# Participatory Ergonomics Design intervention in an Iron factory: Ergonomic workstation design to Decrease musculoskeletal disorders.

**Dr. Aziza Maher Ahmed Abouelsoud[1]**
**Lecturer in product design Department-Faculty of Applied Arts – October6 University**
**aziza.maher.art@o6u.edu.eg**
**Dr. Tamer Mohamed Yousif [2]**
**Lecturers in product design Department-Faculty of Applied Arts – October6 University**
**tameryousif10@yahoo.com**

## Abstract:

To reduce musculoskeletal disorders complaints in an electric Iron esteeming test task, a participatory ergonomic design approach is used. Five phases of a participatory ergonomic Design process were followed (Preparation, Analysis of tasks, Selection of improvements and design, Pilot study with the improvements, Implementation). Two operators on using the steam and water sprayer test workstation they both voluntarily participated in the evaluation of the designed workstation before& after implementing. Prior to the intervention, two interviews were conducted, and one questionnaire was delivered to answer in addition to our own observations of the workers during a full working day, taking notes and discussing realized issues with the workers. These same metrics were employed after the intervention, as well. After the intervention, a new workstation was designed and executed as a prototype considering all the discovered issues that caused musculoskeletal disorders, the new design showed both a posture improvement and comfort improvement. This project shows the importance of iterative testing, deep understanding of the workers complaints, importance of participation of the workers in developing their workstations, considering their needs, and that the right interpretation can lead to the right ergonomic design solutions.

**Research problem:** Highlighting the importance of using Participatory ergonomics design in solving workers' Musculoskeletal Disorders caused by bad workstation design.

**Research aim** : is to improve the quality of work conditions for workers using workstation through developing a better ergonomic design. Vink et al. (2006), states that participatory ergonomics design focuses on adapting the environment to the human by means of involving people who would benefit from the designed workstation, in the design process.

## Key words:

participatory ergonomic Design; musculoskeletal disorders; steam iron tests; workstation, Ergonomic Design considerations.

## ملخص البحث

لتقليل الشكوى من الاضطرابات العضلية الهيكلية أثناء أداء مهمة اختبار انبعاث بخار، ورذاذ الماء في مكواة البخار الكهربية بأحد المصانع الوطنية، قمنا باستخدام تصميم الإرجنوميكس التشاركي. وتم اتباع خمس مراحل في عملية التصميم التشاركي، (الإعداد، تحليل المهام، اختيار التطوير المناسب ووضع التصميم، الدراسة الأولية للتصميم المقترح،

التنفيذ والاختبار). يؤدي المهمة داخل المصنع اثنان من العمال على ورديتين في اليوم الواحد. وافق العاملان على التطوع للمشاركة في تقييم محطة العمل المصممة قبل وبعد استخدامها. قبل بدء العمل تم اجراء مقابلة مع كل عامل على حدة، تم تسليم استبيان للعاملين وتجميع ودراسة الإجابات التي وردت فيه، وقمنا بالاعتماد على الملاحظة الشخصية من خلال المتابعة الدقيقة لكلا العاملين أثناء أداء مهمتهم طوال يوم العمل، وتدوين الملاحظات ومناقشة المشاكل مع العمال والفهم العميق لشكاويهم. نفس المعايير تم تطبيقها بعد التدخل وإعادة تصميم محطة العمل في ضوء احتياجات العاملين وتجنب مسببات الشكوى من الاضطرابات العضلية الهيكلية وتم عمل تصميم تجريبي. وصاحب استخدام التصميم الجديد تحسن في وضعية الجسم وفي مستوى الراحة أثناء العمل.

**مشكلة البحث:**

ابراز أهمية استخدام تصميم الإرجنوميكس التشاركي في حل المشاكل العضلية الهيكلية الناتجة عن سوء تصميم محطة العمل الخاصة بالعمال عند أداء مهام العمل.

**هدف البحث:**

تحسين ظروف العمل للعمال مستخدمي workstationمن خلال تطوير تصميم ارجونوميكس أفضل لها. يهدف البحث لتحقيق ذلك من خلال استخدام مفهوم الإرجنوميكس التشاركي ل vink et al (2008) والذي يسعى لتحقيق تكيف البيئة بالنسبة للمستخدم من خلال الاستعانة بالمستفيدين والمستخدمين لهذه البيئة وتطبيقه على ما يعرف بتصميم الإرجنوميكس التشاركي.

**الكلمات المفتاحية:**

_تصميم الإرجنوميكس التشاركي، الاضطرابات العضلية الهيكلية، اختبارات انبعاث البخار، محطة العمل، اعتبارات تصميم الإرجنوميكس

## 1- INTRODUCTION

We approached one of the national iron factories to study the work environment looking for ergonomic design issues that product designers can help in solving within reasonable, practical and effective solutions that would improve the quality of production while making the workers less fatigue. through real life communication with the workers, it became clear that the electric Iron steam and water spray tests workstation was getting many complaints from the workers like, low back pain, wrist soreness, neck pain, knee pain and upper arm pain as well, especially with the average of repetition of the tasks.

Applying Ergonomics is an essential practice in factories, as implementation of it, has addressed improvement of production and less complains from workers. Unsuitable workstation design can raise the chances for MSDs leading to less job satisfaction and productivity. Low back disorders are common musculoskeletal disorders among workers within factories. The danger of back failure grows for workers whose tasks consist of lifting with a rotated trunk or repeated pending. Also, the risk of a shoulder pain is common to occur when the workers do manual tasks that involve pushing and pulling. workplace MSDs can also occur due to tasks that involve wrist motion and highly repetitive finger motion, as do those at the electric Iron esteeming test workstation.

