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Effect of Lab Environment on the Health and Performance of Students of Industrial Technical Institutes

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Abstract - *Poor design of computer laboratory can result in ergonomics risk factors that lead to work related musculoskeletal disorders of users. This study sought to apply ergonomics office guidelines in computer labs in industrial technical institutes and to study the effect of this on the health and performance of students. A questionnaire consisting of 40 paragraphs and divided into four sections was used to collect student's opinion about workstation design before and after ergonomics intervention. The research sample composed of 50 students. Ergonomics guidelines was applied to improve computer lab equipment such table, chair, keyboard, and monitor as well as the lab environmental conditions such as; lighting, noise, temperature, and ventilation. The mean response of the four parts of the questionnaire was (1.24) with a weight percentage 41.5%. This result shows the lack of ergonomics guidelines in the design of computer lab equipment. Practical experiments were applied to adjust the workstation design to adopt ergonomics guideline and study the effect of this on the health and performance of students. After ergonomics modification, the students mean response was found to be 2.84 with a weight percentage 94%. The highest score was due to the intervention of ergonomically designed chair. The chair consisted of arm rest and back rest that considerably relived low back pain. Finally, this study reached a set of conclusions such are incompatibility of computer lab equipment with the guidelines of office ergonomics will negatively affects the health and performance of students. Also, training on the correct use of laboratory equipment and tools will reduce stress and fatigue.*

***Key Words*: *Computer laboratory, ergonomics, p*hysical conditions, chair specifications.**

1. INTRODUCTION

The lack of applying human factors principles in the design of tools and workplaces has resulted in many injuries. These injuries such as lower back pain (LBD) costs exceeding $ 100 billion in the United States of America. For example, cumulative trauma disorder (CTD) today shares about 11% of all work-related injuries in the United States, and have caused many individuals to stop working for long periods of time or even permanently [1].

Sitting for long hours may cause back stiffness, numbness of the hands and feet, as well as fatigue and nerve infections in the wrist. The severity of these symptoms increases with time and usually appears after several years of persistence in these actions. In order to avoid such injuries, ISO 6385 specifies a set of guidelines when designing workplace layout as follows; 1. That the best angle for resting the eye while looking is the angle that ranges from (15-30) degrees towards the bottom, then the head must be in a position that reduces the pressure force on the neck muscles to the lowest possible extent, and that the head extends slightly forward, Also, the head should not be raised to the top, as raising the head to the top would strain the neck muscles. 2. The angle between the torso and thigh must exceed 95 degrees, preferably between (115-120) degrees, which reduces the pressure of the intervertebral disc and movement of the muscles in the back and works to straighten the spine. 3. The back of the chair should be supportive of the lower back lumbar spine. 4. The height of the chair should be adjustable in the sitting position. 5. The base of the chair must be with five legs to provide maximum stability. 6. That the low seat be large enough to provide support to the thighs and buttocks, in order not to put pressure on the back of the knees. 7. Easily adjustable low slope seat [1-2].

Work productivity does not depend on improving the work methods and good design of its layout, but on improving the physical conditions surrounding the worker such as; lighting, temperature, and noise that are specified by Iso10075. Good lighting is an essential ingredient in efficiency, health of workers, high productivity often depends on speed of visual perception and accuracy in distinguishing between parts. Individual requirements for lighting vary according to age, for a person who is (60) years old needs (10) times what a person who is (20) years old needs, and the degree of backlighting must not be less than (50 candle/foot), and the lighting is distributed uniformly [2-3].

An unwanted annoying sound causes stress and possibly deafness. Noise accompanies productive and manufacturing processes. In general, high levels of noise may lead to professional deafness and may lead to any death in the worst cases. The limits of hearing are 85 decibel (dB) in

laboratories and 65 dB in office work. The sound becomes disturbing when its intensity is 90 dB or more on the eardrum [2-3]. The rules of human engineering in this matter require that the work sites temperature not be less than 20 °C in winter and not more than 35 °C in summer in the indoor places in general, while the levels of humidity acceptable in the office ranges between (40-60) °C [1-3].

