International Journal of
Occupational and Environmental Safety

Factors contributing to low back pain in workers involved in prolonged standing occupational requirements

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Article History

Received November 02, 2022
Accepted June 06, 2023
Published August 02, 2023

Keywords

Low Back Pain
Rapid Entire Body Assessment
Occupational repetitive actions
Foot Posture Index
Work-related musculoskeletal disorders

DOI:
10.24840/2184-0954_007-001_001904

ISSN:
2184-0954

Type:
Research Article

Open Access
Peer-Reviewed

Abstract

Nearly half of all employees worldwide are required to stand for more than 75% of their workdays. Prolonged standing is an occupational risk factor giving rise to numerous complications, especially Low Back Pain (LBP). The present study assesses factors contributing to LBP in occupations requiring prolonged standing. A cross-sectional analytical study was conducted on 135 workers in occupations requiring prolonged standing with or without complaints of LBP. Back pain status, working posture, repetitive actions, core strength, flexibility, and foot posture were assessed. Statistical analysis was done using Spearman's correlation coefficient with alpha set at $p \leq 0.05$ at a 95% confidence interval (CI), and logistic regression analysis was performed to find the odds ratio (OR). A significant correlation was observed between the back pain status with working posture and the foot posture. The percentage of prolonged standing time, repetition, core strength, and flexibility did not show any correlation with back pain status. Work posture and foot posture are major contributing factors in causing LBP in workers involved in prolonged standing occupations.

1. INTRODUCTION

Work has a significant impact on the lives of individuals, businesses, and society. Almost 66% of the total population works 33% of the time (Marras, 2006). Globalization and rapid industrial growth in recent years have resulted in a surge in numerous occupational health-related disorders and injuries, with the International Labour Organisation (ILO) estimating that 40% are attributable to Musculoskeletal Disorders (MSDs) (Saiyed et al, 2004). According to the WHO, LBP accounts for 37% of all occupational risk factors (Bindra et al., 2015). Occupational LBP is defined as work-specific LBP and is classed as accidental and non-accidental LBP under workmen's compensation legislation established by the Ministry of Labour in 1976. The accidental LBP is caused by an unexpected event occurring during the task that injures the muscle, tendon, ligament, and soft tissue (strains or ruptures) in the back, whereas the non-accidental injury is caused by normal activities and task requirements, and poor body mechanics, prolonged activity, repetitive motions, and fatigue are major contributors to injuries. The majority of WRMSDs are caused by a combination of work-related, non-work-related, and individual factors that are likely to contribute to the development of LBP, indicating the need of considering both elements when addressing and preventing the problem (Norasteh, 2012; Riihimäki, 1991). Rapid work pace and repetitive motion patterns, insufficient recovery time, heavy lifting and other forceful manual exertions, non-neutral body postures (either dynamic or static), mechanical pressure concentrations, vibration (both segmental and whole-body), and low temperature are the physical ergonomic features of work that are most frequently cited as MSD risk factors (Punnett, 2005). Individual risk factors include constitutional, postural-structural, psychological, and demographic characteristics, among others (Norasteh, 2012; Riihimäki, 1991).

Almost half of the employees are required to stand for more than 75% of their workdays (Human Factors and Ergonomics Society, 2015). Retail staff, assembly line workers, printing sector, security staff, on-site engineers, catering staff, fuel pump workers, library assistants, hair stylists, and laboratory technicians, among others, require prolonged standing (Punnett et al., 2005). Lis et al. (2007) investigated the relationship between sitting and LBP. However, because of the heterogeneity in task demands, the variables causing LBP in employment requiring standing will change significantly (Kwon et al., 2011). Prolonged standing is defined as standing for more than 50% of a workday without the ability to sit or walk during the work shift (Halim et al., 2012), which is repeated multiple times per week (Meijsen and Knibbe, 2007). Tasks that require prolonged standing cannot be performed efficiently in a seated or any other position. Prolonged standing (which is a static posture) in itself, is considered to be an occupational risk factor giving rise to various complications like MSDs and varicose veins, LBP being one of them (Gallagher and Callaghan, 2015; Capodaglio, 2017). Despite their significant global effect and prevalence, WRMSDs, particularly LBP, are not given the attention they deserve by the medical profession, legislators, or the media, and are not seen as a national health priority (Wu A et al., 2020). This is because WRMSDs are believed to be less dangerous than cardiovascular illnesses, diabetes, AIDS, and cancer among others, whereas WRMSDs are primarily chronic, nonfatal ailments that are seen as a result of ageing (Castillo and Lieberman, 2015). Furthermore, blue-collar/ informal employment workers are at risk of injury on the job due to continual contact pressures and fewer or no health insurance protections given by employers. According to clinical data, only 25% of patients report having totally healed from LBP after one year, with 90% quitting to contact their doctor about symptoms after three months. Within one year, 24-50% of subjects report LBP recurrence (Halim et al., 2011). Energy expenditure and muscle fatigue is more in standing than sitting (Amaro-Gahete, F. J. et al., 2019); also standing would be less stable and higher COG (Gardiner DM., 1953) Thus putting them at more risk like accidents or injuries at work than the ones who have desk jobs.

