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Job characteristics and musculoskeletal pain among shift workers of a poultry processing plant in Southern Brazil

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Abstract: Job characteristics and musculoskeletal pain among shift workers of a poultry processing plant in Southern Brazil: Dânia BARRO, *et al*. Postgraduate Program in Collective Health, University of Vale do Rio dos Sinos, Brazil—Objectives: The purpose of this study was to evaluate the association between job characteristics and musculoskeletal pain among shift workers employed at a 24-hour poultry processing plant in Southern Brazil. **Methods:** This was a cross-sectional study of 1,103 production line workers aged 18−52 years. The job characteristics of interest were shift (day/night), shift duration, and plant sector ambient temperature. Musculoskeletal pain was defined as self-reported occupational-related pain in the upper or lower extremities and trunk, occurring often or always, during the last 12 months. **Results:** The mean (SD) participant age was 30.8 (8.5) years, and 65.7% of participants were women. The prevalence of musculoskeletal pain was greater among female participants than male participants. After adjustment for job characteristics and potential confounders, the prevalence ratios (PR) of lower extremity musculoskeletal pain among female workers employed in extreme-temperature conditions those working the night shift, and those who had been working longer on the same shift were 1.75 (95% CI 1.12, 2.71), 1.69 (95% CI 1.05, 2.70), and 1.64 (95% CI 1.03, 2.62), respectively. In male workers, only extreme-temperature conditions showed a significant association with lower extremity musculoskeletal pain (PR=2.17; 95% CI 1.12, 4.22) after adjustment analysis. **Conclusions:** These findings suggest a need for implementation of measures to mitigate the damage caused by nighttime work and by working under extreme temperature conditions, especially among female shift workers, such as changing positions frequently during work and implementation of rest breaks and a workplace exercise program, so as to improve worker quality of life.
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Key words: Circadian rhythm, Musculoskeletal pain, Night work, Occupational health, Shift work, Temperature

In recent decades, musculoskeletal pain has become a major cause of morbidity and disability in the workforce[1]. Repetitive movements, staying in the same position for long periods of time, and the need to complete tasks quickly, combined with the harmful effects of physical inactivity and unhealthy lifestyle habits on physiological processes, are the main causes of this disabling issue, which is of increasing concern to employers[2].

Market demands have acted as drivers of uninterrupted service in major corporations, thus mandating division of the work day into shifts. Shift work has a massive impact on worker health, as it alters the standard biological system of the human body, which relies on the day-night/sleep-wake cycle[3, 4]. Fixed shift schedules, which prolong worker exposure to factors associated with musculoskeletal pain, are an additional negative factor. It is estimated that nearly half of the Brazilian workforce is employed in shift work, with 10% of the workforce working night shifts. Considering how many services are now available for extended hours, including weekends, and thus require workers to be present overnight, this percentage may be even higher[5].

Evidence of the size of this problem is provided by authors such as Piedrahita[6], who claims that musculoskeletal conditions are the most frequent occupational diseases worldwide. In Brazil, the federal social

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security system recorded 17,693 cases of occupational disease in 2009 alone, and the National Institute of Social Security (Instituto Nacional de Seguridade Social, INSS) lists these conditions as the second leading cause of leave from work. The financial burden of occupational diseases in the country is in the order of R$56.8 billion/year, which includes the sum of disability benefits paid out by the INSS and the operational costs of missed work[7].

Despite the relevance of this topic, few studies have sought to assess musculoskeletal pain in shift workers and its potential associations with job characteristics and labor conditions, such as shift duration, plant sector, and ambient temperature[8–13]. Within this context, the present study sought to evaluate the association between job characteristics and musculoskeletal pain among shift workers employed at a poultry processing plant in Southern Brazil.

