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# The relationship between working posture and musculoskeletal disorders among electrical industrial workers in Isfahan

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**Abstract**

**Background**: Work-related musculoskeletal disorder is the most important occupational disease that threatens the health of employees.

**Aim:** The aim of this study was to investigate the relationship between workers' posture and musculoskeletal disorders.

**Materials and Methods:** Eighty-two male and female workers working in a home appliance factory participated in this cross-sectional study. Musculoskeletal disorders were investigated using Nordic questionnaires. Posture evaluation was performed to measure the angles of forward head, rounded shoulders, and thoracic kyphosis using photogrammetry. Craniovertebral, shoulder, and thoracic kyphosis angles were photographed during the work and then measured using ImageJ software. Data analysis was done using SPSS 26 and Spearman's correlation test at a significance level of 0.05.

**Results**: A significant relationship between the craniovertebral angle and musculoskeletal disorders in the last twelve months was observed in the cervical region ($P$<0.001). Also, a significant relationship was observed between the kyphosis angle and musculoskeletal disorders in the last twelve months in the upper back and lower back ($P$<0.001).

**Conclusion**: The results showed that the workers' posture during work is correlated with the prevalence of musculoskeletal disorders. Therefore, it is suggested to pay attention to ergonomic principles during work to maintain and improve the physical health of workers.

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## 1. Introduction

Today, people spend long hours in the workplace, but if they continue maintaining their posture for a long time, it may augment musculoskeletal disorders [1]. The advancement of technology has improved working conditions and activities; nevertheless, the production and provision of various services have had a negative impact on a person's health, causing musculoskeletal disorders and disability in the short or long term [2]. These disorders are considered as the primary issues related to occupational health in developing countries [1, 2].

Work-related musculoskeletal disorders are caused by risk factors in the workplace and are well known by terms such as cumulative trauma disorders and repetitive strain injury [3]. Excessive cost, time, and injury are critical and influential factors for work-related musculoskeletal disorders, which are counted as the main reasons for limitations in daily activities [4]. People in different occupational groups are faced with some harmful factors due to the differences in the status of their jobs; therefore, researchers present various factors influencing musculoskeletal disorders, the most important of which are improper posture, mechanical stress, and repetitive and excessive force, sitting or standing still during working hours, lack of rest time, and performing activities with inappropriate equipment and tools [5, 6, 7]. Preventing or delaying these disorders has significant effects on the health and safety of employees and increasing productivity [4]. Although research has shown that psycho-social factors can cause these disorders; however, mechanical factors play the main role in the occurrence of these disorders. For example, repetitive movements in the joint, the organs' statuses, and the applied force can be considered as mechanical factors [8].

Hence, different studies have been conducted on the prevalence and complications of musculoskeletal disorders on people in different industrial, administrative work environments, and hospitals. Since the working place affects the physical condition of the person while working, and his/her posture is determined according to the work environment, it may bring about work-related musculoskeletal disorders if the physical dimensions of people while working are incompatible with the tools and equipment as well as the work place [9, 10].

The results of the research conducted on 85 computer users showed that 42% of the subjects had an inappropriate working posture, and the prevalence of musculoskeletal disorders among them were, respectively, in the back (5.37%), neck (4.34 %), and shoulder (1.28 %) [11]. In a similar study, Porter and Gyi (2002) assessed the prevalence of musculoskeletal disorders among 1000 drivers using the Nordic questionnaire [12]. They reported a significant relationship between driving a car and musculoskeletal disorders.

Shuval and Donchin (2005) evaluated 84 workers working in the Hi-Tech Company using Nordic questionnaire and posture assessment method, reporting that the posture evaluation score of all the samples was over 3, and required measures and corrections should be made on their posture as soon as possible. On the other hand, these researchers reported a significant relationship between the prevalence of musculoskeletal disorders in the shoulder, wrist, and fingers and the scores of the neck, arm, and wrist [13].