In clinical practice, improving muscle strength, particularly core strength, and flexibility, is the "go-to" treatment for LBP. While this may help alleviate the current disability, extrinsic factors such as the number of hours spent in static posture, body posture while doing work, the number of repetitions, and manual materials handling should be considered when diagnosing and treating the patient for a more "permanent solution". When WRMSDs arise, individual fitness levels, particularly health-related fitness, and the ability to act as a protective shield against work-related risk factors should be evaluated. Furthermore, most studies on occupation and related topics focus primarily on assessing factors such as job task requirements, job working environment, and individual factors such as job satisfaction, addictions, and so on, but there is a scarcity of studies that assess both extrinsic (work and work site related) and intrinsic (worker related) factors at the same time. It is critical to know why it recurs more frequently for some people or never resolves (Richmond, 2012). The current study focused on both extrinsic factors such as standing time, upper limb repetitions, and intrinsic factors such as lumbar core muscle strength, and thoracolumbar fascia and hamstring flexibility, and foot posture. Posture attained at work is a combination of both the factors.

2. METHODOLOGY

Following clearance from the institutional ethical committee, an analytical cross-sectional study was carried out.

The G-Power software was used to calculate the sample size for non-parametric data using Spearman's correlation for the Biserial model under the t-test family. The effect size (P) for two-tailed with Alpha < 0.05 at 95% power was calculated as 0.3 (medium effect for correlation). As a result, the projected sample size was 134, while the actual samples analyzed were 135. The study used a mixed sample set for analysis since the groups were chosen to be comparable internationally regarding physical demands.

Randomization of a purposive sampling from petrol pumps (gas stations), hairdressers (barbers), and printing machine operators was done. Petrol pump attendants operate at filling stations or garages where petrol is supplied to the customers' vehicles. Hairdressers shape, color, straighten, and permanently wave hair, shave or trim facial hair, and treat scalp conditions. A printing machine operator is a trained individual who produces printed items by following printing job specifications, setting up, operating, modifying, and maintaining the printing equipment. Each of these vocations had 45 samples evaluated.

Workers between the ages of 20 and 40 with at least two years of experience and working in prolonged standing employment (standing for more than 50% of their working time) were recruited for the study to exclude potential confounders. The study's exclusion criteria were working less than 25 hours per week and having LBP pain of more than seven of 10 on the numerical pain rating scale (NPRS) within 24 hours.

Subjects were explained about the study, and consent was obtained.

The subjects' demographic data was collected. The Nordic Musculoskeletal Pain Questionnaire - Low back trouble questionnaire was filled in an interview session that noted people with and without LBP (Tan et al., 2014; Takekawa et al., 2015; Crawford, 2007; Svensson et al., 2009). The ones who had experienced low back trouble answered the further questions. Variables such as risky and major demand posture obtained during work (working posture), repetitions of the upper limb from the task performed, lumbar core muscle strength, flexibility of hamstrings and thoracolumbar fascia, and foot posture were assessed.

The data was collected over a duration of 18 months. The study was designed according to the strengthening of the reporting of observational studies in epidemiology (STROBE) guidelines and made use of several tools.

The rapid entire body assessment (REBA) analysis was applied to assess the different risk postures, such as in Figure 1 (Hignett and McAtamney, 2000; Al Madani and Dababneh, 2016; Syahril and Sonjaya, 2015).

Figure 1. Risk posture assessment at work

The assessment of repeated activities that require applying force (Figure 2) and while handling load (Figure 3) was made using the occupational repetitive actions (OCRA) checklist (Paulsen, 2013; Colombini, 2013; Occhipinti and Colombini 2005; Rhén et al., 2015).

