

A Study of the Application of Ergonomics in Ready-made Garments Factories in Egypt

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Abstract: Garment industry is one of the most important strategic industries which constitute about 7% of total industrial production in the world and 8.3% of the total trade in industrial materials. Also, occupies more than 14% of the total labor force in the world. It employs about 40 million people in various countries of the world. The garment industry suffers from poor efficiency of workers performance due to stress as a result of the following factors: (1) The inappropriate Design of equipment and tools used by the Group. (2) The inappropriate Design of the workplace. (3) The absence of a suitable work environment. The International Organization for Occupational Safety and Health Administration (OSHA) is concerned about providing protection, safety and occupational health of workers. For that their must be application of human Ergonomic which studies the working environment where there is a mismatch between the materials needed of equipments, tools and the physical capacities of workers, thereby reducing or limiting the Musculoskeletal disorder (stresses on the group during the performance of the work), which had not been applied ideally, till now in the garment industry in Egypt. Garment industry passes through numerous stages represented in the (Design - Action Pattern - cut - sewing of all kinds - Finishing – Ironing. etc.) and this research focuses on the stage of sewing and knowledge of occupational diseases resulting from it. By considering ready-made Garment industry and address the problems faced by the employees of poor organization of the workplace and the provision of (a appropriate chair, sewing Tables with standard specifications, comfortable pedals, and appropriate work place, good handling) we could achieve high added values in which we can develop the structure of the industry in Egypt and so increase the size of Egyptian exports. The research aimed at raising the efficiency of the performance of the garment industry, by examining the application of human ergonomics engineering which is interested in improving the employment and upgrading the conditions of the appropriate environmental factor (which prevent the stress-causing diseases). A field study was used in this method where a survey form was prepared covered five different garments factories in different places in Egypt in the governorates of Cairo and Alexandria and El-Gharbia in addition to the observations and interviews. Through the data and information collected by the computers in the extraction of statistical indicators which give indications can be used in a comprehensive picture of strengths and weakness points in the garment industry, particularly in the stage of sewing, and through this step we reach the research results.

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1. Introduction

Garment industry offers opportunities to engage in competitions due to the participation of appropriate quotas from the global markets. This kind of industry in Egypt faces some obstacles as a result of the stresses experienced by workers at work such as:

- Physical stress of the muscles during the phase of sewing

(<http://www.osha.gov/SLTC/ergonomics/outreach.html>).

- Stress due to the continuous work on the computer in various stages of design.

- Stress due to the unsuitable workplace and stress at the stage of ironing, and handling (<http://www.osha.gov/SLTC/etools/grocerywarehousing/packaging.htm>).

Employment in the garment industry is of the most important factors of production, which cannot be compensated and if it is not preserved, that will affect the future of the industry. By providing comfort for them as a result of poor conditions inside these factories which do not take into account the importance of rest of the human factor. It's obvious that most workers in this industry suffer from many diseases, and thus after a certain period of time, we find that the vast majority of skilled workers abandon the profession and turn to other professions which they might see more comfortable.

Some previous studies that examined the improvement of working conditions and the environment in the garment industry in India noticed that we should expanded research using ergonomics to reach a solution to the diseases affecting workers

in the industry. (P parimalam, N Kamalamma and A K Ganguli (2005).

With a simple look, we find that what the workers needs is simple and inexpensive and at the same time may cause him rest if applied or may cause him health problems, if it is absent, for example a worker who works on a sewing machine needs to:

1. Appropriate chair to sit on during sewing.
2. A table with standard size and specifications for sewing machine.
3. The Pedal used in operating sewing machine should be in appropriate angle for convenient operation and the material made with appropriate specification.
4. The workplace should be appropriate to the process of sewing.
5. Proper Handling.

These factors are affected by the size and nature of the process of sewing. In order to overcome these diseases and troubles, we must find other suitable design alternatives which help to solve all the obstacles that workers face.

Therefore, good manufacturing includes identification of the most dangerous tasks that affect worker health and production quality. By setting controls and afford the resources that help reducing or preventing injury to reach the highest production quality possible.

The Organization of Health and Safety establish rules for reducing industrial diseases for many industries but it did not include some industries such as the garment industry, which raises interest in solving this problem as they are willing to contribute to eliminate remaining occupational diseases.