One of the ways to examine the work environment is to check the ergonomic

status. Previous studies have assumed the impact of ergonomic factors on musculoskeletal disorders [14]. According to these risk factors, the ergonomic work environment can be designed and reconstructed [15]. The incompatibility of the anthropometric dimensions of each person with the tools and equipment used is one of the common causes of muscular disorders in people [16]. The use of inappropriate and non-ergonomic and non-adjustable tables and chairs is not suitable for people with different sizes. Their long-term use can cause pain and damage. On the other hand, no study was found on the relationship between the ergonomic and anthropometric status of workers in selected home industries that require long-term sitting and work to assemble electronic components. Understanding the relationship between musculoskeletal disorders and posture during work could assist workshop owners and workers in enhancing their health and reducing medical costs by implementing ergonomic improvements and maintaining proper body posture while working.

Thus, the present study sought to answer the question of whether there is a relationship between working posture and musculoskeletal disorders of the upper limbs of selected industrial factory workers in Isfahan.

## 2. Materials and Methods

A correlational type, cross-sectional study was conducted in one of the electrical household appliance factories located in the Jey Industrial zone of Isfahan. The subject workers were selected through convenience sampling method. Working in the selected factory and in sitting position were the inclusion criteria. The measurements and evaluation of complications were done while sitting, The number of employees in this factory was 123 consisting of men and women, of which 100 workers work in assembly, injection, packaging, and paint sections. A call was announced in the workplace. A sample of 82 people were recruited in this study. Each workers should work in his working position at least for 8 hours per day. To comply with ethical considerations, the workers were assured that all their data will be used only for this research, and the data will remain confidential. Also, participation in the research was voluntary, and it was explained to the subjects that they could withdraw from the project at any time without giving an explanation. The research methods were approved by the ethics committee in biomedical studies of Allameh Tabataba'i University (IR.ATU.REC.1400.010), The inclusion criteria were: at least one year of work experience, willingness to participate in the study, and working in a sitting position. The exclusion criteria were: history of joint diseases or rheumatoid arthritis, working in a standing position, history of heart diseases and heart surgery, history of mental diseases such as depression or anxiety being treated, history of surgery in the cervical spine to the waist, significant posture disorders in the spine such as structural scoliosis or structural thoracic kyphosis based on the New York postural assessment tool, the presence of symptoms suspected of being infected with the coronavirus such as fever, cough, lethargy, and weakness, or sudden onset of musculoskeletal pains in the last 3 days or unprotected contact with patients with a definite diagnosis of COVID-19 in the last 2 weeks, At first, the workers completed the informed consent forms to participate in the research project and were informed about the study process. In the first step, the height and weight of the

workers were measured, and then the Nordic questionnaires were fulfilled.

The angles of forward head, rounded shoulders, and thoracic kyphosis were measured using photogrammetric method. In this method, first anatomical reference points (T12, T1, C7, ear tragus, and the middle point of the arm) were marked on the dominant side of the person with a label on their clothes, and then the camera was set and fixed on a tripod at a 150 cm distance with a height of 90 cm in the lateral view from the person [5]. ImageJ software was used to analyse the angles of craniovertebral, shoulder and thoracic flexion (Figure 1).

**Figure 1.** ImageJ software was utilized to examine the study postural variables (craniovertebral angle)

The craniovertebral angle was measured to extract the forward head angle. To measure this angle, the required reference points (the external occipital protuberance of the seventh cervical vertebra and tragus) were first marked, and photographs were taken from the dominant side of the worker while sitting. Using the software, this angle was measured in such a way that a straight line was drawn from the tragus to the seventh cervical vertebra; the other line is a horizontal line that passes through the seventh cervical vertebra. The angle formed at the intersection of these two lines is the craniovertebral angle [17]. The 50° angle was considered as a cut off angle. If the craniovertebral angle in a person is less than 50°, the person has a forward head problem [18]. In a research study, the validity and reliability of this method was expressed as good to excellent using photogrammetry to evaluate the forward head posture in the sitting position. The intracluster correlation coefficient (ICC) was 0.98 and the validity was 0.89 [19].