The dial sphygmomanometer was used to assess lumbar core muscle strength using a dial sphygmomanometer (Figure 4) (Helewa et al., 1981; Von Garnier et al., 2009; Richardson et al., 2004; de Paula Lima et al., 2011; Lima et al., 2012).

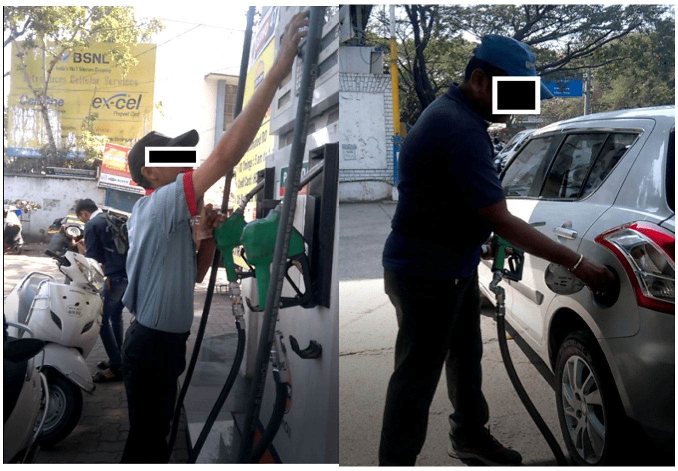

Figure 2. Repeated activities that use force

Figure 3. Repeated activities that require load handling

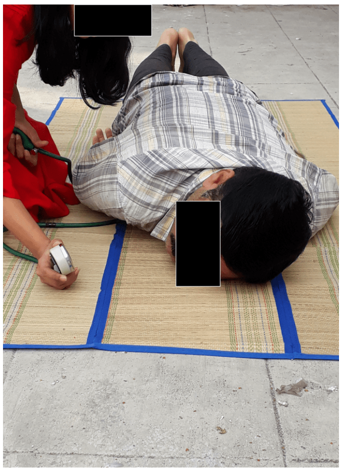

Figure 4. Core muscle strength assessment

The hamstrings and thoracolumbar fascia flexibility was evaluated using YMCA sit-and-reach test (Figure 5) (Chung and Yuen, 2011; American College of Sports Medicine, 2013).

The foot posture index (FPI-6) was used to determine the foot posture (Figure 6) (Redmond et al., 2006; Evans et al. 2012; Redmond et al., 2005).

All collected data were entered into an Excel sheet, tabulated, and put forth for statistical analysis. The analysis was carried out using a statistical package for social sciences (SPSS) software version

17.0. Statistical measures such as Mean, Standard Deviation, and Spearman's correlation coefficient were used P≤0.05.

Figure 5. YMCA sit-and-reach test

Figure 6. Foot posture assessment

Statistical tests were applied to look for a correlation between LBP (as answered in 12 months prevalence rate) and factors such as percentage of standing time, working posture, repetitions of the upper limb, lumbar core muscle strength, flexibility, and foot posture. A logistic regression analysis was conducted to identify factors that may contribute to developing low back pain in people exposed to prolonged standing in their respective occupations (Odds Ratio). The predictive model was achieved.

3. RESULTS AND DISCUSSION

The present study included a total of 135 subjects: the male-female ratio was 127:8. The LBP ratio (Yes: No) found in the present study was 72:63. The mean body mass index (BMI) was 22.42 kg/m^2, as seen in Table 1.

The results showed a mild correlation between LBP, working posture, and foot posture (individual characteristics). Percentage of standing time, movement repetitions, lumbar core muscle strength, and flexibility showed no correlation with LBP.

The odds ratio showed that when the REBA score is raised by one unit, the odds ratio is 2.17 times as large, and, therefore, people with faulty posture, as indicated by an increase in REBA by 1 point, are 2.17 times more likely to develop low back pain. Similarly, prolonged standing, In a similar way, interpretation for other mentioned factors can be made.

According to reports, musculoskeletal problems are the costliest type of work disability out of all work-related ailments and diseases and are on the rise (Kumar et al., 2013;

Yasobant and Rajkumar, 2014). According to studies by Kumar et al. (2013) and Bindra et al. (2015), 48% of patients who visit a general practitioner have WRMSDs, with LBP accounting for the largest number. Because LBP causes discomfort while working or job absence and raises the financial burden of treatment and compensation, it generates socio-economic losses, health difficulties, and clinical issues at the individual and national levels (Norasteh, 2012).