Subjects and Methods

Study design, sampling, and data collection

This was a cross-sectional study of employees working a fixed-shift schedule at a 24-hour poultry processing plant located in Southern Brazil. The work schedule system was divided into 8-hour shifts with variability in the initial hour of work. This system allows different work schedules including day and night shifts. Participant age ranged from 18 to 52 years. The study was conducted with data originally collected for a larger project that sought to ascertain whether shift work is associated with overweight and abdominal obesity[14]. The sample for the present study comprised workers who had been employed by the company for at least 12 months, distributed across three distinct production line sectors (cutting floor, evisceration, and thermal processing). Employees who had been away from work for over 10 days (regardless of reason) were excluded, as were pregnant women. Interviews were conducted at the participants' homes between January and May 2010 using a standardized, precoded, and pretested questionnaire. This study was approved by the University of Vale do Rio dos Sinos—UNISINOS Research Ethics Committee in accordance with National Health Council Resolution 196/96 on research involving human subjects, and written informed consent was obtained from all participants. For quality control of collected data, 10% of the participants were contacted again, either in person or by telephone, and asked to complete a short-form questionnaire consisting of items expected to vary little over time.

Outcome measure

For assessment of musculoskeletal pain, interviewees were asked about the presence of pain during the last 12 months and to identify the affected body segment, if any, on a human silhouette adapted from the Standardized Nordic Questionnaire[15]; the answer choices as follows: none, sometimes, often, or always. Interviewees where then asked whether they believed the pain reported for each affected body segment was in some way related to their work at the plant. Musculoskeletal pain was defined as a report of work-related pain affecting the upper extremities, lower extremities, or trunk, occurring "often" or "always", and presenting during the last 12 months. Upper extremity pain was defined so as to include the following body areas: neck, shoulder, arms, elbows, forearms, and wrist/hand/finger. Trunk pain included the upper and lower back, and lower extremity pain included the hips, thighs, knees, ankles, and feet.

Exposure assessment

The job characteristics of interest were shift, time spent as a shift worker, and temperature of the work sector. Shift was defined on the basis of the times at which workers arrived or left the plant and, consequently, whether they were able to sleep at least 6 hours at night (between 00:00 and 06:00). This period was set on the basis of the biological clock concept, according to which the time between midnight and 6 a.m. is set aside for rest; it is the time of production of melatonin—a major biochemical trigger of vital functions and negative regulator of the production of such biomarkers as cortisol—which is responsible for awakening and wakefulness[4]. Therefore, day shift work was defined as that allowing the worker 6 hours of sleep at night, whereas night shift work was defined as that not allowing at least 6 hours of sleep at night.

Time spent as a shift worker was collected as a continuous variable and dichotomized as up to 2 years or 2 years and up. Temperature was assessed on the basis of company-provided data for each of the three sectors of interest: cutting floor (10–12ºC), evisceration (room temperature, 25ºC on average), and thermal processing (extreme temperature conditions: below 10ºC during receiving of unprocessed material, primary packaging, and secondary packaging; 40ºC on average at the deep fryer room). The cutting and evisceration sectors were pooled for analysis.

The demographic variables of interest were sex, age (collected as a discrete variable [whole years] and stratified into decades), and conjugal arrangement (with or without partner at the time of the study). The socioeconomic variables were educational attainment (categorized as: 1–4 years primary education; 5–8 years primary education; some secondary education; complete secondary education or higher) and household income (total income of all persons living in the household, collected as a continuous variable and categorized into quartiles). A behavioral variable was also assessed, physical activity (duration of physical activity undertaken for leisure or transportation, categorized as "active" if ≥150 min/week and "inactive" if <150 min/week)[16], as well as a nutritional variable, Body Mass Index (BMI), calculated on the basis of self-reported weight and height and categorized as normal, overweight, or obese in accordance with World Health Organization definitions[17].

Data analysis

Data were tabulated in the EpiData software suite, using automated consistency checking and double data entry, and analyzed in Stata 11.0 in the following order: univariate analysis for description of the study population and crude analysis of independent variables versus each of the three outcomes (pain in upper extremities, trunk, or lower extremities). The prevalence of pain in each body segment was also assessed by work shift and stratified by sex.

Crude and adjusted prevalence ratios and their corresponding 95% confidence intervals were estimated by means of Poisson regression with a robust error variance using three models for men and women workers separately: model I—effect of job characteristics, no adjustment; model II—effect of job characteristics, adjusted for physical activity; and model III—effect of job characteristics, after adjustment for each other and for physical activity. Variables associated with exposure or outcome with $p \leq 0.20$ were considered to be confounders.