It encourages employers in the implementation of an effective process of working environment and their role will be as follows:

- Provide administrative support – care of workers - identify problems - implement solutions
- Develop reports of injuries - provide training for workers – evaluate the place and the work environment. - Use of research centers to participate in resolving this problem.

The scientific strategy to reduce occupational diseases resulting from the sewing process is to identify the group of diseases affecting workers and the reasons that led to these diseases, what are the appropriate design solutions to reduce or eliminate these diseases and to find out the efficiency of what has been applied. The Study of the effect of the new variables (machine - a place of work) on the performance and the efficiency of workers which results on determining the effect of new regulations in increasing the quality of production and on workers as well by not leaving their profession.

2. Practical experiences:

Identify the basic features that define the causes of occupational diseases resulting from the process of sewing in the garment industry in Egypt, as well as the role of ergonomics (human engineering) in achieving the ideal work environment, as well as identify constraints faced by both.

To achieve that, a survey form has been designed and developed previously referred aiming at renovating the garment industry in Egypt, which came in three themes, where the data was analyzed and statistically tabulated in appropriate manner. These three themes are: First: occupational diseases resulting from the process of sewing.

Second: tools used in sewing (chair - Desk - pedals etc.). Third: work environment includes (the distribution of the space - Handling - the appropriate distribution of leisure time - Lighting - Ventilation - Noise - health care). The research team conducted field visits to factories during the study of the project to find out the current situations through a survey form, the observations and in-depth interviews for these factories. The survey has been focusing on the following points: (- Martha j. Sanders, ma, Msoosh, OTR /L2004.)¹

	DISEASES	PAIN%		
		bad	average	simple
1	Neck pain			
2	Shoulder pain			
3	Pain upper back (spine)			
4	Lower back pain			
5	Knee pain			
6	Leg pain			
7	Thigh pain			
8	hip pain			
9	Foot pain (ankle)			
10	Forearm pain			
11	Annex pain (elbow)			
12	Wrist pain (wrist)			
13	Problems of low vision			

The field study of the garment factories tested come out with the following results:

3. Result and discussion

As a result of field study found that a large number of the workers in the garment industry are suffering from diseases of the spine, neck, wrist hands, feet, the mother, the knee joints and muscles of the paragraphs and visual impairment, hearing All this is to AFS design table sewing and the use of a wheelchair is appropriate and random order of the workspace and the distribution of lighting.

3-1 - Diseases caused by the use of a chair in the studied factories.

Through statistical analysis of the results showed significant differences between

the studied factories as a result of the use of the chair as table (1) shows:

Table (1) illustrates the moral difference as a result of the use of the chair.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.488097645	4	0.12202441	5.9087113	0.00463	3.055568
Within Groups	0.309774177	15	0.02065161			

The table shows significant difference with a rate of 0.00463 factories as a result of the use of chairs used by the workers and figure (1) below illustrates these relations.

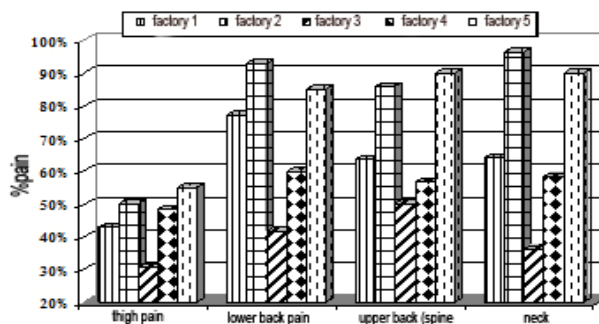


Figure (1): The percentage of pain resulting from the use of chairs

From the previous figure that the most affected factories by the use of chairs are factories number (1, 2, and 5) and the least affected ones are factories number (3, 4) because of the bad settings during the

process of sewing due to the quality of the chair. We will review some of these chairs to see their effect on back pain, neck, and thigh of the worker. The Chairs used for sewing machine in factories (1, 2, and 5) are