The shoulder angle was used to diagnose the round shoulder disorder [20]. To measure this angle, the required reference points (the seventh cervical vertebra and the middle point of the arm in the lateral view) were marked. Photography was done from the dominant side of the person in the sitting position. Using the software, this angle was measured in such a way that a horizontal line was drawn from the seventh cervical vertebra, and another straight line was drawn from the seventh cervical vertebra to the middle point of the arm on the lateral plane. The angle formed at the intersection of these two lines is called shoulder angle [21]. The reliability of shoulder angle measurement by photogrammetric method was reported 0.78 (ICC) [20].

Thoracic flexion angle was used to diagnose thoracic kyphosis [18]. To measure this angle, the required reference points ($7^{th}$ cervical vertebra and $12^{th}$ thoracic vertebra) were first marked and photographed from the dominant side of the worker in a sitting position while working. All of the participants' work involved sitting throughout the day. This angle was measured using the software, i.e. a vertical line was drawn from the $7^{th}$ cervical vertebra and another vertical line was drawn from the $12^{th}$ thoracic vertebra, and then these two lines were connected to each

other. The angle formed at the intersection of these two lines is the thoracic flexion angle [5]. To measure the reliability of photogrammetry, the inter-observer reliability was reported as 0.94, so that the photogrammetry method can be used to measure kyphosis [22].

Moreover, the Nordic musculoskeletal questionnaire, which is a self-report, was used to diagnose and measure musculoskeletal disorders, including 27 questions with yes/no answers. The questions are from nine anatomical regions of the body (three regions of the upper limb, three regions of the spine, three regions of the lower limb) including the neck, shoulders, elbows, hands and wrists, upper back, waist, hips and thighs, knees, and ankles. In this questionnaire, pain, numbness, and discomfort during the last week and 12 months before the research, and also, pain and discomfort causing absence from work or leave are examined [23, 24]. The participants answered questions about the presence and severity of pain over the past twelve months, and those who had pain or discomfort during the study period were included in this research. The number of pain occurrences over the past twelve months was not calculated.

To analyse the demographic data, descriptive statistics were used, and inferential tests were used to measure the normality and correlation of the data. The normality of the data was measured using the Kolmogorov-Smirnov test. Due to data non-normal distribution, the non-parametric Spearman test was used to measure the correlation between posture and musculoskeletal disorders. The tests were analysed with SPSS version 26. All tests were performed at a significance level of 95% and $\alpha>0.05$.

## 3. Results

Individual characteristics of people are briefly presented in Table 1.

**Table 1.** Demographic data of volunteer participants

| Variable | Mean | Standard deviation |
|---|---|---|
| Age (year) | 31.85 | 7.11 |
| Height (cm) | 171.85 | 8.93 |
| Weight (kg) | 74.56 | 14.24 |
| Body Mass Index | 25.19 | 4.12 |
| Craniovertebral angle (degrees) | 27.29 | 11.26 |
| Shoulder angle (degrees) | 47.54 | 16.27 |
| Thoracic flexion (degrees) | 45.20 | 3.77 |

To measure the correlation between the variables of craniovertebral angle and musculoskeletal disorders, Spearman's test was used (Table 2 and 3). The results showed a significant correlation between the craniovertebral angle and musculoskeletal disorders in the last twelve months in the cervical region ($P<0.001$).

**Table 2.** The mean pain experienced during last 12 months in the study participants

| Body zone | Mean | Standard deviation |
|---|---|---|
| Neck | 0.56 | 0.59 |
| Shoulder | 0.50 | 0.59 |
| Elbow | 0.16 | 0.37 |
| Wrist | 0.10 | 0.30 |
| Upper back | 0.44 | 0.50 |
| Lower back | 0.48 | 0.63 |
| Buttock and thigh | 0.10 | 0.30 |
| Knee | 0.13 | 0.34 |
| Ankle | 0.04 | 0.19 |

Spearman's test was used to measure the correlation between the variables of shoulder angle and musculoskeletal disorders (Table 4). A significant correlation was observed between the shoulder angle and musculoskeletal disorders in the last twelve months in the shoulder area ($P< 0.001$), elbow ($P= 0.004$), and upper back ($P= 0.019$).