2. Review of Previous Published Studies:

David et. al. [4] sought to measure the impact of applying human engineering guidelines for computer users on their health and safety. The study was conducted on two groups of users; the first group practicing its normal activities without applying rules of human engineering and the second group in which these rules were applied based on both workstation design, internal arrangements for equipment, devices and spaces and the application of rules on chairs and offices according to the physical specifications of users in the second group. The study found that the absence level decreased from 4% to less than 1% in the second group. The error rate decreased from 25% to 11% in that group. This research recommended that ergonomics rules should be applied in computer offices.

Thaer Al-Samman et. al. [5] concluded that providing the material conditions of work and good workplace design based on the principles of human engineering helps reduce the risks of work and lead to increase productivity and health and safety of individuals. The best angle for the eyes while looking at the screen is (15-30) °C downward. The user of the computer screen should be in a position to reduce the pressure on the muscles of the neck to the strongest possible and do not lift the head up if it would strain the neck muscles. The keyboard and mouse should be placed at hand. The seat position should be adjustable in terms of seating and its base should be five legs to provide a high degree of stability. The back of the chair should be lumbar support.

Anjali Dwivedi [6] provided an assessment of the negative impact on students who use computers or other devices in India. One of the main findings of this study showed that students spend more than 5 hours a day. Most students who use the monitor more than 5 hr/ a day frequently suffer from visual disturbance, musculoskeletal disorder and headaches. The study recommended that the computer user should be given specific times for work environment training so that the computer user can have a slight change in their lifestyle.

M. Sherif Sirajudeen et. al. [7] assessed computer-based ergonomics knowledge for students of computer science and information technology in Karnataka. The research sample was taken from students of Engineering Computer Science and Information Technology. The questionnaire was used to collect Details on personal characteristics, computer usage and knowledge of ergonomics. The results showed that the majority of participants were unaware of ergonomics and had 32.8% correct responses and cumulative shock disorders 18.6% correct responses, elbow-related health attitudes 34.4% correct responses, wrist and hand correct responses 39.5%, observer level 35% correct responses, mouse placement 47.4% correct responses and mini breaks 42.9% correct responses. The study recommended that the need for training in a comfortable approach with regard to health attitudes and measures to reduce the risks of musculoskeletal disorders of students resulting from the use of computers.

A. Sen et. al. [8] sought to study the health risks resulting from excessive computer use such as Computer Vision Syndrome (CVS), low back pain, headache, tension and psychological and social stress. A questionnaire of 136 computer users was conducted on a sample of university students and office staff. The research found that many were using a standard keyboard and mouse without using any convenient adjustments to them and that about 50% of those with some lower back pain did not have an adjustable backrest chair. Many users had higher Rula scores in the wrist and neck suggesting an increased risk of developing Computer Vision Syndrome (CVS) that needed further intervention. More than (64%) were using refractive corrections and still had high scores of CVS including eye fatigue and headaches. Increased CVS scores indicating increased symptoms associated with increased computer usage times. This study recommended that further on-site studies are needed to follow up this survey to reduce the risk of CVS development among young computer users.

David et. al. [9] sought to measure the impact of the adoption of human engineering rules for computer users on the health and safety of users. The study was conducted on two groups of users, the first group practicing its normal activities without the adoption of rules of human engineering and the second group in which these rules were based on both workstation designs and internal arrangements for equipment, devices and spaces and the application of the rules on chairs and offices according to the physical and intellectual specifications of users in the second group. The study found that the absence level decreased from 4% to less than 1% in the second group. The error rate decreased from 25% to 11% in that group. The research recommended that ergonomics rules should be applied in computer offices.

Jannatbi L. et. al. [10] evaluated the effects of computer use on the eyesight of the researchers. The researchers conducted a cross - sectional study covering the city of Gulbarga 4 engineering colleges. The study population was interviewed using a pre-designed and pre-tested pro-model. The Snellen chart was used to measure visual acuity. The results of the study were that among the participants in the study impaired vision was more common among those who sometimes rest (right eye - 9.1%, left eye 9.4%) and less among those who rest their eyes a lot (right eye 2.3%, left eye - 2.5%. This study recommended the possibility of reducing the effects of the computer on the eyes by appropriate adjustment, placement of the computer and good protective habits of vision.

