

# Adverse Effects of Sit and Stand Workstations on the Health Outcomes of Assembly Line Workers: A Cross-sectional Study

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## Keywords

Fatigue • Musculoskeletal symptom • Productivity • Sitting workstation • Standing workstation

## Summary

**Introduction.** *Sitting and standing workstations can affect individual's health outcomes differently. This study aimed to assess the effects of sit and stand workstations on energy expenditure and blood parameters, including glucose and triglyceride, musculoskeletal symptoms/pain and discomfort, fatigue, and productivity among workers of assembly line of a belt factory.*

**Methods.** *This cross-sectional study was conducted on 47 male assembly line workers (24 workers in sitting workstation and 23 workers in standing workstation) with at least one year of working experience. Data were gathered via demographic/occupational characteristics, Fitbit system, medical records, the Persian version of the Nordic Musculoskeletal Questionnaire (P-NMQ), the Persian version of the Numeric Rating Scale (P-NRS), the Persian version of the Swedish Occupational Fatigue (P-SOFI), and Persian version of the Health and Work Questionnaire (P-HWQ).*

**Results.** *The results showed that there were no statistically significant between the demographic/occupational details of the participants in sitting and standing groups, except work experience.*

*The findings of the present study revealed that the energy expenditure, and blood glucose/triglyceride there are not statistically differences between sitting and standing groups. In addition, the prevalence of musculoskeletal symptoms in the neck, lower back, knees, and ankles/feet in standing group was significantly higher than the sitting group. The means of severity of discomfort/pain in all body regions were significantly higher in standing group compared to other group. Generally, occupational fatigue was higher among the standing group compared to sitting group. About productivity, the 'concentration/focus' and 'impatience/irritability' subscales in sitting group were higher than the standing group. Contrariwise, other subscales of the productivity, including 'productivity', 'supervisor relations', 'non-work satisfaction', 'work satisfaction' in the standing group were higher than the sitting group.*

**Conclusions.** *To reduce the adverse effects of sitting and standing workstations on individual's health outcomes, planning to use sit-stand workstations is recommended.*

## Introduction

Prolonged and uninterrupted sitting is a significant risk factor for physical and mental well-being. In sitting position, trunk posture of the individual changes from its neutral position. On the other hand, long period standing is an important factor for developing the musculoskeletal discomfort in lower limbs, varicose veins and other known problems [1]. These situations can lead to individuals' inability, change in work efficiency, and bring significant costs for employees, employers and the community [2].

A person may only use one workstation during work, or may be moved between different workstations due to the type of activity. Generally, workstations can be divided into three categories in terms of performance: 1) sitting workstation, 2) standing workstation; and 3) sit-stand workstation (combined) [3].

Complications of sitting workstation are including blood

pressure [4], type 2 diabetes, obesity, cardiovascular diseases [5], some types of cancers such as breast, colorectal, endometrial, ovarian, prostate, and lung cancers [6], Musculoskeletal Disorders (MSDs) [7, 9], and premature mortality [5]. In addition, some studies have stated a relationship between working in sitting workstation and the risk of fatigue [10, 11].

Standing posture (standing workstation) has advantages that include better access than sit workstation. Also in the standing position, the spine is positioned in its neutral posture and retains its natural curvature (S-mode). In this case, lower pressure is applied to the intervertebral discs. Also, standing can be maintained with less muscular activity and the strength of the trunk muscles in standing position is twice as much as sitting [12]. In addition, some studies have pointed out that heart rate, blood flow, and energy expenditure are significantly elevated in the standing working position vs the seated working position [13].

This study aimed to assess the effects of sit and stand workstations on energy expenditure and blood parameters, including glucose and triglyceride, musculoskeletal symptom/pain and discomfort, fatigue, and productivity among workers of an assembly line of a belt factory.

## Methods

This cross-sectional study was conducted on 47 male assembly line workers (24 workers in sitting workstation and 23 workers in standing workstation) with at least one year of working experience. Employees with underlying diseases (cancer, heart diseases, chronic lung diseases, diabetes (type 1 and type 2), chronic liver diseases, physical disabilities, mental health disorders), accidents affecting the musculoskeletal system, cardiovascular diseases, and mental and hormonal disorders were excluded from the study.

All subjects voluntarily participated in the study after receiving information about the study objectives. They also signed informed consent forms before the commencement of the study. This study was approved by the ethics committee of Shiraz University of Medical Sciences. It also was performed in accordance with the Helsinki Declaration of 2013 [14].