Eason (1995) sees that participatory Design is all about: "establishing design processes in which the end users themselves can influence the design so that it is compatible with their goals and beliefs, etc.". Sundin et al. (2004) consider that it is not enough to improve workplaces and production systems themselves; it is also necessary to involve "the earlier step that affects the production system, i.e., the product design". They coin the term 'participatory ergonomics design' for such activities.

Implementation of ergonomic improvements can be difficult, but an approach showing successes is participatory ergonomics (Vink et al, 2008). Therefore, participatory ergonomic design was the strategy used for the development of an ergonomic intervention in the electric Iron steam and water spray tests workstation. Core of the approach is to improve the quality of work conditions for workers using that workstation through developing a better ergonomic design. Vink et al. (2006), states that participatory ergonomics design focuses on adapting the environment to the human by means of involving people who would benefit from the designed product , in the design process. There is also a possibility to involve other related parties (e.g. Noro & Imada, 1992). Our study involved participation from the workers only. The demand for this workstation design development regenerated from the workers themselves during an ergonomic observation carried out by the researchers. Work-related musculoskeletal disorders (WRMD), such as neck, Low-Back, Elbow, Wrist indicates that even low levels of muscular activity of different muscles for long periods, longer than 8 minutes, over successive years would increase the risk of those MSDs (Østensvik et al., 2009 & Bruce P. Bernard, M.D., M.P.H,1997). Our study aimed to develop a custom design ergonomic workstation, based on the user's needs and improved repeatedly using participatory ergonomic design processes within the factory desire to have an efficient low budget workstation. This process resulted in the development of a prototype and it was tested by the workers themselves. The final version was modified, and mechanical drawings were submitted to be implemented in the factory.

## 2- METHODS

**participants**: As the required design was to be customized, the two workers doing the task were the targeted participants. They are (28& 45) years of age, (160 &177 cm) tall, (70 &85kg) weight and with high school education level & they voluntarily participated in the study. They work in fixed shifts (from 8am to 4pm) of 8 hours a day, from Sunday through Thursday.

**Instruments**: Cornell Musculoskeletal Disorder Questionnaire (CMDQ) (figure1) was used to identify the body discomfort and MSDs faced by workers in their work setup. CMDQ was developed by Dr. Alan Hedge and ergonomics graduate students at Cornell University. The questionnaire was translated and tested for validity in many languages like Turkish and Malaysian (Oğuzhan Erdinç et al. 2008), it is based on previous published research studies of musculoskeletal discomfort among office workers (Hedge, et al. 1999). The CMDQ consists of 54-element questionnaire with a body map graph and questions about musculoskeletal ache, pain or discomfort in 18 areas of the body during the week before. The ergonomic

analysis of the task was done through live observation of postures, unstructured interviews with the workers, recorded videos and pictures. Finally, using the principles of anthropometry, an ergonomic workstation design was developed and was compared to present design of workstation to know if there is a mismatch and identify the gaps in the design. Comparisons of data before and after the ergonomic intervention were done using the CMDQ