**Table 3.** Correlation between craniovertebral angle and musculoskeletal disorders

| Variable | | Body zone | P-value | r |
|---|---|---|---|---|
| Craniovertebral angle | Pain experienced during last 12 months | Neck | <0.001* | -0.56 |
| | | Shoulder | 0.583 | -0.06 |
| | | Elbow | 0.935 | 0.009 |
| | | Wrist | 0.938 | -0.009 |
| | | Upper back | 0.926 | -0.01 |
| | | Lower back | 0.673 | -0.047 |
| | | Buttock and thigh | 0.859 | -0.020 |
| | | Knee | 0.261 | 0.125 |
| | | Ankle | 0.153 | -0.159 |

* Statistically significant correlation observed

**Table 4.** Correlation between shoulder angle and musculoskeletal disorders

| Variable | | Body zone | P-value | r |
|---|---|---|---|---|
| Shoulder angle | Pain experienced during last 12 months | Neck | 0.869 | -0.01 |
| | | Shoulder | <0.001* | -0.52 |
| | | Elbow | 0.004* | -0.31 |
| | | Wrist | 0.360 | -0.10 |
| | | Upper back | 0.019* | -0.26 |
| | | Lower back | 0.273 | -0.12 |
| | | Buttock and thigh | 0.210 | -0.14 |
| | | Knee | 0.647 | -0.05 |
| | | Ankle | 0.559 | -0.05 |

*Statistically significant correlation observed

Spearman's test was used to measure the correlation between the variables of pectoral flexion angle and musculoskeletal disorders (Table 5). The results showed a significant correlation between the thoracic kyphosis angle and musculoskeletal disorders in the last twelve months in the upper and lower back ($P$<0.001).

**Table 5.** Correlation between thoracic kyphosis angle and musculoskeletal disorders

| Variable | | Body zone | P-value | r |
|---|---|---|---|---|
| Thoracic kyphosis angle | Pain experienced during last 12 months | Neck | 0.810 | -0.02 |
| | | Shoulder | <0.132 | -0.16 |
| | | Elbow | 0.228 | -0.13 |
| | | Wrist | 0.320 | -0.11 |
| | | Upper back | <0.001* | 0.42 |
| | | Lower back | <0.001* | 0.47 |
| | | Buttock and thigh | 0.745 | -0.03 |
| | | Knee | 0.398 | 0.09 |
| | | Ankle | 0.732 | -0.038 |

* Statistically significant correlation observed

## 4. Discussion

The results showed that the workers' posture during work is correlated with the prevalence of musculoskeletal disorders. Workers' posture including craniovertebral, shoulder, and thoracic flexion angles were measured to evaluate forward head, round shoulder, and thoracic kyphosis, respectively, by photogrammetric method. The results showed a significant correlation between the craniovertebral angle and musculoskeletal disorders in the last twelve months in the cervical region ($P$<0.001).

In this regard, various studies [20, 26] have pointed out the relationship between forward head and cervical pain in industrial, administrative jobs, and among students. For example, it has been shown that there is

a significant relationship between forward head and cervical pain in the work situation [26], or a negative significant relationship has been reported between the craniovertebral angle in both sitting and standing positions with the severity of cervical pain and disability of students [27].

Forward head disorder is the most common postural abnormality in employees. The main risk factor for forward head posture is related to tasks that require bending the head and neck or moving it forward [28]. With forward head movements, the posterior muscles and muscles around the atlanto-occipital joint become more active and shorter with the aim of establishing balance, and a group of opposing muscles are stretched. Also, excessive activity of the extensor muscles to maintain the extension position brings about headache and fatigue [29]. Forward head posture exerts an informal load on the nerve roots in this area through exerting additional pressure on the vertebrae, ligaments, and joints, and on the other hand, due to the displacement of the vertebral column, causes pain and disability in the neck [30]. As the center of gravity moves forward, the torque arm becomes larger and more force is applied to the cervical muscles, causing a disturbance in the cervical muscles' balance [31]. Other possible causes of cervical pain in people with forward head posture include increased tension on the cervical joints, damage to the disc in the lower part of the neck due to bending of this area [32].