LBP has been linked to more than a hundred risk factors (Bindra et al, 2015). Due to individual variances, varying vocations, and varying health statuses, it is difficult to determine the specific cause of LBP without making an accurate and cautious assessment. The study results of low back pain with association to other factors are summarized in Table 2.

Table 1. Comparative analysis between different groups

Total number of subjects	135
Number of subjects per job	45
Age (in years)	30.15 (±4.21)
Male: Female ratio	127:8
Body Mass Index (kg/m^2)	22.42 (2.95)
LBP Ratio (Yes: No)	72:63

Table 2. Low back pain with associated factors

Outcome Measure Mean (SD)	**Low back pain**		
	r	p	OR (95% CI)
Percentage of standing time 84.84 (4.99)	0.017	0.849	1.013 (0.920-1.115)
Posture (REBA) 8.52 (0.998)	0.351	0.000*	2.279 (1.463-3.549)
Repetitions (OCRA) 96.84 (56.72)	0.114	0.188	1.007 (0.998-1.015)
Lumbar core muscle strength 69.57 (0.89)	0.138	0.111	0.563 (0.235-1.345)
Flexibility (inches) 12.25 (2.26)	0.111	0.2	0.934 (0.785-1.110)
Foot Posture (FPI-6) 4.84 (4.82)	0.258	0.003*	1.154 (1.057-1.261)

r= Spearman's correlation coefficient

OR: Odds Ratio

3.1 Posture as a risk factor for LBP

The REBA ergonomic tool further identified and analyzed the posture with the highest risk.

It revealed a weak relationship between the working posture and LBP. The odds ratio showed that the odds ratio increases by 2.17 times when the REBA score increases by one unit, indicating that those with poor posture, as indicated by a rise in REBA of one point, are 2.17 times more likely to experience low back discomfort. Some of the riskiest postures seen in the subjects included filling ink cartridges, loading paper, washing and cutting hair, filling gasoline for trucks, and filling gasoline/ CNG in a rickshaw. High-risk scores imply that the underlying cause of the posture should be addressed and that the appropriate change has been made. The posture could be adopted due to the requirements of the specific task, because of the workstation arrangements, or one's preference of that posture, or in a combination of all the reasons mentioned.

Sustained and/or repetitive forward bent posture, which the worker had to attain, not only fatigues the extensor musculature due to excessive force to complete the same amount of work in comparison to working in a neutral posture but also eccentrically overloads them, leading to ischemia and strain, thus, predisposing to the development of myofascial trigger points in low back muscles (Kumar et al., 2013; Gangopadhyay et al., 2010). Furthermore, there is constant compression of the intervertebral disc, which alters the moment of force required in the lumbar region, which in turn affects muscle loading and causes mechanical disadvantage of the muscles, thereby accelerating disc degeneration and eventually leading to disc herniation (Das et al., 2013). Workers with a history of LBP are more likely to sustain spinal tissue injury, according to research, because they have increased co-contraction of spinal muscles, which has been linked to the interaction of a non-linear reduction in tissue load tolerance over time, contributing to lumbar micro-rupture (Ribeiro et al., 2012).

3.2 Foot posture as a risk factor for LBP

This study assessed foot posture using Foot Posture Index (FPI-6). The subjects were on their feet for over 80% of the time they worked. The present study showed that alteration of foot posture (pronation of feet) is associated with LBP, and it is statistically significant. When the FPI score changes by one unit, the odds ratio increases by 1.13 times, indicating that patients with altered foot posture, as indicated by a one-unit change in FPI, are 1.13 times more likely to develop LBP. Patients with pronated feet have higher vertical ground reaction force and loading rate (Farahpour et al., 2016).