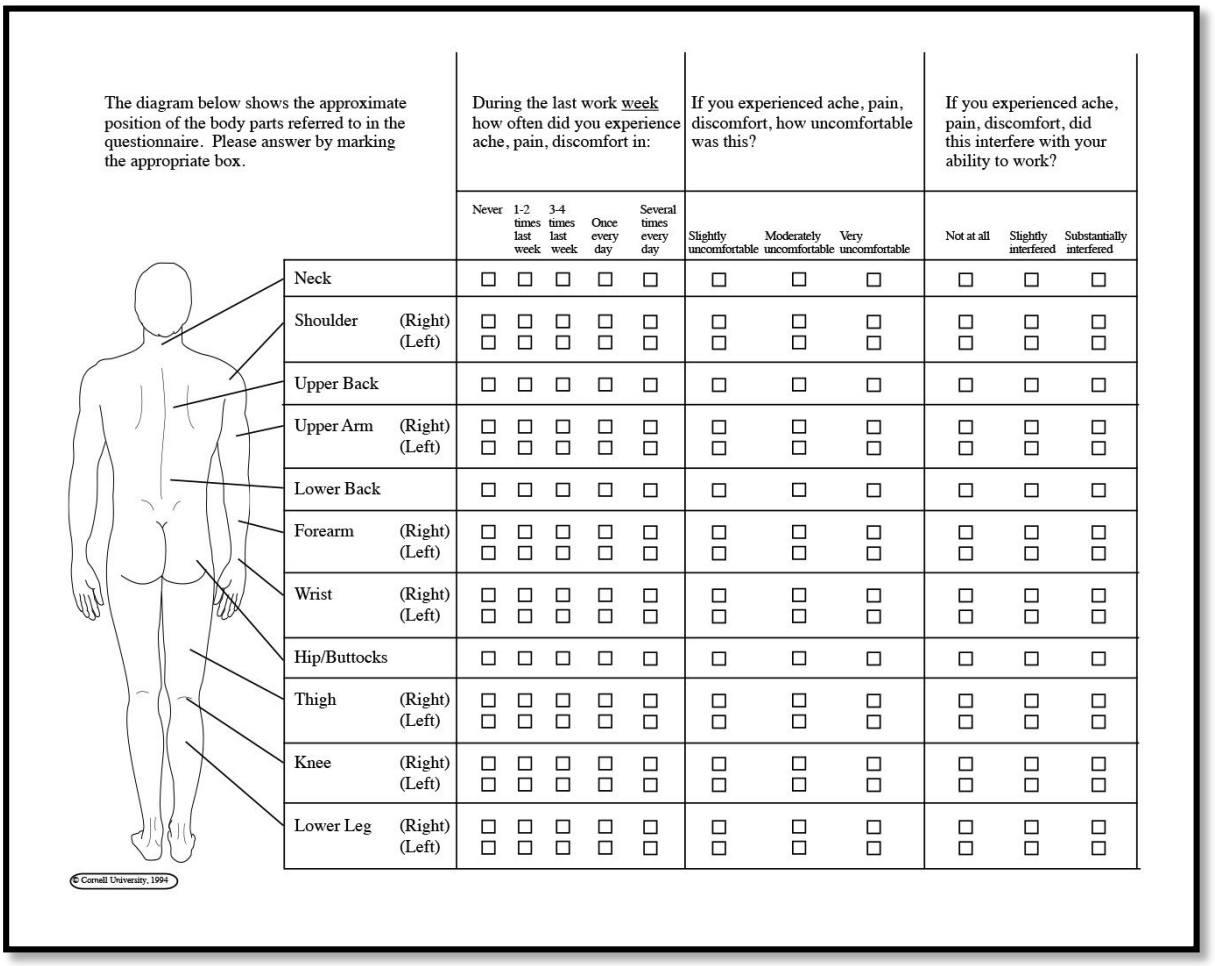


**Figure 1: The original CMDQ questionnaire copy**

**2-1 Analyzing CMDQ scores as mentioned on Cornell University Ergonomics Website**

a. by counting the number of symptoms per person
b. by summing the rating values for each person
c. by weighting the rating scores to more easily identify the most serious problems as follows:

| Rate | score |
|---|---|
| never | 0 |
| 1-2 times/week | 1.5 |
| 3-4 times/week | 3.5 |
| Everyday | 5 |
| Several times/day | 10 |

d. by multiplying the above Frequency score (0,1.5 , 3.5, 5, 10) by the Discomfort score (1,2,3) by the Interference score (1,2,3).
e. In the computational analyses missing values can be coded as 0. If the missing value is for the frequency score then use this as a zero in multiplying, i.e. all combinations of Frequency, Discomfort and Interference become 0. However, if the missing value is in the Discomfort or Frequency score then treat it as missing so that the multiplied score will be at least the value of the Frequency score.
f. The individual items should also be analyzed to determine where there may be a postural problem for the person.
g. calculating the final scores for each part per person:
Example: if we have a worker who has right shoulder pain every day (score of 5), and this is very uncomfortable (score of 3) and it substantially interferes with their work (score of 3), if we multiply their score for the right shoulder it is 5x3x3 = 45. So let's compare this to someone who says they had right shoulder pain 3-4 times in the last week (score of 3.5) that is was moderately uncomfortable (score of 2) and that it slightly interfered with their work (score of 2), then if we multiple their scores for the right shoulder it is 3.5x2x2 = 14, which is almost 1/3 of that for the previous. So by multiplying out the scores it really stretches the scales and helps us see people with the greatest problems specially if the number of workers using the same workstation is big.

## 3- APPROACH AND RESULTS:

The participatory ergonomics Design process used in this paper consisted of 5 phases:

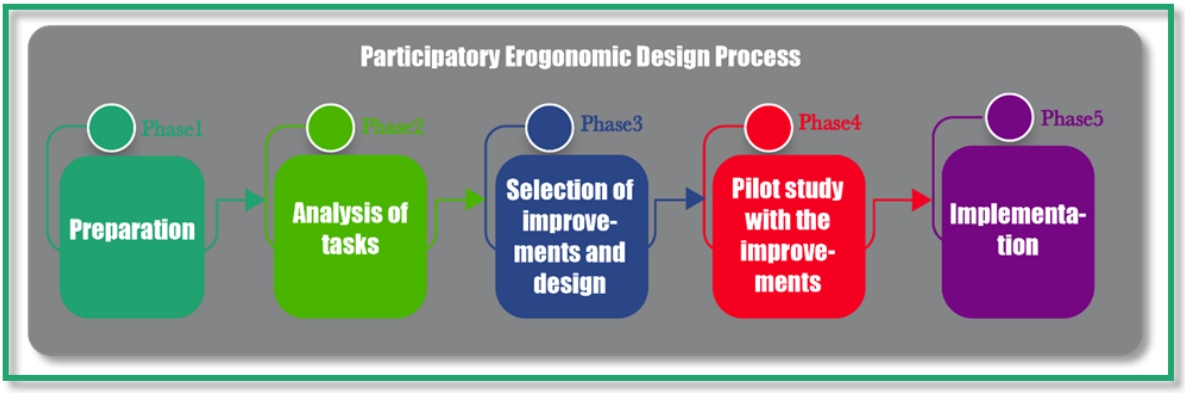


**Figure2: The used participatory ergonomics design process, adapted from Vink et al. (2006) and Kuijt-Evers (2006)**

### 3-1 Preparation

After 3 visits to the factory decision was made and the stakeholders were informed of the planned to redesign workstation and its overall goals. The stakeholders included end users (the two workers), management and the foreman. The overall strategy for how to involve them and turn their feedback into a solution was discussed with them.

