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Ergonomic Design and Fabrication of Photocopier Machine Table

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Abstract

The purpose of this study is to improve the life span of photocopier machines by ergonomic designing and fabrication of table based on the anthropometric characteristics of photocopier operators. The approach to this research is essentially a quantitative approach. An ergonomic awareness survey questionnaire was used to study the prevailing opinion of photocopier machine operators concerning their awareness of the issue of office ergonomics and table design as a branch of workplace safety, health, and enhancing the life of machines were studied. A sample of 34 female secretaries, randomly selected, between the ages of 18 - 38 years, working in the Institute of Technology (IoT) in HachaluHundessa (HH) Campus, Ambo University (AU), Ambo, Ethiopia is considered for the anthropometric study. All anthropometric measurements were collected for every secretary in different department. Mean and variance are used as a measure of central tendency and spread respectively. The design and fabrication of the table is done accordingly.

Keywords:Ergonomic, Photocopier machine, Table, Anthropometric measurements

1. INTRODUCTION

A. Background of the Study

Photocopier machine is one the essential facility for the proper running of academic institutions. As these machines and paper are purchased from aboard in terms of foreign currency USD, proper utilization and care must be taken to increase machine life span and use of paper. Photocopy machines with accessories like tables with drawers are costly. Due to a number of reasons copying machine may stop working at any time. One of the main reasons for the photocopy machine's improper function is its placement and location on a table. The tables may be too high which leads to wrong photocopy, incomplete photocopy, horizontal and vertical (misfeed) wrongly placed paper for photocopywhich leads to wastage of electricity, paper, and ink. Secondly, photocopy machines are laying inappropriate on the ground level, located on a wooden pallet which leads to many other problems like the inconvenience of opening and closing paper drawers, employee backbone pain, injuries due to employee hitting their forehead on nearby objects (cupboard, metal shelf, table,etc).

Additionally, while cleaning the floor the dust particles and water drops go easily inside the machine which leads to the malfunction of the machine sensors, and eventually,the machine stops working. Thiscreates spare parts demand which is to be purchased from foreign in terms of USD. When the spare parts are not available on time, another new machine is taken from the store or purchase orders are prepared to buy a new machine instead of thinking of preventive measures for such issues in the future. Most of these cases have been observed practically in the study area. These all-mentioned problems emphasize the design and manufacturing of a copying machine table which will improve the life span of the copying machine, reduce the cost of spare parts, electricity consumption, paper wastage, prevent employee injuries, and proper functioning of the institution. Data collection is based on anthropometric measurements of office secretaries in the various department and employees in the central photocopy office in study area.

B. Design Considerations for Standing Workstations

The height of the work surface is vital and depends on the task being carried out. If the work surface is too low, the user will have to bend to work which increases stress on the spinal cord, if the work surface is too high then the user will have to raise their arms which puts undue pressure on the shoulders. Although it is not possible to fit a workstation height to all members of the population, in general, it is possible to fit the middle 90% of the population. The general recommended height for work surfaces is between 95cm to 110cm from the floor.

However, the height of the workbench will also depend on the task being carried out. For tasks that require precision, the work should be positioned 5cm to 10cm below elbow height. For those classified as light work, which requires little force, the work should be positioned between 10cm and 15cm below elbow height. For tasks classified as heavier work that requires more force, the working surface should be 15cm to 40cm below elbow height. If possible, adjustability should be built into workbenches. However, where this is not possible, raising the floor level should be considered for shorter users [1].

C. Statement of the Problem

Normally allphotocopy machines are available along with accessories like table with drawers. But the cost of the machine also increases if purchased with such accessories. When machines stop working, in most cases the new machine is taken from the store or purchase orders are prepared. In the department and office, most such cases have been observed instead of takingpreventive actions and proper actions to prevent the malfunction of photocopy machines.