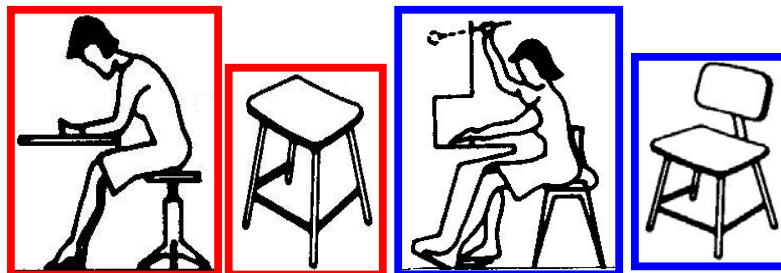


Figure (2) shows a sample of chairs used for factories (1, 2, and 5)

We discover from the figure that the chairs used in these factories are not suitable to sit on during the process of sewing. As it force the worker to stoop forward to complete the process of sewing and thus causing troubles and pains for the back and this is due to the lack of a back support of the chair and others with a wooden back. You cannot adjust the height considering workers tall, and also buttock and thigh pain are high compared to other factories as a

result of non-upholstered chair and a small area of seat as shown in the graph. Always each worker uses the appropriate method to sit comfortably on a chair by putting a pillow or fill chair seat with more things in order to be suitable for him only when sitting on the sewing machine, and then come another worker and changes the chair position in a way to suit him, and so on, without founding a fixed system in the

factory that cares of the proper environment for the workplace.

The definition of stress physically is (a force /an area) and in this case uses a weight instead of force thus stress becomes (body weight / area) and the space in question here is the base of the chair the less the base of the chair the more stress and this is what exactly happened in these factories. This is a result of poor specifications of chairs used during tailoring and irregular breaks during the shift which increase stress on the worker and causes lack of desire in the Working and hope to finish his shift in order to get rid of the chair he sits on it and thus affect the production process and quality (the Union of Needle trades, Industrial and Textile Employees, the Institute for Work & Health, and the Occupational Health Clinics for Ontario Workers, Inc. Copyright © 2001 UNITE).²



Figure 3: This sample shows chairs used for factories (3, 4)

These factories differ from the previous ones so they use another type of chairs as shown in figure (3).

They seem appropriate for workers to use in sitting on sewing machine and thus reduce the stresses on the back due to the possibility of adjusting its height but its non-upholstered and back shape to the body causes pain in hip and neck area. Also we recognize through figure that the average pain were reduced for knees, legs and forearms lower than the

previous factories and this is due to the improvement of using pedals and regular lengths for all types of machines thus reduces stress on those areas of the body during the process of sewing.

The following figure (4) shows the incorrect posture of sitting on sewing machine, which often causes trouble for spinal cord as a result of bending forward constantly. Figure (5) below shows the allowable limits for the angle of dip backbone.



Figure (4): The wrong posture of sitting down causes curvature and pain on the back

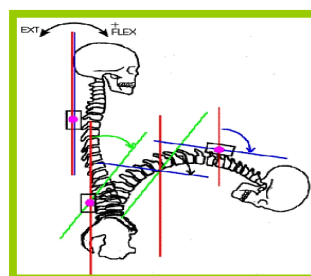


Figure (5): shows the form of curvature of the spine as a result of worker pending during sewing because incorrect sit

The angle of inclination of the spine in figure (5) is more than 60 degrees, which is higher than the permissible limits. The angle of inclination of the spine should not exceed 20 degrees, otherwise it will cause back pain. The inclination angle of previously used chairs in factories was more than 20 degree. By continuing this situation while sewing; workers in the garment industry will be led to many troubles,

which will affect their health- (P parimalam, N Kamalamma and A K Ganguli (2005).

Therefore, they must change these chairs with other chairs have special specifications fit the conditions of movement of the workers during the process of sewing and has all the ergonomic design requirements appropriate for the formation of the

spine and hip to prevent back, neck and thigh pain of the workers.