**3-2 Analysis of tasks, work and health**

This phase is considered decisive for understanding the problem (Howard et al., 2008; Niku, 2009). A baseline for the design was established by studying the current practices, needs, problems and solutions suggested by the workers in the context of the workstation. This was achieved using direct observation, video analysis, interviews, or questionnaire. The aim here is not to change or guide, but to know in detail how the tasks are implemented. The workstation is made of metal steel frame, heavy duty 4 spaced square(3*2cm) rods for creating a space for the tested Irons before and after the tests, width of 120cm, depth of 35 and a height of 90, there is a steel sheet fixed at the back side of the benchwork where sockets connecting to electricity are fixed, source of water is a bucket stored underneath the workstation, no storing unites attached

a- The worker manually picks up the irons when delivered, from the assembly line to his right, then arranges them upside down on their place on the surface in front of him [difficulty1].

b- The worker plugs in the iron and waits for it to heat up then, unplugs it from electricity source(socket), the electric socket in which he plugs the iron is far from the level of his arm and hand [difficulty2]

c- The worker bends over and takes water from a bucket placed under the workstation using a standard cup and fills the iron spray container [difficulty3].

d- The worker presses the steam button to test the steam holes and presses the water button to test the water spray process. (wrist ach due to repetition). [difficulty4]

e- Once again, the worker bends down to empty the water from the iron in the bucket placed under the workstation and straightens back to put the fixed iron on its place on the assembly line to finish its cycle till end of production. That is again in a lower level of the workstation which causes a wrist pain for the worker at the end of his shift due to uncomfortable repeated movements[difficulty5].

f- The irons that need to be returned back for fixing, are put back in their place on the workstation till another worker comes to pick them up [difficulty6].

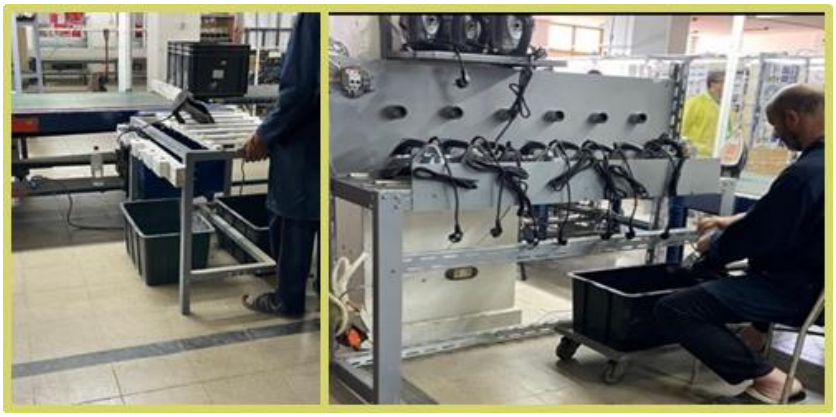

**Figure 3 shows the workstation Design and its relationship with the worker**

**Figure4: shows the steps of the task.**

### 3-2-1Result of CMDQ Scores

Table1: scores of activities done by the two workers using their old workstation (W1stands for worker1&W2 stands for worker2)

| Body parts | Plugging & unplugging the iron | | Filling sprayer with water | | Testing water & vapor esteem spray | | Emptying water sprayer | | Iron put back on assembly line | | Irons need fixing returned back | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Worker 1,2 | W 1 | W2 | W1 | W2 | W1 | W 2 | W 1 | W 2 | W1 | W 2 | W 1 | W2 |
| neck | 6 | 14 | 90 | 20 | 90 | 90 | 90 | 90 | 45 | 90 | 60 | 20 |
| shoulder | 20 | 90 | 14 | 30 | 31. 5 | 40 | 90 | 20 | 90 | 90 | 40 | 90 |
| | 1.5 | 3 | 1.5 | 14 | 6 | 10 | 20 | 10 | 0 | 3 | 0 | 0 |
| Upper back | 1.5 | 14 | 14 | 20 | 7 | 30 | 10 | 40 | 60 | 10 | 20 | 1.5 |
| Upper arm | 14 | 45 | 90 | 3 | 60 | 40 | 21 | 3 | 60 | 10 | 20 | 14 |
| | 3 | 1.5 | 14 | 0 | 0 | 1.5 | 30 | 90 | 0 | 3 | 0 | 7 |
| Lower back | 20 | 14 | 90 | 90 | 90 | 60 | 90 | 90 | 0 | 90 | 90 | 90 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| forearm | 0 | 0 | 1.5 | 1.5 | 45 | 45 | 3.5 | 14 | 20 | 7 | 45 | 45 |
| | 0 | 0 | 0 | 0 | 0 | 7 | 45 | 30 | 0 | 0 | 6 | 0 |
| wrist | 45 | 90 | 60 | 90 | 90 | 40 | 14 | 6 | 20 | 20 | 90 | 90 |
| | 1 | 6 | 5 | 10 | 0 | 6 | 30 | 90 | 0 | 3 | 0 | 0 |
| Hip/ buttocks | 0 | 3 | 7 | 40 | 14 | 1.5 | 14 | 1.5 | 0 | 20 | 0 | 14 |
| thigh | 0 | 40 | 1.5 | 20 | 3 | 1.5 | 7 | 3.5 | 1.5 | 1.5 | 0 | 5 |
| | 0 | 20 | 14 | 90 | 1.5 | 20 | 1.5 | 3.5 | 0 | 7 | 0 | 3.5 |
| knee | 14 | 30 | 60 | 20 | 60 | 90 | 60 | 30 | 3.5 | 90 | 60 | 60 |
| | 14 | 7 | 15 | 90 | 15 | 90 | 60 | 14 | 3.5 | 90 | 20 | 60 |
| Lower leg | 3 | 31.5 | 14 | 20 | 14 | 1.5 | 5 | 40 | 20 | 10 | 0 | 0 |
| | 3 | 31.5 | 14 | 6 | 14 | 3 | 20 | 10 | 5 | 7 | 0 | 0 |
| foot | 45 | 90 | 40 | 60 | 40 | 60 | 1.5 | 0 | 40 | 0 | 10 | 7 |
| | 45 | 90 | 10 | 14 | 10 | 7 | 0 | 0 | 10 | 0 | 10 | 7 |