### DATA GATHERING TOOLS

Data were collected via demographic/occupational characteristics questionnaire, the Persian version of the Nordic Musculoskeletal Questionnaire (P-NMQ), the Persian version of the Numeric Rating Scale (P-NRS), the Persian version of the Health and Work Questionnaire (P-HWQ), the Persian version of the Swedish Occupational Fatigue (P-SOFI), Fitbit system, and medical records:

- demographic and occupational characteristics: This questionnaire included questions about age, height, weight, work experience, working hours per day, sex, marital status, number of children, and education level;
- Persian version of the Nordic Musculoskeletal Questionnaire (P-NMQ): P-NMQ examined the reported prevalence of musculoskeletal symptoms in different body regions among the study population [15]. In the present study, the reported musculoskeletal symptoms were limited to the past week. The psychometric properties of the P-NMQ have been examined by Choobineh et al. [16];
- Persian version of the Numeric Rating Scale (P-NRS): P-NRS is a unidimensional measure of discomfort and pain intensity [17]. In order to assess the intensity of musculoskeletal discomfort/pain, the subjects were required to rate P-NRS at the beginning, and end of the shift. Then, difference between the P-NRS scores at the beginning and end of the shift was calculated and was considered as musculoskeletal discomfort/pain in the work shift [18];
- Persian version of the Health and Work Questionnaire (P-HWQ): HWQ was developed by Shikiar et al. (2004) to assess various aspects of workplace

productivity. HWQ consists of 30 questions responded through a 10-point Likert scale. The items are divided into six subscales, including productivity (own assessment and other's assessment), concentration/focus, supervisor relations, work and non-work satisfaction, and impatience/irritability in this questionnaire [19]. It is worth mentioning that concentration/focus and impatience/irritability subscales are in reverse mode. This means that higher scores represent lower concentration/focus and impatience/irritability. The psychometric properties of the P-HWQ have been examined by Daneshmandi et al. ( $\alpha \geq 0.65$  for all subscales) [20];

- Persian version of the Swedish Occupational Fatigue (P-SOFI): The SOFI-20 consists of 20 items using an 11-point numerical rating scale (0 = not at all, and 10 = to a very high degree) for each item. The items have been categorized into five dimensions, including (1) lack of energy, (2) physical exertion, (3) physical discomfort (4) lack of motivation, and (5) sleepiness. Scores on each dimension range from a minimum of 0 to a maximum of 40. Based on the SOFI-20 users' guide, the score on each dimension was also rated on severity as follows: low (mean score < 8.5), medium (8.5 < mean score < 23.5), and high (mean score > 23.5) levels of fatigue, based on quartiles of the score distribution [21]. Psychometric properties of the Persian version of SOFI-20 (P-SOFI-20) were reported by Javadpour et al. [22];
- Fitbit system: The Fitbit apparatus (Charge model; made in China) was used to estimate energy expenditure during the work shift. Diaz et al. stated in their study that Fitbit was an accurate and reliable device for wireless physical activity tracking and estimation of energy expenditure [23]. In the present study, energy expenditure during the work shift was estimated;
- medical records: Data related to individuals' blood parameters, including glucose and triglyceride were extracted from their medical records. Normal range of glucose was considered  $\leq 99$  mg/dl and  $> 100$  mg/dl shows a high level of the blood glucose [24]. In addition, normal range of triglyceride was  $\leq 200$  and  $> 200$  mg/dl was considered high [24].

### DATA ANALYSIS

The Statistical Package for Social Sciences 16 (SPSS Inc., Chicago, IL, USA) was used to analyze the data. At first, Kolmogorov-Smirnov and Shapiro-Wilk tests were used to test the normality of the data. To analyze the data, descriptive statistics (frequency/percentage, and mean/standard deviation), independent sample t-test, chi-square test, and Fisher's exact test were used. A p-value < 0.05 was considered to be statistically significant.