Abanum Isapka. et. al. [11] investigated the relationship between anthropometric data for Nigerian students in higher education, the ergonomic design of classroom furniture and the risk of musculoskeletal disorders. One hundred and seventy-five (175) students, aged between 17 and 34, were

selected in thirty-one (31) of the randomly selected classrooms in the research. Students' anthropometric data were collected by measuring different body dimensions such as sitting elbow height, shoulder height, knee height, height using human measurements, and tape measure. Also, the dimensions of classroom furniture were measured by a metal tape measure, a caliper and a goniometer. A survey was conducted using a questionnaire to identify areas of discomfort (MSDs) experienced by students. The research concluded that there was a mismatch between the available classroom furniture and the anthropometric data of the students. The study recommended decision makers and analysts in designing appropriate learning workstations that use different human student data in order to avoid the risk of musculoskeletal disorders.

Anjali Dwivedi [12] provided an assessment of the negative impact on students who use computers or other devices in India. One of the main findings of this study showed that students spend more than 5 hr/day. Most students who use the monitor more than 5 hr/day frequently suffer from visual disturbance, musculoskeletal disorder and headaches. The study recommended that the computer user should be given specific times for work environment training so that the computer user can have a slight change in their lifestyle.

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Rima Khawi [14] used the descriptive approach and adopted several tools including information gathering, interviews with workers who were exposed to work accidents, as well as observation. The use of a questionnaire designed by the researcher consisting of 20 paragraphs to prove or negate the hypotheses of the study. The comprehensive survey of the research community, estimated at 50 workers, was adopted and the statistical analysis of the data included the SPSS program by calculating the mean, standard deviation, iterations, percentages and graphical representation. The research revealed that the design of work sites role in the work accidents in the institution of tile industry under study the absence of anthropometric measurements in the design has a role in the work accidents at the tile industry in Barhoum - Messila. This study recommended improving the working conditions, providing all means of work and equipment for industrial security, adapting everything that surrounds the worker to his body measurements and capabilities, monitoring all work sites, analyzing the dangers that could cause future accidents and holding lectures and forums that raise interest in the subject of ergonomics.

From previous studies, it can be concluded that: ergonomics interventions in the material and physical work environment are necessary for the safety and health of students. The need for training in a comfortable approach with regard to health attitudes and measures to reduce the risks of musculoskeletal disorders of students resulting from the use of computers.

The objectives of this research are summarized as follows: 1- Evaluating and diagnosing the layout of the current computer workstations inside the labs of the Industrial Technical Institute in Zagazig. 2- Examine the impact of poor workplace planning on students 'achievement and productivity. 3- Implementing a new (engineering safe) chair design that fits with students' human measurements and evaluating the impact of the new design on student health and safety. 4- Training students on the work environment and its importance for their health, safety and academic achievement. 5- Identify work-related diseases associated with poor workplace design, such as back and neck pain, poor vision, and upper extremity disorders resulting from poor office and chair design. This study was conducted in the computer labs of the Industrial Technical Institute in Zagazig, which is one of the institutes of the Ministry of Higher Education

3. Methodology and Procedures

In this study, a questionnaire was applied to answer questions and then achieve its goals. The preparation of the questionnaire went through various stages: First, researchers designed and prepared a questionnaire. Second, it was presented to a group of arbitrators from the field of study including university professors. Third, it was developed according to the reviewer's comments. Fourth, the stability of the questionnaire was calculated by applying to a survey sample consisting of ten students. Fourth, the calculation of Pearson's correlation coefficient was 0.86 and the stability coefficient from the Spearman Brown equation was 0.92.

3.1 Sections of the questionnaire:

The questionnaire is designed to have four main sections:

1. The first section consisted of paragraphs (1-9) and was used to collect data about student's knowledge about office ergonomics and how you feel about it.
2. The second section consisted of paragraphs (10-21) and was used to measure the extent to which ergonomics rules related to the chair are applied.
3. The third section consisted of paragraphs (22-32) and was used to measure the extent to which ergonomics rules related to computer monitor are applied.
4. The fourth section consisted of paragraphs (33 - 40) and was used to collect data about the physical

conditions of the office work environment such as noise, temperature, lighting, and ventilation.