Also, a significant correlation was observed between the shoulder angle and musculoskeletal disorders in the last twelve months in the shoulder area ($P< 0.001$), elbow ($P= 0.004$), and upper back ($P= 0.019$).

Previous studies have not taken into account the relationship between rounded shoulder and pain in the upper back area, but the cause of pain in this area may be a possible change in the length-tension relationships of the muscles in the pectoral and upper back area. The back muscles are stretched and possibly weak, and the front muscles are shortened [33]. The change in the size and activity of the upper back muscles causes tension in them, which may be one of the causes of pain in people with round shoulders [34]. Also, it may be possible to consider the change in the movement pattern of the hand and arm, which is associated with an increase in the shoulder angle, as one of the factors affecting pain since improper posture is the most important identified factor among the occupational risk factors affecting musculoskeletal disorders [34]. Limitation in mobility caused by wrong body posture initially exerts additional load on the joints and in the long term on the bones, ligaments, and soft tissue and causes a change in proprioceptive sense [31]. One of the signs of dysfunction in these parts is pain in the involved areas and its surroundings [33]. Rounded shoulder causes defects in the functioning of the muscular, nervous, and skeletal systems by change in the location of the scapula. The created imbalance disrupts the movement patterns of the hands and arms, and the forward movement of the shoulders and the internal rotation of the arm are reported to be the causes of shoulder pain in people with rounded shoulders [32, 35].

Also, the results showed a significant correlation between the thoracic kyphosis angle and musculoskeletal disorders in the last twelve months in the upper and lower back ($P<0.001$). The results are in line with other studies showing that thoracic kyphosis is significantly related with pain in the upper back [5].

A significant relationship was observed between thoracic kyphosis and back pain,

which is contrary to the results of other studies. In Valachi and Valachi's study, despite the widespread prevalence of thoracic kyphosis and back pain among dentists who spent a lot of time sitting in a bent position, no significant relationship was observed between thoracic kyphosis and back pain [36].

One of the factors that may cause back pain in the subjects with thoracic kyphosis is maintaining a static sitting position for a long time with posterior tilt of the pelvis and reducing lumbar lordosis [5]. Incorrect body posture changes the functions of different body systems and is known to cause disturbances in balance, flexibility, and strength of muscles and joints. Decrease in the activity of the posterior stabilizing muscles with the task of protecting the body against gravity reduces their strength and creates stiffness in the ligaments and joints connected to it. In addition, with the change of the intervertebral discs, the mobility of the vertebral column and the muscles connected to it decreases, especially in the direction of opening the thoracic spine. Limitation of mobility exerts additional load on the upper back tissues, which all bring about pain and fatigue of the upper back muscles [31, 33].

Research limitations should be taken into account to generalize the research data to all workers' community. The data collected on musculoskeletal disorders and working postures were self-reported, which may introduce recall bias or social desirability bias. Additionally, since the study only focused on electrical industrial workers in Isfahan, the findings may not be generalizable to other occupations or regions. Furthermore, the cross-sectional study design used in this research precludes establishing causality or determining temporality. Moreover, the absence of a control group in this study makes it difficult to compare the results to a group without musculoskeletal disorders or with different working postures. Finally, this study did not account for other factors that may contribute to the development of musculoskeletal disorders, such as age, gender, or job tenure.

## 5. Conclusion

The results showed that the workers' posture during work is correlated with the prevalence of musculoskeletal disorders. Therefore, it is suggested to pay attention to ergonomic principles during work to maintain and improve the physical health of workers.

## Conflict of interest

The authors declared no conflicts of interest.

## Authors' contributions

All authors contributed to the original idea, study design.

## Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

## Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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