## Results

The demographic/occupational characteristics of the subjects are presented in Table I. Based on the results,

**Tab. I.** Comparison of demographic/occupational characteristics between sitting and standing groups (n = 47).

Quantitative variable	Sitting group (n = 24)	Standing group (n = 23)	P-value <sup>†</sup>
Age (years)	36.45 ± 8.997	35.37 ± 3.639	0.091
Height (cm)	173.26 ± 7.927	175.93 ± 6.627	0.174
Weight (kg)	74.25 ± 12.659	74.44 ± 9.204	0.946
BMI (kg.m <sup>-2</sup> )*	30.37 ± 3.639	30.37 ± 3.639	0.379
Work experience (years)	11.44 ± 6.444	6.12 ± 3.344	< 0.001
Qualitative variable	Sitting group (n = 24)	Standing group (n = 23)	P-value
<b>Marital status</b>			
Single	2 (12.5%)	3 (15.4%)	0.522**
Married	22 (87.5%)	20 (84.6%)	
<b>Education level</b>			
Diploma and lower	24 (90.3%)	21 (70.4%)	0.061*
Associate degree and higher	0 (0%)	2 (29.6%)	
<b>Dominant hand</b>			
Right	23 (97.1%)	22 (85.2%)	0.147*
Left	1 (2.9%)	1 (14.8%)	
<b>Smoking</b>			
Yes	2 (9.5%)	1 (0%)	0.477*
No	22 (91.4%)	22 (100%)	

\* Body Mass Index; † Independent sample t-test; \*\* Chi-square test; ‡ Fisher's exact test.

**Tab. II.** Comparison of the energy expenditure between sitting and standing groups (n = 47).

Variable	Sitting group (n = 24)	Standing group (n = 23)	P-value <sup>†</sup>
Energy expenditure (kcal.min <sup>-1</sup> )	3.13 ± 0.77	3.50 ± 0.63	0.114

\* Independent sample t-test.

**Tab. III.** Comparison of the glucose and triglyceride between sitting and standing groups (n = 47).

Variable	Sitting group (n = 24)	Standing group (n = 23)	P-value
<b>Glucose (mg/dl)</b>			
Normal	23 (95.83)	23 (100%)	0.251*
High	1 (4.17%)	0 (0%)	
<b>Triglyceride (mg/dl)</b>			
Normal	19 (79.16%)	18 (78.26%)	0.936†
High	5 (20.84%)	5 (21.74%)	

\* Fisher's exact test; † Chi-square test.

**Tab. IV.** Prevalence rate of the reported musculoskeletal symptom in different body regions amongst the studied workers during the past 12 months (n = 47).

Body region	Sitting group (n = 24) No. (%)	Standing group (n = 23) No. (%)	P-value
Neck	9 (37.50)	16 (69.56)	0.016*
Shoulders	11 (45.83)	10 (43.47)	0.912*
Elbows	2 (8.33)	5 (21.74)	0.089†
Wrists/Hands	6 (25.00)	11 (47.82)	0.072*
Upper back	13 (54.16)	15 (65.21)	0.511*
Lower back	9 (37.50)	16 (69.56)	0.022*
Thighs	6 (25.00)	10 (43.47)	0.163*
Knees	9 (37.50)	17 (73.91)	0.040*
Ankles/Feet	9 (37.50)	20 (86.95)	0.001*

\* Chi-squared test; † Fisher's exact test.

there is a significant relationship between the work experience of the sitting and standing groups:

- energy expenditure: the working energy expenditure of the participants is compared in Table II in sitting and standing groups. As shown in the table, the energy expenditure there is not statistically differences between sitting and standing groups;
- blood parameters: in Table III, the levels of the blood

parameters, including glucose and triglyceride have been compared in the sitting and standing groups. The findings revealed that the blood glucose and triglyceride there are not statistically differences between sitting and standing groups;

- musculoskeletal symptoms/pain and discomfort: Table IV shows the prevalence rate of the reported musculoskeletal symptom in different body regions

**Tab. V.** Comparison of severity of discomfort/pain in different body regions of the participants (n = 47).

Body region	Sitting group (n = 24)	Standing group (n = 23)	P-value*
Neck	1.60 ± 0.09	3.70 ± 0.03	0.001
Shoulders	2.00 ± 0.79	2.50 ± 0.40	0.004
Elbows	1.00 ± 0.06	2.60 ± 0.30	0.001
Wrists/Hands	1.70 ± 0.40	1.80 ± 0.33	0.006
Upper back	1.00 ± 0.48	2.80 ± 0.60	0.001
Lower back	0.90 ± 0.35	2.90 ± 0.40	0.001
Knees	2.00 ± 0.21	3.00 ± 0.60	0.001
Ankles/Foot	1.00 ± 0.21	4.00 ± 0.70	0.001

\* Independent sample t-test.