4. Results and Discussions

Before any ergonomics interventions, the questionnaire was used to collect student's opinion about the current layout of computer workstation and the position of monitor, keyboard, and chair as well as the current lighting, temperature, and noise levels. The students of the institute in question use computer labs to study computer-drawing programs such as: AutoCAD where students spent more than 8 hours in the lab. The researcher interviewed the students after each lab session and asked them about work related musculoskeletal disorder and It was noticed that, by the researcher, repeat complaints of students and about pain in the neck, back, shoulders, eyestrain. In addition to, inability to interact between each other due to high noise level and poor lighting level inside the lab, especially computer laboratories are located close to public road for cars. The questionnaire was distributed to the students twice before and after ergonomics modifications. Students opinions were collected on a scale from 1 to 3 where 1 is dissatisfied, 2 is indifferent, and 3 satisfied.

4.1 Students opinion on ergonomics knowledge:

This section dealt with paragraphs (1 - 9) as shown in Table (1). Paragraph 1 showed that the student response to knowledge about ergonomics was 1.04 with a weight percent 35% indicating that students had no knowledge about office ergonomics. However the mean response after ergonomics interventions was 2.62 with 87%. The overall mean response for the first section was 1.29 with a weight percent of 43% before ergonomics interventions, however, the overall mean response was improved to 2.84 with weight 94% after interventions indicating that knowledge and training about human engineering rules and the safe use of computers, keyboard and mouse was very important for students.

Table-**1**: student's opinions on ergonomics knowledge before and after interventions

Item No.	Paragraphs	Mean response	Weight %	Mean response	Weight %
1	You have knowledge about ergonomics.	1.04	35	2.62	87
2	The material and physical components of the laboratory are good and have a positive effect on health and performance.	1.14	38	2.82	94
3	Computer users are trained to prevent disease.	1.12	37	2.88	96
4	The work desk and chair design is suitable for spine comfort when using a computer.	1	33	2.98	99
5	The office and chair dimensions are suitable for shoulders rest when using the computer for a continuous period of 4 hours.	1.08	36	2.92	97
6	Mouse and keyboard on the same surface.	1.16	37	3	100
7	The mouse design is suitable for the hand and does not cause carpal tunnel inflammation (wrist)	1.66	55	2.76	92
8	Workplace design, good arrangement and increased performance.	1.24	41	2.9	96
9	Aesthetics, comfort and safety are taken into account in the design and implementation of practical exercises for your specialty.	2.18	73	2.76	92
Average		1.29	43	2.84	94

4.2 Students opinion towards chair design:

This section of the questionnaire dealt with paragraphs (10-21) to determine the effect of applying ergonomically designed chair. The chair is adjustable to fit the disparity in physical body measurements of users. It is worth mentioning that the chairs used from hard wood type and non-adjustable and has no armrest and neither back support. As shown in Table (2), students mean response about the chair was 1.10 with a weight percent of 37%, which clearly shows absence of the principles of ergonomics, and rules in chair design, which negatively affects students health and performance and makes them get fatigued and feel uncomfortable. However, the researcher introduced ergonomically designed chair, make it available to the students use and got their opinion about it. It was found that students mean response 2.84 with a weight percent 94%, which means that ergonomically designed chair meets their expectations.

Table **-2**: Student's opinion about the use of poor design chair and ergonomically designed chair

No.	Paragraphs	Mean response	Weight %	Mean response	Weight %
10	You can adjust the height of	1	33	2.98	99

	the chair to fit your height				
11	You can adjust the back of the chair to reduce lower back pain. (At an angle from 90 ° to 113 °).	1	33	2.92	97
12	The seat can be adjusted to make the distance between the back of the knee and the edge of the seat (2-4) inches, i.e. approximately (5-10 cm).	1	33	2.96	98
13	The chair design is convenient and reduces the feeling of knee pain when using the computer.	1.08	36	2.98	99
14	The chair has adjustable armrest.	1	33	2.96	98
15	The feet are attached to the floor when sitting on the chair.	1.54	51	2.94	98
16	The chair is flexible in use and reduces fatigue during prolonged sitting.	1	33	2.98	99
17	Streamlined back design with lumbar support to reduce back pain when sitting for 4 hours continuously.	1	33	2.96	98
18	The chair allows you to rotate to interact with the annotation and apply it to your device.	1.02	34	2.96	98
19	The chair manufacturing material is good, comfortable and does not affect your focus and performance in the lesson.	1.06	35	2.94	98
20	The thighs are almost parallel to the ground.	1.2	40	2.84	94
21	Feet are flat on the ground for most of the time you use a computer.	1.38	46	2.92	97
	Average	1.10	37	2.94	98