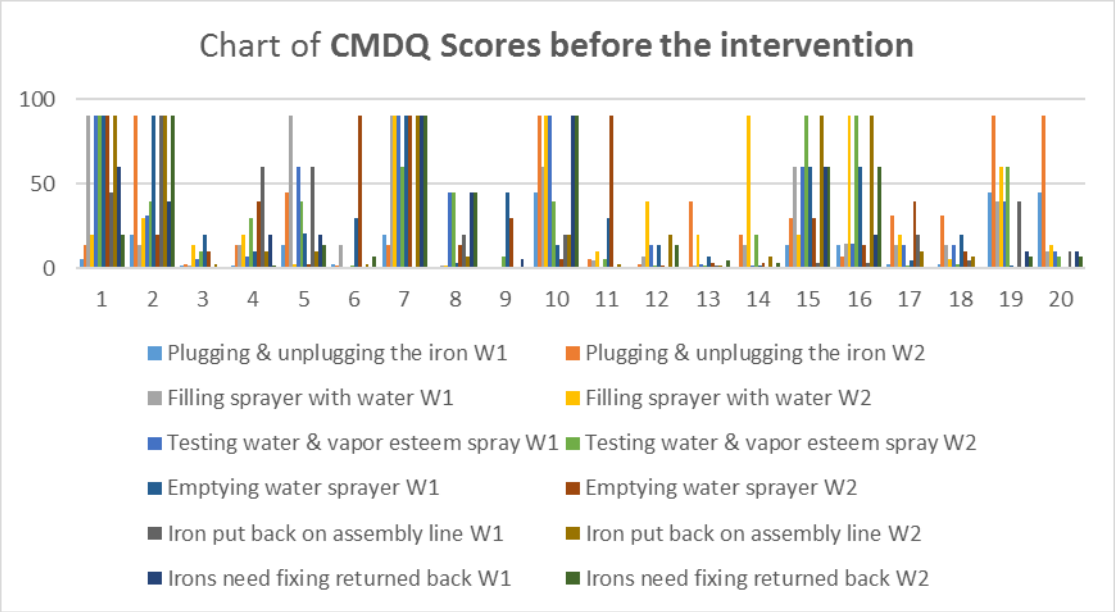


**Figure5: Chart of CMDQ Scores before the intervention**

### 3-2-2 Musculoskeletal Disorders: Evidence for its Work-Relatedness:

- The way the irons are laid on the counter gives a very bad grip posture that causes lots of strain on the wrist and fingers
- High levels of repetition (e.g. the task takes 5 minutes per iron and each group delivered contains 8 irons.

- The delivery continues happening each 40 minutes- shift of the worker is 480 minutes minus 60 minutes break which would lead to average 80 irons to be tested).
- Poor work position and posture (there isn't enough space to work on the bench surface so, the worker puts the iron on the bucket edge with his left knee stuck to the backet and bends in a real uncomfortable position to be able to finish the task)
- Awkward manual handling tasks;(the partition at the end of the irons location is high and forces to worker to bend his wrist in a real uncomfortable position in order to pick up the iron)
- excess bending, stretching or effort. ;(bending to pick up the iron, then bending down to fill it with water, then bending to un fill the iron tank with water and bending forward again to relocate the iron in its place).

**Needs as stated by the researchers:**

- Top work surface has to have enough (benchwork counter) room for the user hands movement within the right rich zone while working to avoid any strains on the wrist and elbow.
- Water tap must be on the standing workbench top surface and it should be connected to a sensor to reduce wrist movements to open the tap.
- Height of the workbench is suitable for a standing position, leveling up with the workbench surface, water tap level and assembly line, as the worker needs to change body posture from time to time in order to avoid lower back& neck pain.
- Adjustable workbench would be a great solution but, would require a higher budget. Platform for shorter worker can solve the issue.
- A space for saving personal belongings of the workers is important.
- Sockets must be in a place where no awkward posture is required within the right rich zone.
- Irons allocation on the workbench counter, should be an easy and comfortable activity before and after the test.

**3-2-3 Needs as stated by the workers:**

As part of the participation in the design process, workers were asked to write down their needs related to their workstation, the following is a translation to what they have wrote in Arabic:

**a- Worker1**

- I need a water tap & a sink suitable to my height and sitting position I'm tired of continuous bending.
- I need an easy access to the irons I have to bend my wrist and that hurts a lot
- I want to stand up while doing my work, but the bucket is very low and the counter height is not suitable for either standing or sitting.
- Easy access to plug and unplug the iron I stretch my arm so much and my shoulder ache
- Enough space for testing the efficiency of the steaming and spraying water process to bench has no space for that, I have to carry the iron on my lap while testing it
- I need labels to put on the iron with deficiencies.

**b- Worker2:**

- A place on the workstation for water bucket will make my job a lot easier
- I think the sockets will be better in front of me at the level of my hand with outraising them.
- I need a place on the workbench to put the iron as I'm testing it.
- I need drawers to store my personal stuff& lunch
- I prefer to work standing and then rest from to time on a suitable chair as the available counter is not suitable for the task.
- I need a place for the not working irons, I get confused sometimes.
- I need more space for the irons, so I can finish more per test

**3-3 Selection of improvements and design**

We created the requirements that would meet the identified needs (based on worker's needs& wishes& ergonomic design considerations). Workers were allowed to express those needs through interviews and writing. When this input was collected, new design ideas were drafted, and evaluated by the researchers and the workers.

**3-3-1 Ergonomics Design Suggested improvements**

As specified by the Ergonomics systems associates incorporated (2009), work surface height is important and depends on the task being carried out. If the work surface is too low, the worker will have to bend over to work, if the work surface is too high the worker will have to raise his arms which puts extra pressure on the shoulders (Figure6).