**Tab. VI.** Comparison of occupational fatigue subscales between sitting and standing groups (n = 47).

	Occupational fatigue subscale	Sitting group (n = 24)	Standing group (n = 23)	P-value*
Lack of energy	Low	11 (34.4%)	6 (22.2%)	> 0.001
	Moderate	21 (65.6%)	9 (33.3%)	
	High	0 (0%)	12 (44.4%)	
Physical exertion	Low	14 (43.8%)	8 (29.6%)	0.170
	Moderate	16 (50%)	13 (48.1%)	
	High	2 (6.3%)	6 (22.2%)	
Lack of motivation	Low	14 (45.2%)	6 (22.2%)	0.181
	Moderate	15 (48.4%)	18 (66.7%)	
	High	2 (6.5%)	3 (11.1%)	
Sleepiness (drowsiness)	Low	17 (53.1%)	8 (29.6%)	0.011
	Moderate	15 (46.9%)	13 (48.1%)	
	High	0 (0%)	6 (22.2%)	
Physical discomfort	Low	15 (48.4%)	6 (22.2%)	0.004
	Moderate	13 (41.9%)	8 (29.6%)	
	High	3 (9.7%)	13 (48.1%)	

\* Chi-square test.

**Tab. VII.** Comparison of productivity dimensions between standing and sitting groups (n = 47).

Productivity subscale	Sitting group (n = 24)	Standing group (n = 23)	P-value*
Productivity	7.66 ± 2.34	7.95 ± 2.65	0.655
Concentration/Focus	2.52 ± 1.19	2.32 ± 0.95	0.333
Supervisor relations	1.48 ± 0.42	1.49 ± 0.45	0.906
Non-work satisfaction	1.66 ± 0.57	2.05 ± 0.69	0.020
Work satisfaction	2.28 ± 0.77	2.32 ± 0.75	0.867
Impatience/Irritability	2.26 ± 0.66	1.98 ± 0.75	0.139

\* Independent sample t-test.

amongst the workers during the past 12 months. The prevalence of the musculoskeletal symptoms in the neck, lower back, knees, and ankles/feet in standing group was significantly higher than the sitting group. Mean ± standard deviation of severity of discomfort/pain in different body regions among the sitting and standing groups has been compared in Table V. As the table depicts, the means of severity of discomfort/pain in all body regions were significantly higher in standing group compared to other group;

- occupational fatigue: Table VI shows comparison of the occupational fatigue subscales between sitting and standing groups. As shown, the 'lack of energy', 'sleepiness', and 'physical discomfort' subscales were statistically significant between two studied groups; so that, occupational fatigue was higher

- among the standing group compared to sitting group; productivity: Table VII compares the subscales of productivity between sitting and standing groups. As shown in the Table, the 'concentration/focus' and 'impatience/irritability' subscales in sitting group were higher than the standing group. Contrariwise, other subscales of the productivity, including 'productivity', 'supervisor relations', 'non-work satisfaction', 'work satisfaction' in the standing group were higher than the sitting group.

## Discussion

The results of the current study showed that there were no statistically significant between demographic/



occupational details of the participants in sitting and standing groups, except work experience. This means that the mean of work experience in the sitting group (11.44 years) was statistically higher than standing group (6.12 years) ( $p < 0.001$ ). In fact, it seemed that workers with higher work experience were more likely to use sit workstations:

- energy expenditure: findings the present study revealed that the energy expenditure in the sitting group was slightly lower than the standing group, but no significant difference was obtained between the mentioned groups; In the current study, evaluated activities in the sitting and standing groups (3.13 vs 3.50 kcal.min<sup>-1</sup>, respectively) placed in the moderate jobs [25]. In a study by Forkan et al. [26] in order to assess the energy expenditure in the sitting and standing groups on office workers for six weeks, no significant results were found. On the other hand, Daneshmandi et al. [20] in their study stated that the sit-stand workstation can be effected on the energy expenditure of the individuals. Similar results have also been obtained in other studies conducted in this context [27, 28]. For example, Fryar et al. stated that 2 to 4 hours of standing per day could lead to an additional 25-57 kcal/day for an average-sized American man (88.9 kg) and an additional 21-48 kcal/day for an average-sized American woman (75.5 kg) [29].
- blood parameters: the findings of the study depict that there are not statistically differences between blood glucose/triglyceride in sitting and standing groups. In this context, a study showed a relative improvement in individuals' blood parameters at the sit-stand workstation [30]. In a study conducted by Mantzari et al. [31] concluded that sit-stand workstation had no a significant effect on energy expenditure, heart rate, and metabolic diseases. Conflicts with the findings of various studies can be attributed to the: 1) type of workstation (sit or stand or sit-stand workstation), 2) duration of use the workstation, and 3) demographic differences. In order to have a more accurate and consistent comparison of blood parameters between the two standing and sitting groups, it is recommended that a larger sample size be examined;
- musculoskeletal symptoms/pain and discomfort: the results of the study showed that the prevalence of musculoskeletal symptom in the neck, lower back, knees, and ankles/feet in standing group was significantly higher than the sitting group. Standing position is expected to exert more biomechanical pressure to the above-mentioned body regions. Therefore, the long-term standing in the subjects could provide a good reason for the high prevalence of musculoskeletal symptoms in these regions. In addition, findings revealed that severity of pain/discomfort in all individuals' body regions in standing group was statistically higher than the sitting group. Daneshmandi et al. in a study amongst assembly line workers reported a high prevalence of musculoskeletal symptom in the lower back, wrist/

hands, and neck [32]. Roelofs and Straker in their study pointed out that greatest musculoskeletal discomfort is related to the lower limb and back in standing bank tellers group [33]. In the same line, Daneshmandi et al. noted that longer standing in office workers could lead to musculoskeletal symptoms in some body regions, such as shoulders, wrists/hands, and ankles/feet [20];

- occupational fatigue: the findings of the present study showed that the 'lack of energy', 'sleepiness', and 'physical discomfort' subscales of the occupational fatigue were higher (statistically significant) among standing group compared to sitting group. In a study to compare sit, stand and sit-stand workstations, the results showed that long standing over than 90 minutes resulted in fatigue in the legs and back regions, and people tend to reduce pain and discomfort during standing by leaning backwards. According to the study, the standing condition causes fatigue in the legs and the sit-stand situation causing more discomfort in the buttocks region [34];
- productivity: the results of this section showed that the 'concentration/focus' and 'impatience/irritability' subscales in sitting group are higher than the other group (standing group), but, these differences are not statistically significant. On the other hand, our findings revealed that other subscales of the productivity, including 'productivity', 'supervisor relations', 'non-work satisfaction', 'work satisfaction' in the standing group were higher than the sitting group, but, only 'non-work satisfaction' subscale was statistically significant. In the same line, Pronk et al. [35], Hedge et al. [36], and Nevala et al. [37] stated that using the sit-stand workstation improved productivity. Thorp et al. also demonstrated that there is a significant improvement in total productivity among the individuals who used the sit-stand workstation compared to the sitting position, but this result was contrariwise about the 'concentration/focus' subscale [38].

## Limitations

Given the cross-sectional nature of the study and a significant difference in work experience between sitting and standing groups, the findings should be interpreted cautiously. Additionally, due to the fact that the study was conducted in the field under real conditions, the outcomes might have been affected by confounding variables such as workplace policies, management issues, stress, lifestyle factors, financial and family commitments. Moreover, the sample sizes in each group were small. Therefore, using larger sample sizes could lead to achievement of more robust results.

## Conclusions

In summary, the energy expenditure, blood glucose/

triglyceride there are not statistically differences between in sitting and standing groups. In addition, the prevalence of musculoskeletal symptom in the neck, lower back, knees, and ankles/feet in standing group was significantly higher than the sitting group. Generally, occupational fatigue was higher among the standing group compared to sitting group. About productivity, the 'concentration/focus' and 'impatience/irritability' subscales in sitting group were higher than the standing group. Contrariwise, other subscales of the productivity, including 'productivity', 'supervisor relations', 'non-work satisfaction', 'work satisfaction' in the standing group were higher than the sitting group. To reduce the adverse effects of sitting and standing workstations on individual's health outcomes, planning to use sit-stand workstations is recommended.

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## Conflict of interest statement

None declared.

## Authors' contributions

AMMJ: idea, data gathering, data interpretation, article drafting, final approval of the article. AC, MR, HD: idea, data interpretation, article drafting, final approval of the article. HG data analysis and interpretation, article drafting, final approval of the article.

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