4.3 Student's opinion toward monitor design:

As shown in table 3, Paragraphs (22-32) focused on knowing the extent of the application of ergonomics rules before intervention in using the computer monitor. Student's response was 1.74 with a weight percent 58%. Paragraph (22) shows the level of the screen top with the eye level or slightly less with student opinion about 1.4 and weight of 47%. For paragraph (23), shows the possibility of adjusting screen height in a manner that provides comfortable viewing. In general, this section (computer monitor) got a score of 1.42 and weight 47%, which is a low score indicating that the Ergonomics office rules are not applied. The researcher found that the screens are equipped by the manufacturer with all the capabilities that support the rules of ergonomics. The researcher attributed the reasons for not applying the lack of training and providing information on the optimal use of the computer screen until safety and comfort are available to the user. After ergonomics intervention, as shown in table 3, training students to adjust the top of the screen, (height, level of illumination, and correct way to sit in front of the screen). The overall average student score for the screen was 2.9, with a weight of 96%. This indicates that students adhere to the rules of ergonomics when using the screen.

Table-3: Student's response about computer monitor before and after ergonomics interventions

No.	Paragraphs	Mean response	Weight %	Mean response	Weight %
22	The top level of the monitor with the level of the eye or just below it.	1.74	58	2.92	97
23	The monitor height can be adjusted to provide comfortable visibility.	1.4	47	2.94	98
24	The monitor brightness level reduces eye fatigue when using a computer.	1.44	48	2.86	95
25	Monitor placement is	1.32	44	2.92	97

	suitable and can be adjusted and does not cause neck fatigue when using the computer for 4 continuous hours.				
26	Do you do exercises for your body parts, especially the neck and head, when using the computer.	1.28	43	2.82	94
27	The Monitor brightness level allows you to see all the icons and tools you use to work without eye strain.	1.3	43	2.96	98
28	You can direct the screen orientation to avoid any glare.	1.58	53	2.94	98
29	Adjusts the brightness and contrast of the screen lighting to suit you.	1.32	44	2.9	96
30	Computer screen free from glare stains.	1.54	51	2.92	97
31	The screen size is suitable and reduces fatigue and increased performance.	1.44	48	2.88	96
32	The head extends slightly forward so that the chin is tilted down slightly.	1.28	43	2.88	96
Average		1.42	47	2.9	96

4.4 Students response to lab physical condition:

Health and safety laws and standards for human engineering focused on the necessity of providing physical conditions in the work environment according to the specifications for each of them as stated in the ISO10075 standard. AS shown in table 4, Paragraphs (33-40) determine the extent of application of the rules of physical conditions in the laboratory. For example, Paragraph (33) related to the level of noise inside the laboratory, which must not exceed 85 decibels, got a student response 1.16 and a weight percent 39%, while, paragraph (35) got a score of 1.28 and a percentage 43% indicating that the temperature inside the laboratory and its effect on reducing fatigue are not satisfactory. Paragraph (38) obtained a response of 1.26 with a percentage weight 42%, which indicates that the level of illumination is low inside the laboratory causing eye strain and fatigue. However, Paragraph (39) obtained a score of 1.22 with a percentage weight of 41% indicating that adequate ventilation is not available in the laboratory. The average score for physical working conditions before interventions was 1.17 with a weight of 39%, which indicates in adequate physical conditions that affects comfort and productivity in computer labs. After improving the physical conditions inside the laboratory (heat - lighting - noise - ventilation) according to ergonomics guidelines and standards, student's opinion about the physical conditions improved to 2.68 with a weight 89 percent.

