.87)
BMI					
Under weight (<18.5)	24	88.89	3	11.11	27 (2.40)
Normal weight (18.5-24.9)	449	85.04	79	14.96	528 (46.85)
Over weight (25-29.9)	389	83.30	78	16.70	467 (41.44)
Obese (>30)	87	82.86	18	17.14	105 (9.32)
Tenure in current job (years)					
<=5	536	87.01	80	12.99	616 (54.66)
6-10	172	83.90	33	16.10	205 (18.19)
11-15	129	77.71	37	22.29	166 (14.73)
>=16	112	80.00	28	20.00	140 (12.42)
Accident experience					
No	740	89.16	90	10.84	830 (73.65)
Yes	209	70.37	88	29.63	297 (26.35)
Shift work					
No	644	83.64	126	16.36	770 (68.32)
Yes	305	85.43	52	14.57	357 (31.68)
Smoking status					
No	834	85.19	145	14.81	979 (86.87)
Yes	115	77.70	33	22.30	148 (13.13)
Exercise status					
More than one time in a month	373	86.34	59	13.66	432 (38.33)
One time in a month	194	86.61	30	13.39	224 (19.88)
Never	382	81.10	89	18.90	471 (41.79)
ERI					
No	404	91.20	39	8.80	443 (39.31)
Yes	544	79.53	140	20.47	684 (60.69)

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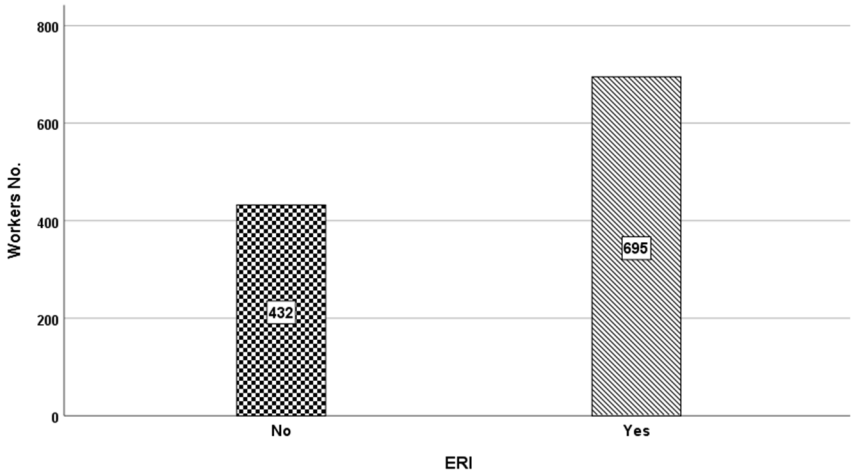

Figure 1. Prevalence of effort-reward imbalance (ERI) among the workers

Table 2. Associated factors with LBP according to the univariate logistic regression, Tehran, Iran, 2017

Factors	Odds ratio	Std. Err.†	P-value	95% CI‡
Sex	1.141	0.284	0.642	0.654 ; 1.992
Age	1.167	0.112	0.166	0.938 ; 1.453
Education level	0.872	0.120	0.254	0.689 ; 1.104
Marital status	1.824	0.220	0.006	1.184 ; 2.809
BMI	1.132	0.119	0.299	0.896 ; 1.430
Tenure in current job (years)	1.242	0.075	0.004	1.073 ; 1.437
Accident experience	0.288	0.170	0.0001>	0.206 ; 0.402
Shift work	0.888	0.182	0.438	0.607 ; 1.241
Smoking status	1.667	0.218	0.019	1.087 ; 2.557
Exercise status	0.818	0.094	0.033	0.681 ; 0.984
ERI	2.683	0.228	0.0001>	1.711 ; 4.208

† Standard Error; ‡ 95% Confidence Interval

Table 3. Final risk factors of LBP in Tehran, Iran, 2017

Factors	AOR†	Str. Err.	*P*-value	95%CI
Marital status				
Single		Ref.‡		
Married	1.602	0.227	0.037	1.028 ; 2.498
Accident experience				
No		Ref.		
Yes	3.338	0.173	0.0001>	2.378 ; 4.685
ERI				
No		Ref.		
Yes	2.985	0.206	0.0001>	1.994 ; 4.470

† Adjusted Odds Ratio; ‡ Reference group

2.498]; $P = 0.037$) were identified as factors contributing to an increased risk of LBP among industrial workers.