Results

Out of the 1,278 workers selected, 25 (2%) were pregnant at the time of the interview, and 47 (3.8%) were lost because they were dismissed or moved to another municipality not included in the study. There were no dropouts. In all, 1,206 workers were interviewed. For the purposes of this study, 103 employees who had worked at the plant for less than 12 months were excluded because the pain recall questionnaire referred to the 12-month period preceding study inclusion. Hence, the final study sample comprised 1,103 workers aged 18 to 52 years. This sample size enabled a statistical power of 80% for detection of an effect of job characteristics on musculoskeletal pain at a prevalence ratio of ≥1.5 and a 95% confidence level.

As shown in Table 1, the majority of participants were female workers (65.7%) who had a mean (SD) age of 30.8 (8.5) years, were living with a partner (69.2%), had a complete secondary education (48.1%), had a household income of R$1268.00 to R$1600.00 (26.4%), were physically inactive (63.8%), and had a normal BMI (64.7%). Most participants worked the night shift (66.3%; among them, 35.6% men vs. 64.4% women) and had been working the same shift for over 2 years (67.5%; 35.0% men vs. 65.1% women); 16.1% (37.6% men vs. 62.4% women) were exposed to extreme temperature conditions in the thermal processing sector.

Of the 1,103 workers interviewed, 43.5% (95% CI 40.6, 46.4) reported experiencing musculoskeletal pain in at least one of the assessed body segments "often" or "always" during the last 12 months. The overall prevalence of work-related musculoskeletal pain was 40.3% (95% CI 37.4, 43.2), which corresponded to 92.7% of all participants who reported pain. The upper extremities were the most commonly affected body area (31.9%; 95% CI 29.1, 34.7), followed by the trunk (17.1%; 95% CI 14.9, 19.4) and lower extremities (11.1%; 95% CI 9.3, 13.0).

Musculoskeletal pain in the upper extremities and trunk was more common in women than in men (Table 1). The prevalence of lower-extremity musculoskeletal pain was 47% higher in physically active participants than in inactive ones. Of the job characteristics assessed, temperature, shift, and time employed as a shift worker were associated with musculoskeletal pain. Higher prevalence was reported by participants who worked under extreme temperature conditions as compared with those who worked in temperatures ranging from 10ºC to room temperature (17.4 vs. 10.0%), by night shift workers as compared with day shift workers (12.6 vs. 8.3%), and by workers who had been working the same shift for >2 years as compared with those who had worked shifts for <2 years (12.5 vs. 8.4%).

Figures 1 and 2 show the prevalence of work-related musculoskeletal pain in each assessed body area by shift and stratified by sex. Among men, night shift workers reported higher prevalences of arm and forearm pain than day shift workers (8.9 vs. 2.5 and 5.0% vs. 0.9%, respectively) (Fig. 1). Among women, both day shift and night shift workers reported a high prevalence of shoulder pain (day shift: 22.4%: night shift: 24.4%). Night shift workers reported a higher prevalence of lower extremity pain (14.4 vs. 8.3% in day shift workers) (Fig. 2).

Tables 2 and 3 provides the crude and adjusted results for the association between job characteristics and lower-extremity musculoskeletal pain for male and female shift workers, respectively. Sector temperature revealed a statistically significant association with lower-extremity musculoskeletal pain for both sexes. After controlling for physical activity and job characteristics (model III), the prevalence ratios of lower-extremity musculoskeletal pain among workers employed in the extreme-temperature sector were 2.17

Table 1. Profile and prevalence of work-related musculoskeletal pain (upper extremity, trunk, and lower extremity) according to demographic, socioeconomic, behavioral, nutritional, and job-related variables for a sample of shift workers employed at a poultry processing plant in Southern Brazil (N=1,103)