- Provide a space for both workers knees and toes, enough clearance helps to ensure both workers to move and shift their body weight while change their postures
- Ergonomics systems associate incorporated stated that Enough thickness of the worksurface would enable the workers to get close comfortably to the workbench
- All frequent reaches must be kept within the workers' normal reach zone(figure7).
- Height adjustable workstations are the ideal solution, but in order to reduce the cost non-adjustable workstation would be more appropriate solution, well target the tallest user(177cm), and provide a platform for shorter worker(160cm), recommended height for counter is 110cm from the floor(10-15cm) under elbow level , a space for both workers knees & toes will be provided, working surface thickness is 42 cm to avoid causing pain when standing close to the front age in order to avoid digging into the workers 'thigh during work.

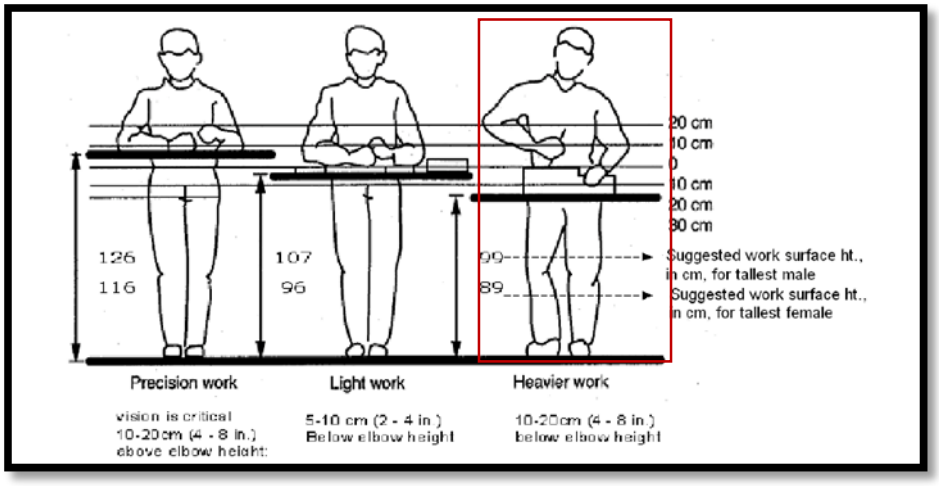


**Figure6: acceptable work surface heights for standing workstations.**

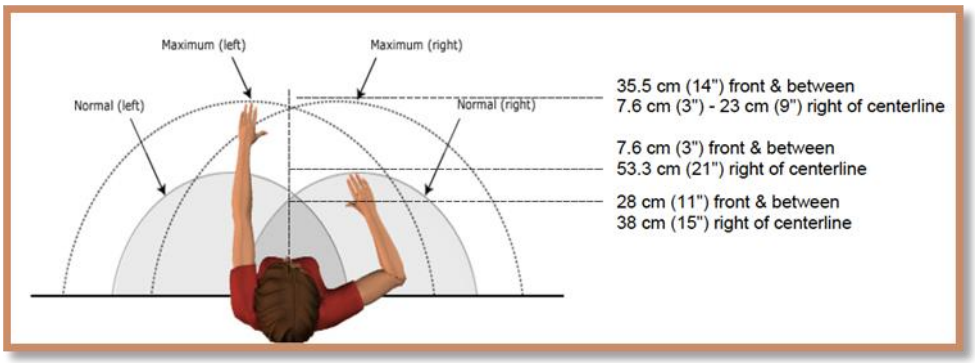


**Figure7: Workstation specifications- Reach distance- top view.**

### 3-4 Pilot study with the improvements

In This stage we tested the final design in 3D format(figure8&9) – it was tested in the context of the if it would work in real life workplace in order to direct attention away from details that shouldn't be the subject of feedback. After identifying the problem in phase 2, an ergonomic workstation was designed. The design reflected the needs of the workers and aimed to reduce the ach, pain and uncomfortable postures as indicated from the CMDQ.

**Figure (8) Workers were shown the designs in 3D and had some comments related to irons place on the counter, and the storage area of the ones that is not working, notes were taken and modifications were made**

**Figure (9) modified design after a discussion group session with the workers.**

### 3-5 Implementation

Vink (2008) assured that it is extremely important to test any new design in real working environment and to re-evaluate the outcome in order to make sure the goals have been achieved properly. Taking facts from pilot study phase into consideration plus the low budget constrain–, a prototype was implemented in its real context. the prototype of the workstation was made of plywood& beech pine wood. Workers were guided and educated about the new design advantages, the workstation was left for use in the factory for three-weeks' trial, then CMDQ was distributed again to see if the workers pain, ache, uncomfortable signs are less, same, or even more than before. Scores were calculated and compiled in one table as before the intervention.

**Figure10: The new workstation prototype in use**

The workers neck, shoulder, lower back and knee pain became less and the repetition of the pain is becoming less, even the effects of ach, pain and feeling uncomfortable, on doing their task is becoming less.

**Figure11: The new workstation prototype.**

**Table2: scores of activities done by the two workers using the new designed workstation (W1 for worker1&W2 for worker2)**