3-2 Diseases caused by inappropriate design of sewing table in the studied factories

Through statistical analysis of the results, we have determined significant differences between the studied factories as a result of the lack of inclination angles of sewing table and its sharp edges, as shown in table 2:

Table (2): shows the difference as a result of the lack of inclination angles of sewing table and its sharp edges

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.397335	4	0.099334	13.41624	0.000499	3.47805
Within Groups	0.07404	10	0.007404			

The previous table shows there is significant difference between factories with a rate of 0.000499 as a result of the lack of inclination angles sewing table and its sharp edges used by workers. The following drawing illustrates this difference by graphic Relations

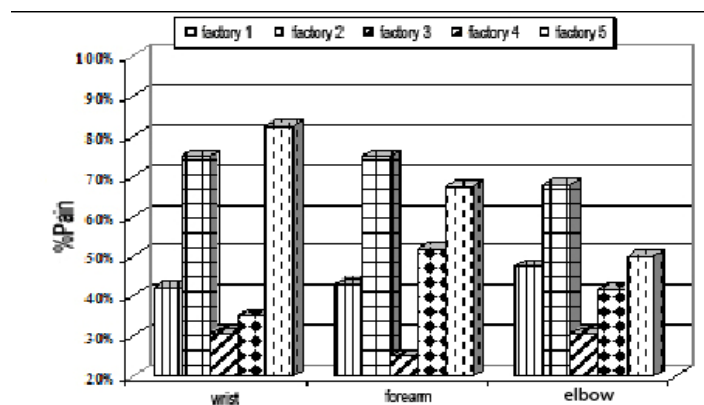


Figure (6): The proportion of pain resulting from the inclination angles of sewing table and its sharp edges

It is clear from the previous figure that the most affected factories are (1, 2, 5) due to the lack of inclination angles of sewing table and its sharp edges, in addition to the lack of an appropriate chair compensate to that lack. The least affected factories are (3 and 4) and this is due to the presence of an appropriate chair. The process of sewing requires that hands hold cloth down and push forward. The process of stretching arms to pull and push the cloth forward needs continuous effort, causing pain in hands, arms, and bending of the back. The pain increases sharply as a result of inappropriate sewing table design in its inclination angles and sharp edges, which makes the worker exert more effort to flatten the cloth during sewing, so we must search for design alternatives to reduce this pain. Figure (7) illustrates this <http://osha.europa.eu>



Figure (7): illustrates the effect of the design of inclination angles of sewing table and its sharp edges on hands and arms pain

As for the different heights of sewing table in the studied factories there are differences in height and shape figure (8) below illustrate this:

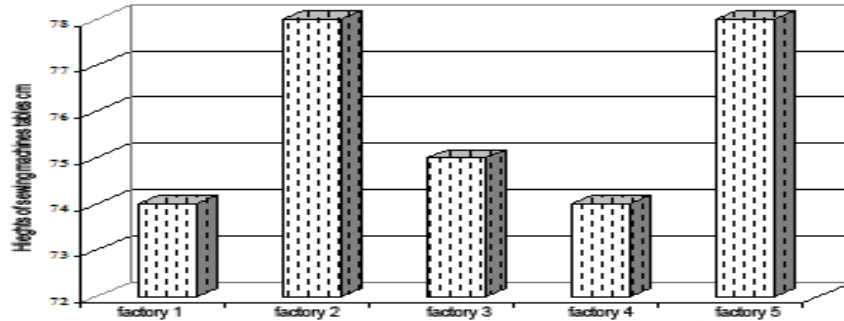


Figure (8): shows the percentage raises of Sewing Table

The previous figure demonstrates a discrepancy varying between heights of sewing machines tables, which in turn affects the rest of people at work. This indicates the lack of commitment of factories with standard heights suitable for sewing machines, considering adjusting heights to match the tall of workers. This causes major problems while working because of discomfort factor. It also increases the hands, arms and back pain. In addition to the above, despite the presence of natural and industrial light, the worker needs to add lighting in the machine to improve the vision of the cloth and maintain the vision of the worker. Beside

the level of noise in sewing machines could exceed the limit 90db, which could lead to hearing impairment or deafness of the worker? Furthermore, most sewing workers are of women, thus they need to shut the table side to hide their legs which must be taken into account in the design.

3-3 - Diseases caused by the different inclination angle of pedals in the studied factories

Through statistical analysis of the results turned out significant differences between the studied factories as a result of inclination angle of pedal as shown in table (3):

Table (3): shows the difference result of inclination angle of Pedal

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.65316	4	0.1633	15.39386	3.4437E-05	3.055568
Within Groups	0.159112	15	0.0106			

The previous table shows the value of P is almost zero which explains the difference between the studied factories due to the lack of appropriate

inclination angle of the pedal in sewing machines used by the factories and figure (9) below illustrates this difference.