Variable			Prevalence of musculoskeletal pain		
	N	%	Upper extremity	Trunk	Lower extremity
Overall	1,103	100	31.9	17.1	11.1
Sex			<0.001*	<0.001*	0.100*
Male	378	34.3	18.8	11.6	9.0
Female	725	65.7	38.8	20.0	12.3
Age (years)			0.555**	0.274**	0.307**
18–30	615	55.8	31.1	16.3	10.2
31–40	296	26.8	33.1	17.2	12.2
41–52	192	17.4	32.8	19.8	12.5
Conjugal arrangement			0.234*	0.964*	0.692*
No partner	340	30.8	29.4	17.1	10.6
Living with partner	763	69.2	33.0	17.2	11.4
Educational attainment			0.132**	0.454**	0.842**
1–4 years primary education	190	17.2	32.6	19.5	13.2
5–8 years primary education	289	26.2	36.0	17.0	10.0
Some secondary education	93	8.4	31.2	16.1	8.6
Complete secondary education or higher	530	48.1	29.4	16.6	11.5
Household income (quartile)***			0.646**	0.246**	0.688**
I (R$ ≤1,015.00)	259	23.8	31.3	18.9	12.0
II (R$ 1,020.00–1,265.00)	272	25.0	30.2	18.0	9.6
III (R$ 1,268.00–1,600.00)	288	26.4	32.3	15.3	10.1
IV (R$ >1,600.00)	271	24.9	32.5	15.9	12.9
Physical activity			0.473*	0.372*	0.022*
Inactive	704	63.8	32.7	17.9	9.5
Active	399	36.2	30.6	15.8	14.0
Body Mass Index			0.256**	0.842**	0.555**
Normal	714	64.7	33.1	17.4	11.9
Overweight	284	25.8	30.3	16.6	8.8
Obese	105	9.5	28.6	17.1	12.4
Sector temperature			0.308*	0.232*	0.004*
10ºC–room (cutting/evisceration)	925	83.9	32.5	17.7	10.0
Extreme (thermal processing)	178	16.1	28.7	14.0	17.4
Duration of shift work			0.291*	0.339*	0.042*
≤2 years	358	32.5	34.1	18.7	8.4
>2 years	744	67.5	30.9	16.4	12.5
Shift			0.234*	0.643*	0.034*
Day	372	33.7	29.6	16.4	8.3
Night	731	66.3	33.1	17.5	12.6

*Chi-square test for heterogeneity of proportions. **Test for linear trend. ***This variable had the greatest number of missing values (13).

(95% CI 1.12, 4.22) and 1.83 (95% CI 1.27, 2.65) in men and women, respectively. The other job characteristics were significantly associated with lower-extremity musculoskeletal pain only in female workers (Table 3). The prevalence ratios for lower-extremity musculoskeletal pain were 1.64 (95% CI 1.03, 2.62) for female night shift workers and 1.69 (95% CI 1.05, 2.70) for those who had worked the same shift for >2 years.

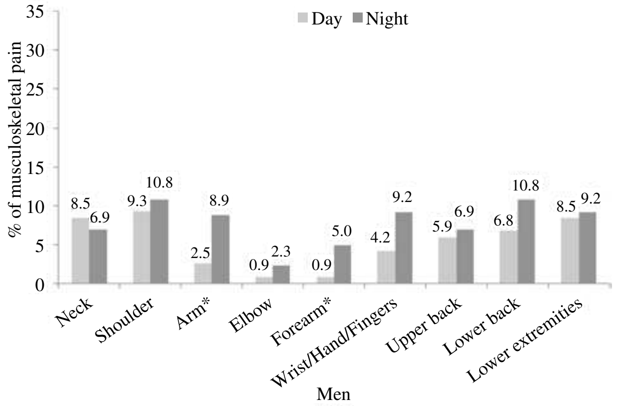

Fig. 1. Prevalence of occupational musculoskeletal pain, stratified by affected body area and work shift, among male shift workers at a poultry processing plant in Southern Brazil (n=378). *$p<0.05$, chi-square test for the association between work shift and musculoskeletal pain.

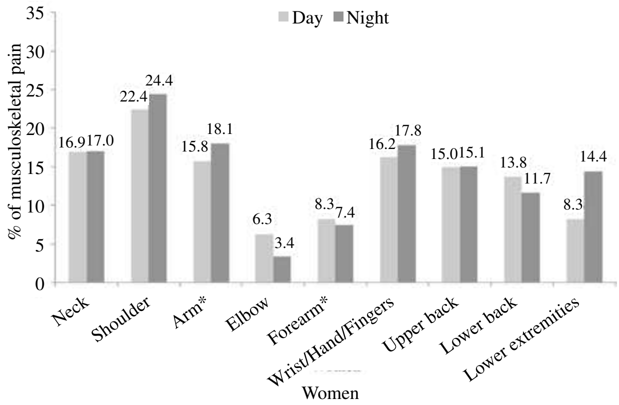

Fig. 2. Prevalence of occupational musculoskeletal pain, stratified by affected body area and work shift, among female shift workers at a poultry processing plant in Southern Brazil (n=725). *$p<0.05$, chi-square test for the association between work shift and musculoskeletal pain.