Discussion

LBP has emerged as the most frequently reported musculoskeletal disorder among individuals, significantly impacting health and social care systems, with indirect costs playing a predominant role (6). This condition is associated with a range of adverse outcomes—including disability, diminished quality of life, and increased rates of absenteeism in the workplace. Given its substantial implications for both individual well-being and broader societal costs, this disorder was prioritized for analysis and scrutiny within the parameters of this study.

According to our findings, 3 factors—marital status, accident experience, and ERI—emerged as significant risk factors for LBP among industrial workers, even after adjusting for age, tenure in current job, smoking, and exercise status. Our results indicated that married workers face a higher risk of LBP compared with single workers, aligning with similar findings from other studies (5, 26, 27). This result may be justified by the fact that married individuals often bear greater responsibilities for their families, such as caring for children and striving to increase household income. The additional responsibilities of marriage, including potentially longer working hours, can lead to more exposure to extended repetitive movements, standing, awkward postures, and whole-body vibration in the workplace. These factors, alongside other organizational stressors, can contribute to more LBP. In contrast, single individuals may have fewer of these stressors (26, 27). Therefore, these circumstances may increase the risk of LBP among married individuals. On the other side, studies have shown that greater stress can be correlated with an increased likelihood of experiencing LBP. A study conducted by Choi et al has demonstrated a significant association between chronic

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LBP and the degree of stress experienced by individuals (28). It is essential for individuals to be mindful of their stress levels and take proactive measures to manage and mitigate its effects on their overall well-being.

Several other studies (29, 30) have shown that marital status is not a risk factor for LBP and their finding were not aligned with our findings. In examining the discrepancies between our findings and those reported in other studies, it appears that the primary reason for these inconsistencies stems from variations in the research settings. Differences in environmental factors, population demographics, and methodological approaches employed across studies may significantly influence results.

The correlation between work-related accident experience and the increased risk of LBP is a topic of great importance in the field of occupational health. Our recent study has provided clear evidence that those who have experienced work-related accidents are at a higher risk for developing LBP. The findings from our research align with previous studies, such as the one conducted by Hincapié et al, which demonstrated a direct link between previous occupational low back injuries and the severity of existing LBP (31). Based on our understanding, work-related accidents can cause damage to various parts of the body, it appears that such accidents specifically render the lower back susceptible to pain. According to the World Health Organization (32), this specific type of LBP can be attributed to various causes, including tissue damage such as fractures, as well as referred pain originating from other organs, exemplified by conditions affecting the kidney or aortic aneurysms (32). In our study, we did not specifically inquire about the particular body parts affected among participants who reported work-related accidents. Consequently, we were unable to ascertain whether those experiencing LBP had a history of previous low back injuries or whether injuries to other anatomical regions could potentially influence the prevalence of LBP. To enhance the understanding of the interplay between these variables, we strongly recommend that future research endeavors make a concerted effort to differentiate among these factors, which may provide valuable insights into the multifaceted nature of LBP and its associated risk factors.