| Body parts | Plugging & unplugging the iron | | Filling sprayer with water | | Testing water & vapor esteem spray | | Emptying water sprayer | | Iron put back on assembly line | | Irons need fixing returned back | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Worker 1,2 | W1 | W2 | W1 | W2 | W1 | W2 | W1 | W2 | W1 | W2 | W1 | W2 |
| neck | 1.5 | 0 | 20 | 7 | 7 | 7 | 14 | 3.5 | 14 | 3.5 | 3.5 | 1.5 |
| shoulder | 7 | 10 | 1.5 | 14 | 3 | 7 | 10 | 5 | 20 | 20 | 3.5 | 7 |
| | 1.5 | 3 | 1.5 | 14 | 1.5 | 1.5 | 10 | 3.5 | 0 | 0 | 0 | 0 |
| Upper back | 0 | 1.5 | 3 | 7 | 3 | 14 | 3.5 | 3.5 | 14 | 3.5 | 3.5 | 0 |
| Upper arm | 3.5 | 14 | 20 | 1.5 | 7 | 10 | 1.5 | 0 | 3 | 3.5 | 3 | 1.5 |
| | 0 | 1.5 | 7 | 0 | 0 | 0 | 7 | 14 | 0 | 0 | 0 | 1.5 |
| Lower back | 3.5 | 3 | 14 | 20 | 3.5 | 7 | 7 | 7 | 0 | 14 | 3.5 | 7 |
| forearm | 0 | 0 | 0 | 0 | 14 | 3.5 | 7 | 3 | 1.5 | 1.5 | 14 | 6 |
| | 0 | 0 | 0 | 0 | 0 | 3.5 | 7 | 7 | 0 | 0 | 6 | 0 |
| wrist | 7 | 3 | 0 | 20 | 14 | 10 | 1.5 | 3 | 3 | 7 | 3 | 6 |
| | 0 | 1.5 | 0 | 7 | 0 | 1.5 | 7 | 10 | 0 | 1.5 | 0 | 0 |
| Hip/ buttocks | 0 | 1.5 | 1.5 | 3.5 | 1.5 | 0 | 14 | 0 | 0 | 7 | 0 | 7 |
| thigh | 0 | 5 | 1.5 | 0 | 0 | 0 | 1.5 | 1.5 | 0 | 0 | 0 | 3.5 |
| | 0 | 3.5 | 1.5 | 0 | 0 | 0 | 1.5 | 1.5 | 0 | 3 | 0 | 1.5 |
| knee | 1.5 | 3.5 | 5 | 1.5 | 7 | 3.5 | 7 | 7 | 1.5 | 3 | 14 | 7 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.5 | 1.5 | 1.5 | 1.5 | 7 | 3.5 | 7 | 3.5 | 1.5 | 3 | 7 | 7 |
| Lower leg | 0 | 3 | 1.5 | 10 | 1.5 | 0 | 3.5 | 20 | 3.5 | 1.5 | 0 | 0 |
| | 0 | 1.5 | 1.5 | 3 | 1.5 | 0 | 3.5 | 3.5 | 3.5 | 1.5 | 0 | 0 |
| foot | 14 | 20 | 20 | 40 | 5 | 7 | 0 | 0 | 3.5 | 0 | 1.5 | 1.5 |
| | 14 | 20 | 3.5 | 20 | 3.5 | 7 | 0 | 0 | 3.5 | 0 | 1.5 | 1.5 |

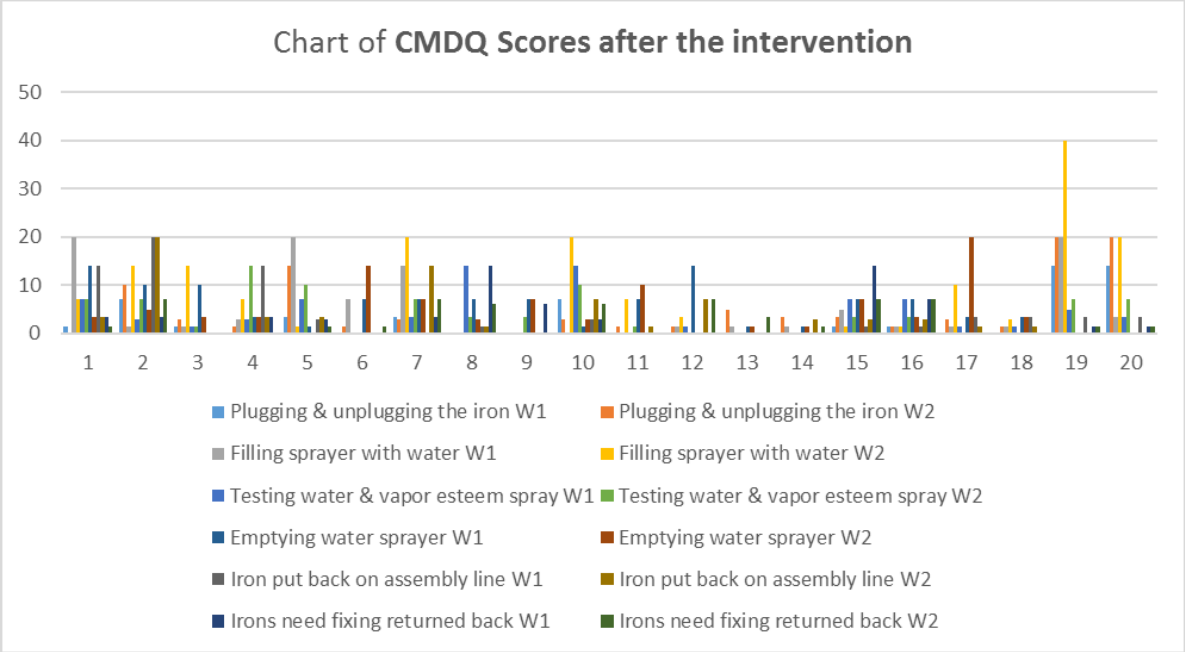


**Figure12: Chart of CMDQ Scores after the intervention**

## 4- Discussion

This study shows how participatory ergonomics Design can contribute to practical, within low budget workstation design solutions. Same task description was implemented before and after the intervention. as it can be noticed in the photos, the new workstation design allowed workers to adopt better working postures during all the activities of the task. CMDQ Scores after the intervention also confirms the improved body postures through the lessening of the scores for pain, ach and discomfort when compared to before the using the new workstation design, Workers who used the Prototype gave satisfied feedback.