Table 2. Prevalence ratios (PR) and 95% confidence intervals (95% CI) for the association between job characteristics and lower-extremity musculoskeletal pain by statistical model in male shift workers (N=378)

Variable	Model I		Model II		Model III	
	PR	95% CI	PR	95% CI	PR	95% CI
Sector temperature						
10ºC–room (cutting/evisceration)	1		1		1	
Extreme (thermal processing)	1.93	0.97–3.86	1.98	1.01–3.87	2.17	1.12–4.22
Duration of shift work						
≤2 years	1		1		1	
>2 years	1.09	0.54–2.21	1.09	0.54–2.21	1.29	0.64–2.58
Shift						
Day	1		1		1	
Night	1.09	0.54–2.21	1.09	0.54–2.22	1.16	0.58–2.31

Model I: effect of job characteristics, no adjustment. Model II: effect of job characteristics, adjusted for physical activity. Model III: effect of job characteristics, after adjustment for each other and for physical activity. Variables associated with outcome or exposure with a significance level of $p\leq0.20$ were kept in the model as potential confounding factors.

Discussion

This study revealed an association between job characteristics and lower-extremity musculoskeletal pain, even after adjustment in multivariate models, with approximately twice the probability of pain among participants who worked under extreme temperature conditions. Higher prevalence of musculoskeletal pain in the upper extremities and trunk was reported by women as compared with men, regardless of job characteristics. Night shift work was associated with musculoskeletal pain in the arm and forearm among men and in the lower extremities among women.

Regarding the greater prevalence of upper-extremity pain, other studies have reported similar findings[18–20]. One potential mechanism of this would be the monotonous and highly repetitive nature of upper-body movements in this type of work[2, 21–23].

Furthermore, as in previous studies[10, 19, 23], a higher prevalence of musculoskeletal pain was reported by women, particularly in the shoulders[2]. This association was independent of shift, as was also reported in a previous study[10]. Women exhibit distinct biologi-

Table 3. Prevalence ratios (PR) and 95% confidence intervals (95% CI) for the association between job characteristics and lower-extremity musculoskeletal pain by statistical model in female shift workers (N=725)

Variable	Model I		Model II		Model III	
	PR	95% CI	PR	95% CI	PR	95% CI
Sector temperature						
10ºC–room (cutting/evisceration)	1		1		1	
Extreme (thermal processing)	1.71	1.09–2.67	1.65	1.05–2.57	1.75	1.12–2.71
Duration of shift work						
≤2 years	1		1		1	
>2 years	1.71	1.07–2.75	1.76	1.10–2.81	1.69	1.05–2.70
Shift						
Day	1		1		1	
Night	1.75	1.10–2.78	1.66	1.04–2.65	1.64	1.03–2.62

Model I: effect of job characteristics, no adjustment. Model II: effect of job characteristics, adjusted for physical activity. Model III: effect of job characteristics, after adjustment for each other and for physical activity. Variables associated with outcome or exposure with a significance level of $p \leq 0.20$ were kept in the model as potential confounding factors.

cal differences that contribute to the occurrence of work-related musculoskeletal pain, such as lower bone mass, lower muscle resistance (approximately 30% lower than that of men), and greater joint instability.

In this study, workers considered physically active reported a lower prevalence of musculoskeletal pain as compared with physically inactive workers, although this association was found only on crude analysis. According to some authors, continuous high-intensity physical exercise leads to the production of free radicals, which lead to cell membrane changes and, consequently, cell injury, which is followed by inflammation and pain[24, 25]. This inflammation is usually repaired after exercise. However, when demands on muscle tissue continue, repair processes are not triggered; this leads to chronic injury[26]. Such damage is explained by four key factors: high levels of stress induced by continuous activity, changes in microcirculation, production of toxic metabolites, and intramuscular depletion of energy substrates[24–26].