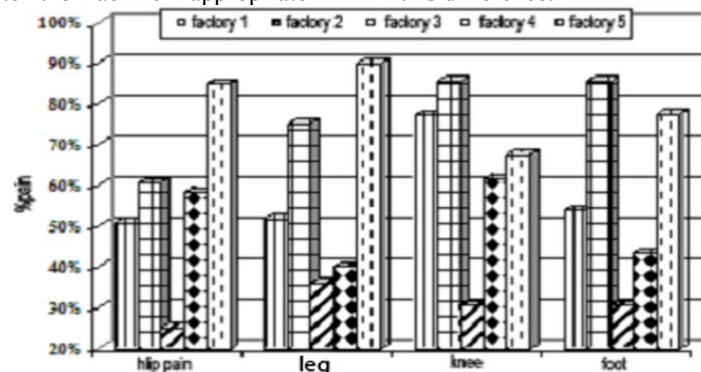


Figure (9): Shows the proportion of pain resulting from the inclination angle of pedal

It is clear from the previous figure how the foot suffers from stress during the process of sewing because of the type and inappropriate inclination angle of pedals in the way of movement carried out by the foot, whether left or right foot or both together.

At the factory number (2, 5), we observed a change in the focal point of pedal. Sometimes the link between motor and pedal is long and other times is short, which leads to a change in the effort made by the worker foot during the process of sewing, and hence lead to stress increase on the foot and the knee together during sewing. And figure (10) below shows a type of pedals used:

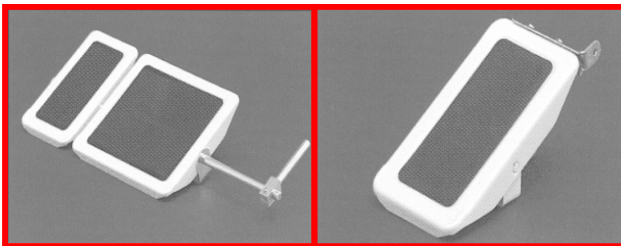


Figure (10): shows the types of pedals used

The previous figure shows the design of the used pedals by the user. As we notice high inclination angle of the pedal, which increases the stress on the worker's foot while running the sewing machine. Figure (11) below shows the ideal inclination angles of pedals that should be followed while using sewing machines.

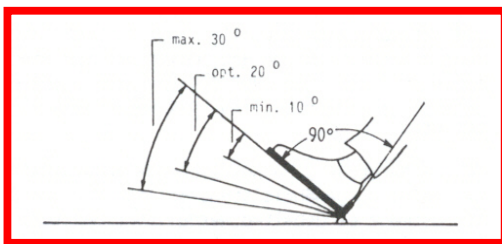


Figure (11): The ideal inclination angles of pedals used in sewing machines.

The previous Figure illustrates some of the different inclination angles of pedals used in sewing machines. The worker's foot must be in a right angle (90 degrees) on the pedal, while running sewing machines. The lowest inclination angle of the pedal should be 10 degrees, while the maximum angle is 30 degrees. In factory no (3) the ideal inclination angle used was 20 degrees, thereby reducing stress on the leg during sewing to 180 Nm, as shown in the following figure (Chris j. Snijders, 1998):

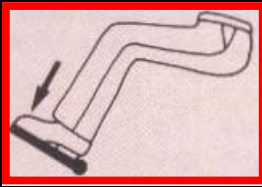
Description of Stress	The stress value in Newton	Type of stress
When the focal point is at the back and you press the pedal with the front part of foot.	180	

Figure (12): Shows similar movement of the foot in the factory

Regarding the legs and feet pain, they were more than 85% in factories (2, 5) followed by factory (1). It was observed that the irregular inclination angle of pedal is sometimes large (greater than 30 degrees), so the worker who sits on the sewing machine is forced to raises his feet up. Therefore, the inclination angle of foot on the leg becomes less than 90 degrees, which causes him tension stress on the heel, pressure on the instep, and thus causing trouble and pain of the foot.