The ERI model posits 2 distinct forms of imbalances between effort and reward, specifically high effort coupled with low reward, and low effort accompanied by high reward. It is imperative to differentiate between the implications of these imbalances associated with stress theory and health outcomes. The model advances a critical hypothesis: the relative risk of developing stress-related disorders is significantly heightened when high effort is aligned with low reward, as opposed to scenarios involving low effort with high reward (33). Consequently, within the context of this study, the focus is predominantly placed on the condition characterized by high effort and low reward, which is identified as the ERI. The phenomenon of ERI in the workplace, characterized by perceptions of unfair exchange, breaches of trust, or unfulfilled promises, is posited to engage specific neural circuits associated with reward processing, notably the nucleus accumbens, anterior cingulate cortex, and insula. This neural activation has the detrimental effect of diminishing the production of dopamine and oxytocin, both of which are crucial neurotransmitters linked to positive emotional experiences and the alleviation of stress. Furthermore, heightened activity in the insula correlates with the perception of physical and emotional distress, manifesting as intense visceral and somatic sensations. When these neural responses are compounded by threats to an individual's self-worth or social standing, the sustained activation may disrupt the body's intrinsic regulatory systems, influenced by heightened stress responses and compromised physiological mechanisms for stress mitigation. Consequently, this interplay can lead to the onset of stress-related disorders (33, 34). According to the mechanisms underlying this effect, our findings indicate that ERI emerges as a significant risk factor for LBP. This observation aligns with prior research that has established a correlation between ERI and the experience of LBP (21, 23). This finding indicates that most industrial workers have many stressful conditions at work and such conditions are important risks of LBP. The workers reported that their rewards—including wage/salary, esteemed conditions, and job promotion/security for workers—are considerably low when compared to their requested job demands and obligations. In Iran, many workers typically have temporary contracts with their employers, which often leads to a lack of job security. The job promotion mechanisms in many Iranian organizations are incomplete and vague, often not being based on the organizational performance of workers. This is largely due to the absence of clear performance evaluation methods or indicators in most organizations. As a result, promotions are often not tied to merit or achievement, leading to a lack of transparency and fairness in the process. In a study conducted by Aghaz et al, it has been revealed that Iranian ministries are facing 11 significant human resource management (HRM) challenges as follows: an unstable and personalized organizational structure; outdated job descriptions; inconsistent employee recruitment practices; a lack of systematic career management; generalized rather than specialized training programs; disparities in pay and performance evaluation; misalignment between organizational strategy and HRM practices; superficial knowledge management efforts; silo mentality within HR departments; nonconformity in HR systems; and the issue of noncompetent employees (35).

According to the World Bank, Iran has been categorized as a lower-middle-income country in the world (36). As a result, it is expected that most workers report low salaries/wages. The results confirmed this hypothesis. In this circumstance, the increase in ERI among workers will be a logical phenomenon.

Job demands encompass a wide range of physical, psychological, social, and organizational aspects that require ongoing effort from a worker. These demands can have both positive and negative effects on individuals, depending on their ability to cope with them. Positive responses may include increased motivation and job satisfaction, while negative responses can lead to depression, anxiety, or burnout. It is important to recognize that job demands are a

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common source of work-related stress (37). Iran, as a developing country in the global landscape and on the path towards globalization, is actively striving to accelerate its industrial production. This endeavor inevitably leads to a rapid increase in the job demands of industrial workers. Such a phenomenon is not unique to Iran, as it has been observed in other developing countries as well. Based on the observation by Cheng et al, it has been noted that the combination of globalization and recession has increased the likelihood of employees facing higher job demands in both Taiwanese (38) and in Malesia (37).

In light of the established influence of organizational factors on job demands and obligations, this study did not include direct measurements of such factors to isolate their effects on LBP. However, it is advisable for future research to incorporate the measurement and adjustment of these risk factors associated with LBP. Additionally, conducting similar studies across diverse occupational groups with larger national samples is recommended, as this could yield valuable insights into the prevalence and determinants of various occupational-related diseases. Such comprehensive investigations would enhance our understanding and assist in developing more effective interventions to mitigate health risks in the workplace.

Conclusion

Like in many other countries and across various professions, ERI is prevalent among industrial workers in Iran, and our findings underscore its role as a significant risk factor for LBP. Addressing the reduction in LBP prevalence requires more than just workload adjustments; it necessitates implementing measures such as salary increments, enhancing job esteem, and ensuring job security.

Authors' Contributions

S.A.Z.: Data management and cleaning, critically revising the manuscript. S.B.: Drafting the work, critically revising the manuscript; A.M.: Data management and cleaning, and critically revising the manuscript; H.A.: Conception and design of the work, data management and cleaning, data analysis, drafting the work, and critically revising the manuscript.

Ethical Considerations

This study received approval from the ethics committee at Tehran University of Medical Sciences (ethical code: IR.TUMS.SPH.REC.1395.950).

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Conflict of Interests

The authors declare that they have no competing interests.

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