The association between lower-extremity musculoskeletal pain and job characteristics, such as day or night shift, has not been the subject of extensive study[10, 11, 27]. However, some research has expounded on static overload as a potential source of musculoskeletal conditions[28]. In this study, the night shift had an effect on pain in the lower extremity pain but not in the other body segments. Our hypothesis is that there is an effect of night shift on lower extremity pain due to the standing position adopted by workers during their work activities. Static overload plus a smaller number of hours of sleep at night can lead to a shorter time for recovery of damage caused by this position. This is applicable to the female workers assessed herein--women who carried out their duties while standing and who, due to their poor sleep schedules, may have had less time available to recover from the damage caused by prolonged standing, considering that women often perform double duty in the workplace and as homemakers. The lower-extremity pain may have been caused by three mechanisms: a circulatory deficit, musculoskeletal microtrauma, and joint overload. Regarding circulatory deficit, prolonged standing is known to require prolonged contraction of the lower extremity muscles, which increases pressure on veins and arteries, thus hindering blood flow and, consequently, reducing transport of nutrients vital to proper cell function, forcing muscle tissues to use up their stores of (mostly) oxygen and glucose. Furthermore, standing leads to a generalized impairment of lymphatic circulation, thus causing a tissue buildup of fluid products of the biochemical process of muscle contraction, which leads to muscle pain and fatigue. Some studies[29, 30] have reported that venous return in the late afternoon was reduced as compared with that measured in the early morning, which might be explained by a larger blood volume in the lower extremity veins after a prolonged period of standing upright. This is due to venous distension, which pushes venous valve cusps apart, rendering them less competent. Another factor that may contribute to a circulatory deficit in the lower extremities is gravitational pressure, which, according to Belczak *et al.*[31], interferes with filtration and absorption of tissue fluids. Daily performance of job duties leads to excessive exposure to gravitational pull, which worsens venous hypertension. The body reacts in response to this stressor, potentially altering the integrity of vessel walls and local control mechanisms that modulate vasodilation, which, consequently, may lead to impairment of the physiologic anti-gravitational pressure system[31].

The second mechanism occurs because the lower extremity muscles must remain in isometric contraction for prolonged periods for the individual to remain standing. The resulting microtrauma, which is due to a lack of substrate for production of adenosine triphosphate (ATP, a molecular energy source required for muscle contraction), triggers degradation of structural skeletal muscle proteins, leading to cytoskeletal damage with consequent pain[26].

The last mechanism implicated in musculoskeletal pain is joint overload. When a joint is subjected to excessive strain due to prolonged standing, its surrounding tendons, muscles, and ligaments distend, producing discomfort and painful microtrauma. Joint overload in the lumbar spine area may lead to bone wear and degenerative intervertebral disc changes, producing sciatic nerve compression and, consequently, pain, numbness, and heaviness in the lower extremities[32].

According to Smit *et al.*[28], prolonged orthostatic stress requires additional adjustments, involving arterial and cardiopulmonary mechanoreceptors, which, in turn, are controlled by regulatory hormones. The synthesis of these hormones takes place under the influence of melatonin and cortisol, which are produced in greater quantities during nighttime sleep[4]. Therefore, one may infer that night shift workers are exposed to circadian rhythm changes that have direct effects on hormonal control, thus leading to organizational deficits in other body systems, such as the musculoskeletal system. In our study, this effect was more evident among female workers than in male workers. Although not statistically significant, the prevalence of pain in male night shift workers was higher than in male day shift workers. So, we emphasize that the prevalence of pain in the lower extremity was low; furthermore, the population of men in the plant investigated was approximately half the population of women, which may have affected the analyses in this group when stratification per shift was performed.

In the present study, workers exposed to extreme temperature conditions in the workplace—above 40ºC or below 10ºC—reported a higher prevalence of lower-extremity musculoskeletal pain. This finding is consistent with those reported by Soares *et al.*[33], who found that extreme-temperature conditions were perceived by workers as an occupational hazard. Soares *et al.*[33] also note that "extreme temperatures" are one of the factors regarded by the Brazilian Ministry of Health as a physical hazard in the workplace. Regarding exposure of workers in the food processing sector to sudden temperature changes, studies such as that by Fassa *et al.*[34] show that these changes are perceived by workers as an influential burden on their quality of life. The literature reports that the physiological adaptation capabilities of the human body may be limited at extreme temperatures. These temperature conditions lead to imbalanced homeostasis, the effects of which are metabolic derangements such as excessive cytokine release, increasing inflammation in the skeletal muscles and negatively impacting tissue repair.