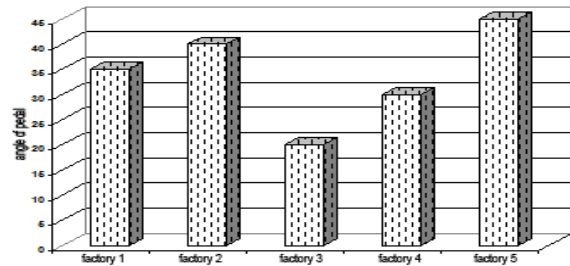


Figure (13): Shows the amount of pain because of difference in angle of pedal in factories

We can observe from the previous figure that the inclination angles used in the factory number (3), followed by factory number (4) is appropriate, as it registered the lowest inclination angle ranged between 20: 25 degrees. Although the proper angle should not exceed 20 degrees, it is the ideal angle during usage.

The difference in inclination angles resulted from the different lengths of the connection between the pedal and the operation motor. If this connection is broken it will be connected again, leading to reduction in the length of the connector and therefore high inclination, and so on. In the beginning, the inclination angle does not exceed 15 degrees and because of the frequent break of connector and reconnecting them up again this angle reaches 45 degrees. This lead to foot, knee, and crippling (hip) pain.

3-4 diseases caused as a result of different means of handling in the study factories

Through statistical analysis of the results we find out significant differences between the studied

factories as a result of different means of handling, as shown in table (4):

Table (4): Shows the difference result of different means of handling

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.480377525	4	0.1200944	10.895199	0.00115	3.4780498
Within Groups	0.110226878	10	0.0110227			

The previous table shows, the value of P 0.00115 which explains the difference between the different studied factories as a result of the different means of handling in factories and figure (14) below illustrates this difference in a graph.

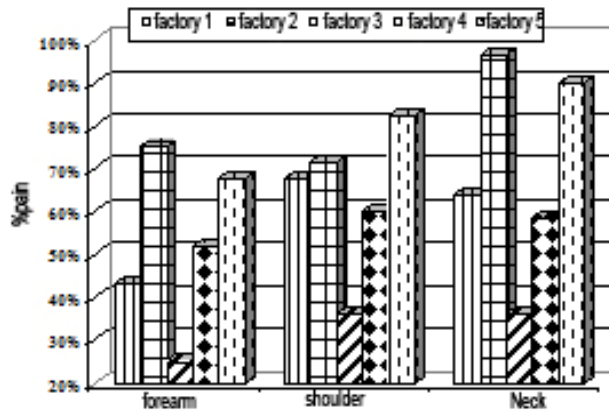


Figure (14): Shows the amount of pain as a result of different means of handling in factories

This figure shows the most affected factories because of bad design of handling process in factories number (2,5), followed by factories (4, 1, 3). The reason is that the handling unit is stable and far to the reach to by the worker, the chair is also fixed in place, leading the worker to rotate the upper part only to the left and right which makes him stress in twisting and causes pain in the neck, forearm and the back. But if the handling unit is adjustable to the needs of the sewing process and the seat has steering wheels, and movable, thus the worker will be able to rotate his body a complete cycle easily and avoid the pain of the shoulders and arms. We must look for other designs taking into consideration the upright position of the worker during handling. The following figure shows the position of a worker at the sewing machine during handling of the cloth (http://www.osha.gov/SLTC/etools/sewing_sp/index.html)



Figure (15): Shows the position of a worker at the sewing machine during handling of the cloth

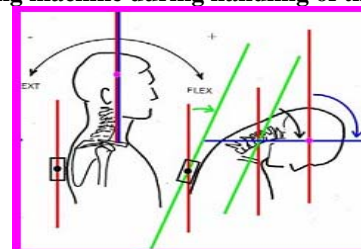


Figure (15): Shows the position of a worker at the sewing machine during handling of the cloth

The previous figure shows the wrong position during the process of handling while sitting on the sewing machine which leads to increase the inclination angle of the neck than the permissible limits (25: 65) degrees. This will lead to vertebra stress of the neck and back. This will be taken into account when designing a new handling method suitable for workers in garment industry to avoid neck pain.

3 - 5 diseases caused by the unsuitable workplace design in the studied factories

In addition to the above mentioned points and as a result of the observation of the research group, it has been noticed that the poor workplace design led to other diseases and reduce the speed of the production process and lack of quality. The design of the workplace contains (arranging the work components in accordance to the dimensions of the human body - Lighting - Ventilation - Noise), in addition to the social dimensions.