It is suggested that aberrant foot pronation, in which the limb acts as if it were shorter, causes greater internal rotation of the leg and an ipsilateral pelvic tilt. This may increase the load on various pelvic muscles, including the iliopsoas, piriformis, and gluteal muscles, resulting in the rotation of the afflicted lumbar vertebral body. To reduce the stress on the iliopsoas, a backward lean will be produced by active contraction of the erector spinae, presumably resulting in muscle fatigue (Menz et al., 2013). Foot posture and function have also been linked to low back pain, with some authors claiming that those with low back pain are more likely to have pes planus (low-arched or pronated) feet (Betsch et al., 2011). The Foot, on the other hand, not only responds to ground pressures but also imposes forces from the spine, pelvis, hip, knee, and ankle. Lower back postural muscle weakness and mechanical LBP are related to reduced ankle range of motion and increased navicular drop. This makes determining whether foot deviations are the cause or the result of LBP challenging. However, it is widely assumed that abnormal mechanical characteristics of the lower limbs are closely related to functional and mechanical problems (Betsch et al., 2011).

3.3 Task repetition as a risk factor for LBP

In this study, task repetition was assessed using OCRA. According to literature, an activity is considered repetitive if at least 50% of the work cycle comprises comparable motion patterns that were observed in the given population (Silverstein et al., 1986). Studies have discovered a link between repeated activities and LBP, which may be explained by two principles: one is proximal-distal, and the other is through the motor program. When a worker performs upper limb movement, the muscles are sequentially activated, which continues throughout the working time, resulting in intervertebral loading and muscular fatigue, which leads to LBP (McMullen and Uhl, 2000).

The population under study required high repetitions in their tasks, such as entering the amount and litre on the screen, lifting the nozzle and placing it back every time while filling petrol, collecting money; and washing, cutting, and smoothing the hair which the hairdresser had to maintain the arm position at shoulder level and work with more hand skills. Loading the paper, checking the ink, aligning the paper, and reviewing the job results were all repetitive tasks for printing machine operators. According to the classification of the OCRA checklist, the workers come under the purple category and are in a high-risk zone. However, there was no link with LBP; this could be because the break duration was adequate to counteract the load exerted on the joint. Furthermore, repetitive jobs necessitate a combination of static and rhythmic muscle activity, which would have washed out pain-causing metabolites while the employees were still in the subclinical phase to demonstrate the effect of the task requirement (Ghosh et al., 2011).

3.4 Core muscle strength as a risk factor for LBP

In the present study, core strength was assessed using a dial sphygmomanometer. It was determined that there was no correlation between lumbar core muscle strength and LBP. One reason is that these workers were normal subjects with and without moderate pain intensity and still did not exceed their clinical threshold limit. Therefore, core muscle strength did not correlate with LBP. Also, the transverse abdominis muscle, which is regarded as an essential component of the core due to its stabilizing effects and has few of its attachments to the thoracolumbar fascia and lumbar spinous process, may have contributed to the lack of LBP symptoms. They are constantly working when any action is being conducted (Wang et al., 2013).

Various studies have reported core weakness as an explanation for LBP for a variety of reasons, the most important of which are: it is essential for correct force distribution and maximum force generation with minimal compressive, translational, or shearing forces at the kinetic chain joints (Akuthota et al., 2008). The stability of the spine is dependent not only on muscular strength but also on proper sensory input, which alerts the central nervous system about the interaction between the body and the environment, providing constant feedback and allowing movement enhancement, as explained by Panjabi's model of core stabilization by passive, active, and neural control (Akuthota et al., 2008). The surrounding musculature is critical for core stability and is a key target of rehabilitation and injury prevention programs; thus, analyzing them allows you to comment on how it works in detail. According to a meta-analysis conducted by Xue-Qiang W et al. (2013), strengthening or weakening of these muscles does not appear to improve pain levels or impairment in LBP participants. They determined that it is most likely related to alterations in neural activation of lumbar muscles and psychological factors affecting pain tolerance.

3.5 Flexibility as a risk factor for LBP

In this study, flexibility was assessed using the YMCA sit and reach test. The maximal range of motion of a joint or series of joints is commonly used to define flexibility (Mayorga-Vega et al., 2014). The results demonstrate no correlation between hamstring flexibility and LBP. The occupational requirements chosen for this study could not indicate tightness because either the hamstrings or the thoracolumbar fascia might be extended at some point. Furthermore, assessing the population's flexibility in standing could have aided in better understanding the component.