Regarding low-temperature conditions in the workplace, some studies have found that workers employed in sectors where ambient temperatures are extremely low reported a greater prevalence of musculoskeletal pain[35, 36], particularly in the lower extremities[35]. The relationship between pain and extremely low temperatures may be attributable to excessive contraction and increased metabolism of the skeletal muscles in an attempt to generate heat and protect the body from the aggressive effects of a cold environment. Continued exposure to these extreme conditions may lead to painful muscle contractions, as well as to blood vessel damage due to increased blood pressure.

As for the association between musculoskeletal pain and high temperatures, an experimental study that assessed pain in two groups of individuals, one subjected to intramuscular infiltration with warm saline solution and one subjected to infiltration of cool saline solution, found that the former reported greater muscle pain[37]. The greater prevalence of lower-extremity musculoskeletal pain at extremely high temperatures may be explained by the fact that physical labor in intense heat requires greater blood flow to the skeletal muscles, which increases their oxygen and nutrient demand; furthermore, in hot conditions, blood flow is redirected to the skin surface to enable heat exchange through perspiration, which places substantial additional strain on the heart[38].

Within this context, the association found between longer time spent employed in shift work and musculoskeletal pain in women may be explained by the length of exposure to the abovementioned factors, such as extreme temperature conditions and muscle and joint overload, and the physiological changes induced by reversal of the sleep–wake cycle[39].

Some limitations should be taken into account when interpreting the findings of this study. The cross-sectional design employed provides an overview of the current situation but cannot establish a temporal causal relationship. This limitation must be considered when assessing the potential association between self-reported musculoskeletal pain in the last 12 months and onset of job activity. Another limitation concerns the site and frequency of self-reported pain. Site of pain was classified into broad body segments that did correspond to distinct muscle groups, which might have provided a more specific estimate of the origin of pain. Regarding frequency, it bears noting that self-reported pain scales are widely used in the assessment of musculoskeletal pain[2, 9–11], despite their reliance on respondent recall. Nevertheless, the relationship between musculoskeletal pain and work-related activities depends on each participant's opinion, and overestimation cannot be ruled out. Furthermore, ambient temperatures in each sector of the production line were not measured but instead were based on information provided by the company, and thus they may not have reflected the actual average temperatures in each of the assessed sectors. Finally, only workers active at the time of the study were included in the sample; therefore, the true prevalence of work-related musculoskeletal pain may have been underestimated due to the healthy worker effect[8, 39].

Despite these limitations, the findings reported herein are important given the dearth of studies about musculoskeletal pain in shift workers. Furthermore, most prior studies into this topic used small sample sizes and heterogeneous populations, with participants from a variety of occupations, which limits the accuracy of their estimates and precludes comparison of their results.

In conclusion, the present study found a high prevalence of musculoskeletal pain among shift workers at a poultry processing plant. Musculoskeletal pain was associated with job characteristics, especially among women, and was worst in night shift workers, in those who had been employed in shift work for longer, and in workers exposed to extreme temperature conditions. Shift work is becoming an increasingly widespread practice as industries seek to achieve their production goals. However, prolonged standing in night shift workers places excessive strain on the muscle system and may lead to chronic musculoskeletal pain. Potential solutions that could mitigate this effect include changing positions frequently during work and the implementation of rest breaks. Takahashi *et al.*[27] found that night shift nurses who took rest breaks of approximately 1 hour reported a 50% reduction in the prevalence of musculoskeletal pain. Rest or nap breaks help lower gravitational pressure, improving venous return, reducing edema, and relieving pain[28], and thus improve worker quality of life. Another potential mitigating measure is the implementation of a workplace exercise program, involving stretching and relaxation exercises during mandatory, organized breaks over the course of the working day. Such programs have been proven to have positive effects in terms of pain reduction, as reported in a systematic review[40]. Therefore, targeted measures geared toward these aspects may have a role to play in the prevention of musculoskeletal conditions, with consequent reductions in absenteeism, improvement of worker self-esteem, and enhancement of worker motivation, which, in turn, can increase corporate productivity and reduce healthcare expenditures.

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