Regarding the order of components of the work:

To order the components of the sewing process efficiently around the worker so as to achieve speed, quality of this process, and to avoid any more stress.

While planning the worker position and the components in the workplace, we must take into account the following:

- To accommodate the work surface height and shape with the worker's body and type of work.
- Consider space limits within the body movement.
- All handling and modify process with foot should be in reliable positions within the natural movement of the worker body parts.

The concept in factories in arranging the components of the work is not as the former concept, but regarding the space between the sewing tables and concerning the given area the length of the space is large to an end, what is disproportionate to the speed of the process of sewing, quality, posterior borders, and mobility of the worker body.

For lighting:

It must be appropriate and compatible with the necessary requirements to perform the desired function of the worker, especially during the performance of assembly and finishing. Also the worker should be sitting in the right position during the operation without obstructing the visual perception and accuracy in discrimination. The best way for the light to be parallel with the natural lighting and close to the worker in addition to lighting joined to the machine itself to see the minute pieces. But for lighting in factories, it takes the orthogonal position with natural lighting and high for

the worker and one factory only takes the parallel position with natural light, but the elevation is not suitable for the worker. In addition to the lack of a lighting unit connected to the machine (Abdel-Nabi Abu al-Majd, first edition, 1420 E – 2000) figure (17) below illustrates this:

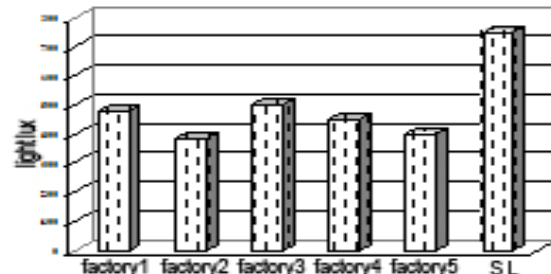


Figure (17): the amount of the impact of lighting on worker

The previous figure illustrates the most closer factories to using the best light distribution is factory number (3) then (1, 4, 5, 2).

For the noise: Noise is generated because of the lack of ongoing maintenance of machines and with the continuous use the noise increases, which lead to reduction or losing hearing. Also, there is absence of audio units next to the worker which send or receive instructions. This requires taking into account the periodic maintenance and running a system to receive instructions.

For ventilation: It relies on the traditional windows .we can also notice the absence of filters for dust suction and they do not give workers covers for their faces to protect their noses, which in turn leads to chest sensitivity.

We will review in the next part of this research designs that concentrate on all these obstacles faced by those workers on sewing machines in the garment industry to maintain their health and comfort and not forsaking the profession.

4-Conclusion

The garment industry in Egypt suffers from poor efficiency of workers performance at work, as a result of using inappropriate design of sewing table, seat, and workspace. The research target is to improve the performance of this industry by applying ergonomic human engineering which is interested in raising the efficiency of labor and improve the environmental conditions by preventing stress-causing diseases. I chose to use a field study method in this research which showed clearly how the workers face many health problems due to inappropriate equipments in performing the sewing process.

5. Recommendations:

1 - From the previous results it was observed that most of the factories of the garment industry do not stick to the standard specifications in the workplace which forces the worker to sit by till the end of the shift and he is not even allowed to complain of the inadequacy of the place or he will be subjected to harassment especially in private sector. As a result of these circumstances, ready-made garment industry has become expelling employment as a result of bad work conditions. Thus, these conditions and nature of work should be improved and this is what will be developed in Part II of the research work by creating design solutions to meet all these obstructions.

2 - We recommend that employers apply a systematic process to identify and resolve the problems of work environment, and integrate this process into the overall work programs to prevent injuries and occupational diseases.

3 - Engage workers in determining the workplaces threats, classification, and participation in resolving these problems. This leads to great success of design solutions and gives the worker motivation and satisfaction of the workplace. The worker will be required to do the following:

- Provide suggestions for what they suffer from.
- To discuss methods of work and the workplace.
- Participation in workplace design, equipment, procedures, and training.
- Evaluation of equipment and tools used.
- Respond to surveys employee.
- Participating in preparing tasks with the responsible groups for the work environment.
- Participating in developing the work environment by establishing a place of health care.

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