Table **-4**: Students response to laboratory physical condition before and after ergonomics intervention

No	Paragraphs	Mean Response	Weight %	Mean Response	Weight %
33	The internal noise level is low and does not cause stress or lack of focus (note that the noise level must be less than 85 decibels inside the laboratory)	1.16	39	2.24	74
34	Windows and walls are made of sound-proof materials so that external sounds do not reach the laboratory and negatively affect health and performance.	1.04	35	1.96	65
35	The temperature inside the laboratory is appropriate and reduces fatigue. (The temperature inside the laboratories is from 20 to 27 °C	1.28	43	2.94	98
36	Moisture content inside the lab is appropriate and does not make you feel uncomfortable	1.1	37	2.88	96

	and upset.				
37	Windows do not allow sunlight to fall into the devices.	1.06	35	2.84	94
38	The level of illumination inside the laboratory is appropriate and does not cause eye train. Located between 300 - 500 Lux)	1.26	42	2.86	95
39	There is adequate ventilation in the laboratory.	1.22	41	2.86	95
40	Students who wear glasses can see the screen without eye fatigue.	1.24	41	2.9	96
Average		1.17	39	2.68	89

4.5 Summary of Results:

Table (5) shows a comparison between the results before and after engineering modifications and the application of ergonomics specifications according to ISO10075 - ISO6385.

- The chair got the lowest students score 1.10 and a weight of 37% because using it for long periods of time will result in lack of comfort and fatigue and the feeling of neck, torso, and lower back pain. After modification, student's opinion improved to 2.94 with a weight percent 98%, which exports the rest of the axes in providing comfort and ease of use.
- The physical conditions of the work environment got the second order as the least degree before modification by 1.17 and a weight of 39% due to the lack of maintenance of the air conditioners and the presence of laboratories on public roads and next to the train road, which resulted in noise exposure as well as the low lighting levels. After making some improvements, students mean response was found to be 2.68 with weight percent of 89%.
- The Knowledge and training about office ergonomics got the third least score by 1.29 and weight 43%. This indicates that lack of knowledge and training for the correct use of computer and the layout of the mouse and keyboard on two different surfaces, which resulted in wrist and pain shoulder. After introducing knowledge and training on the safe use of computer, students score increased to 2.84 with a weight 94%.

Table-5: Summary of results before and after ergonomics intervention

	Before		After	
	Mean Response	Relative weight%	Mean Response	Relative weight%
Knowledge about ergonomics	1.29	43	2.84	94
Chair	1.10	37	2.94	98
Monitor	1.42	47	2.9	96
Physical conditions	1.17	39	2.68	89
Average	1.24	41.5	2.84	94

5. Conclusions and Recommendations:

- The material and physical conditions of computer labs in colleges of technology do not match the principles of human engineering.
- The majority of the participants in the sample before the intervention were not aware of the ergonomics and the importance of applying its principle.
- There is a correlation between the material and physical components of the laboratory and the health and performance of students.
- Providing the material and physical conditions for work based on human engineering principles helps reduce work risks and increases performance.
- Weak adherence of the sample members to the rules of human engineering to properly deal with the computer indicates a lack of guidance and training.
- Improving the performance of the participating students and increasing their satisfaction after engineering modification of the work components.
- Lack of complaint of feeling of back, neck and shoulder pain after using chairs that are adjustable according to the rules of ergonomics.

For the Recommendations:

- It is necessary to have anthropometric measurements for students at all levels of study separately to design the physical components of classes and classrooms according to their measurements to achieve the greatest degree of comfort.
- Providing material conditions for computer labs (chairs - tables - screen - keyboard - marking devices) that depend in their design on the rules of human engineering.
- Providing physical conditions (heat - humidity - lighting - noise) as appropriate in accordance with ISO10075, safety and health laws.
- Training students on the correct use of computers prevent injuries, diseases and increase performance.
- It is preferable to have the mouse and keyboard on the same surface to reduce arm and wrist pain.
- The forearms should be parallel to the floor when the hand is resting on the keyboard.
- The angle between the groin and thigh should be between 90 and 120 degree, and the two feet should be slightly forward.

- Chair must have adjustable armrests and the back of it must be supportive of the lower back lumbar spine.

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