## 5- Conclusion

For the conclusion of the study, the following points were inferred in the analysis, first, based on the evaluation of MSD using CMDQ, the workers in task activities experienced body discomfort on their neck, shoulder, wrist, lower back and knee. Second, additionally. Lastly, using the anthropometric data obtained from respondents, we were able to design an ergonomic workstation for workers. These workstation design where then compared to the existing design of workstation and determined that there is a mismatch or gap between the design that that is why the workers to experience body discomfort while performing their task.

## 6- Recommendations

- Including “Participatory Design” in national product design programs’ courses.
- Increasing the cooperation between industrial society& product design institutions, through joined conferences, seminars, protocols, etc....
- Offering factories ،counselling in design issues faced by workers through product design councelling centers in faculties.
- Increasing the dose of production ergonomics in ergonomic design courses in the offered product Design programs.
- Encouraging scientific efforts in this field either as translation, field studies, print outs, websites, etc…
- Encouraging joint research between product design academic faculties with other faculties interested in ergonomics like medical, physical therapy or production Engineering

**REFERENCES**

1- Borghouts, J., Koes, B., Vondeling. H, Bouter L. (1994), “Cost of illness of neck pain in the Netherlands in 1996”. Pain, 80, 629-636.
2- Bruce P. Bernard, M.D., M.P.H.(1997), “Musculoskeletal Disorders and workplace factors”, 5a-5.
3- Eason, K.D., 1995. User-centred design: for users or by users? Ergonomics 38, 1667e1673.
4- Ergonomics systems Associates incorporated” Guidelines for the design of the standing workstation” April,2009. 1, 2
5- F. Gerr, N. Fethke, L. Merlino, D. Anton, J. Rosecrance, M. Jones, M. Marcus and A. R. Meyers, "A Prospective Study of Musculoskeletal Outcomes Among Manufacturing Workers," Human Factors: The Journal of the Human Factors and Ergonomics Society, 2013.
6- H, Afifehzadeh-Kashani, A, Choobineh, S, Bakand, M. R, Gohari, H, Abbastabar, P,Mostagi.(2010) Validity& Reliability of Farsi version of Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)”,Iran.
7- Haines, H., Wilson, J.R., Vink, P., Koningsveld, E. (2002) Validating a framework for participatory ergonomics (the PEF). Ergonomics 45, 309e327
8- Hedge, A., Morimoto, S. And McCrobie, D. (1999) Effects of keyboard tray geometry on upper body posture and comfort, Ergonomics, 42 (10), 1333-134.
9- Howard, T.J., Culley, S.J., & Dekoninck, E. (2008), “Describing the creative design process by the integration of engineering design and cognitive psychology literature”. Design Studies, 29, 160-180.
10- Hussain. T, “Musculoskeletal symptoms among truck assembly workers (2004)” Occupational medicine (Oxford), pp. 506-512.
11- J. M.Deeb, "Administrative Controls as an Ergonomic Intervention. (2006) " in Interventions, Controls And Applications in Occupational Ergonomics, Boca Raton, Taylor & Francis Group, pp. 21-1 to 21-8.
12- McAtamney, L. and Corlett, E.N. (1993), “RULA: A survey method for the investigation of work-related upper limb disorders”. Applied Ergonomics, 24 (2), 91-99.

13- Niku,S.B. (2009) "Creative Design of Products and Systems". Hoboken, NJ: Wiley. Noro, K. and Imada, A. (1992), Participatory Ergonomics, London: Taylor & Francis.
14- N. M. Nur, S. Z. Md Dawal and M. Dahari (2014) "The Prevalence of Work Related Musculoskeletal Disorders Among Workers Perfoming Industrial Repetitive Tasks in the Automotive Manufacting Companies," in International Conference of Industrial Engineering and Operations Management, Bali.
15- Oğuzhan Erdinç, Kubilay Hot, Murat Özkaya (2008)" Cross-Cultural Adaptation, Validity and Reliability of Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)"Istanbul, turkey,.
16- Patry, L., Cote, M. and Kuorinka, I. (1991), "Participatory ergonomics of two work stations : Warehouse employees and police officers. " In: Y. Quéinnec and F. Daniellou, eds., Designing for Everyone: Proceedings of the 11th Congress of the International Ergonomics Association, Vol. II, London: Taylor & Francis, 1747-1749.
17- Østensvik, T, Veierste,K.B., and Nilsen, P. (2009), "Association between numbers of long periods with sustained low-level trapezius muscle activity and neck pain". Ergonomics, 52 (12), 1556-1567.
18- Sundin, A., Christmansson, M., Larsson, M (2004) "A different perspective in participatory ergonomics in product development improves assembly work in the automotive industry). International Journal of Industrial Ergonomics 33, 1e14.
19- Sundin, A., Medbo, L (2003). Computer visualization and participatory ergonomics as methods in workplace design. Human Factors and Ergonomics in Manufacturing 13, 1e17.
20- The University of Birmingham (1998)" Health& Safety guidance, Workstation Design, Guidance/5/wd/98". March.page1
21- Van der Linden, J. (2007), Ergonomia e Design: prazer, conforto e risco no uso de produtos. Porto Alegre: Editora UniRitter.
22- Vink, P., Imada, A.S, Zenk, K.J. (2008), "Defining stakeholder involvement in participatory design processes". Applied Ergonomics, 39, 519-526.
23- Vink, P., Koningsveld E.A.P., Molenbroek J.F (2006), "Positive outcomes of participatory ergonomics in terms of greater comfort and higher productivity". Applied Ergonomics, 37, 537-546.

**Websites:**

http://ergo.human.cornell.edu/ahSSCMDQquest.html