Both the thoracolumbar fascia and the hamstrings have been proposed as risk factors for LBP. The thoracolumbar fascia is essential for the muscles involved in the spinal column, posture, load transfer, and respiration. Tensional dysfunction caused by static posture and the thoracolumbar fascia transmits pain signals to the spinal cord neurons, resulting in LBP. When the fascia is not in its usual physiological state, i.e., when it is tight, normal fascial receptors can transform into nociceptors, resulting in more complex symptoms (Bordoni et al., 2014). The hamstrings' flexibility is diminished due to poor posture and a lack of full-range muscle activity, which contributes to LBP. When the hamstrings are tight, they pull the pelvis backwards, causing lumbar lordosis to decrease, resulting in biomechanical abnormalities in the pressure distribution of the spine and spinal diseases (Reis and Macedo, 2015; Bordoni et al., 2014). Changes at the level required to cause LBP would not have reached the population investigated.

3.6 Prolonged standing as a risk factor for LBP

Prolonged standing was defined in this study as standing for more than 50% of one's working time. The majority of the participants had a higher percentage of standing. The lack of a correlation between the percentage of standing time and LBP may be because there was a shortage of standard tools used in the literature review for assessing standing duration and its effects, and the range of standing time among workers was limited. Standing for an extended period increases the risk of LBP due to excessive co-activation of postural stability muscles (Marshall et al., 2011). Many muscles, especially the back muscles, are always tense during standing labor. The intramuscular pressure in these muscles is greater than the blood pressure. The blood supply to the muscles is hindered when functioning under such stress. Initially, there is fatigue and muscle soreness, which might occur in minutes. If limits are consistently exceeded, irreversible changes in muscle tissue might happen, and tolerance for fatigue can decrease, resulting in low back discomfort (Gallagher et al., 2015). The vertebral body resists most of the compressive stress acting down the long axis of the spine, while the neural arch protects the spinal cord and offers attachment points for muscles and ligaments. Because the nucleus pulpous behaves like a pressurized fluid and causes tensile 'hoop' stresses on the annulus, severe compressive loading of the spine can result in annular tensile collapse. The endplate or the trabeculae right behind it are the most commonly damaged areas. Compressive damage caused by recurrent loading may be a common occurrence in life. Localized stress concentrations caused by disrupted tissues can be unpleasant. Microscopic damage would build most quickly in heavily stressed tissues with a weak blood supply and a low metabolic rate, such as discs or tendons (Adams, 2004).

Confounders and challenges faced in the study (limitations) were that different departments were not evaluated separately, the pattern of the work was not taken into consideration due to variations in the work demands, core strength could have been assessed in functional position, nutritional status or dietary habits were not considered, internal factors like bone mineral density (BMD), Vitamin D and Vitamin B12 levels were not assessed. The study can be further proceeded by finding an association between various psychological and psychosocial factors, individual task-wise assessment to find the risk of each task, comparing factors with and without LBP respectively, and comparing between the occupations will give an insight as to which factors are contributing to the LBP in a different occupation, long term study can be conducted by giving an intervention to these workers in the form of group exercises, ergonomic education, and safety at work; to minimize the pain and disability. Knowing about the health care use and sick leave attributable to musculoskeletal problems will add more value than just knowing the risk factors (IJzelenberg and Burdorf, 2005). Psychosocial risk factors reported in the literature include stress, anxiety, negative emotions, and depression. It has also been suggested that work-related psychosocial factors like high work demands, poor peer support, and low control over the work may increase the danger of LBP. A recent study reported that these work-related psychosocial factors (high work demand and low job control) are associated with a new episode of LBP, but only if workers were exposed to increased physical demand at work. It is also accepted that a history of LBP is the most powerful predictor of a fresh episode of LBP in the future (Ribeiro et al., 2012). Thus, this study implies that the factors like postures (including foot posture), repetitions, core strength, flexibility, and other factors like BMI and psychological and psychosocial factors should also be considered while treating workers at work. Understanding the contributing factors for LBP will help in generating a preventive-based philosophy. It will also help eliminate the risk and contributing factors to ensure a safe and productive workplace. As the prevalence of occupational LBP is higher and there are multiple factors responsible for it, it is essential to educate these workers and even the organization on the factors responsible for LBP and the intervention should be done in the form of counseling, group exercises, fitness check-ups, and ergonomic training.

4. CONCLUSIONS

The authors conclude that working posture and foot posture are major contributing factors in causing LBP in workers involved in prolonged standing occupation.

Their assessment hence serves many purposes: it may help motivate and plan preventive strategies to increase the efficiency and productivity of these workers, the recommendation of return-to-work modifications which would further help in legal considerations (e.g., adjudicating worker's compensation claims).

CONFLICT OF INTEREST

No conflict of interest is declared.

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