FIGURE 1

INAPPROPRIATE HIGH LOCATION OF PHOTOCOPY MACHINE AT DEPARTMENTS

D. Significance of Study

The ergonomic design and fabrication of table for photocopier machine and their effect on operational performance is not widely investigated in Ethiopia in general. As a result, examining problems associated with photocopier machines and operators on operational performance in the context of this study is of paramount importance.

Even though there is relatively more literature about photocopier machines on ergonomically and environmental performance separately, there is a lack of attention from researchers on the effects of the design of photocopier machine table which effect of machine life and influence operational performance. For this reason, the researcher perceived that this study can be conducted for the first time in Ethiopian university (Ambo) which initiates others for future studies.

Finally, it is dedicated to providing references for university administrators and photocopier operators to use as a direction for the proper use of photocopier machines and about the effect of photocopier tables on operational performance.

E. Scopeof the Study

Geographically, the area of the study was delimited to AU with a particular reference toHH Campus (Ambo). Conceptually, the scope of the study also focused on the measurements of three major anthropometric characteristics of photocopy operators, dimensions for ergonomically designing photocopier machine tablesbased on anthropometric principles, and design cum fabrication of photocopier machine tables by using. The study used quantitative and explanatory research by using a random sampling technique. The sample size was 30 photocopier operators who are currently working in HH Campus, AU, Ambo, Ethiopia.

2. LITERATURE REVIEW

The photocopying process depends on the principle of electrophotography. In 1906 Rochesterfounded Xerox. In 1958 its name was changed from Haloid Photographic Company to Haloid Xerox and got fame due to Xerox 914, the first-ever commercial push button photocopier using the process of Xerography, developed by Chester Carlson [2].

Workplaces of workers had not always been safe, poor lighting, noise, heat stress, ventilation, extra working hours, and low wages were common challenges, which did improve to some extent in the course of the nineteenth century [3].

Ill health effects of industrial workers brought into focus the health and safety risks at the workplace which gave rise to the discipline of occupational health and safety which covers occupational hazards and injuries. Bernardo Ramazinni, an Italian physician recognized more than 200 years ago that work may adversely affect workers' health and productivity [4].

Providing a workstation that fits with users' anthropometry in order to encourage better or the so-called natural working posture is usually one of the major objectives in ergonomics application. Correct standing and sitting posture are considered important factors for the prevention of musculoskeletal problems [5].

Anthropometric measurements are an important consideration in designing ergonomically appropriate furniture (table, chair, bed, etc.) for universities. The availability of data on anthropometric measures, particularly for university employees is very limited in Ethiopia, and as a result, the design and fabrication of photocopier machine tablesare typically not based on anthropometric principles.

Thus, the present study was conducted to evaluate the possible mismatch between university furniture dimensions and anthropometric characteristics of Ethiopian university employees and to propose dimensions for designing a photocopier machine table based on anthropometric principles.

Over the years photocopy has become a mandatory component of offices, schools, and bookstores, as it has brought ease to our busy schedule Work, plays an integral part in people's lives. Up to 80% of the time is spent indoors of which 30% is the time at the workplace. Many things exist in the workplace that adds to discomfort, stress, and even injury. In a developing country like Ethiopia, less consideration has been given to the health and safety of workers, and workplace design and control measures are inadequately incorporated. Furthermore, due to the high illiteracy rate and lack of awareness the workers are exposed to occupational hazards either directly or indirectly which in most cases are not even perceived as hazards. The occupational illness and injury as a result greatly affect the worker's work capacity and puta psychological strain.

The demand for any task in reference to workers' capacity over a specific period of time needs to be analyzed for making an ergonomic fit working environment. The worker's task is accomplished in either desk sitting position, standing, or walking depending upon the type of occupation. According to the Occupational Requirements Survey conducted by the Bureau of Labor Statistics and National Compensation Survey program on Standing or walking versus sitting jobs in 2016 rationalizes that standing versus sitting varied by the Occupation for example waiters and waitresses spent 96.3% of their workday standing or walking and just 3.7% sitting. Similarly, the average rate was found to be 90%for the software developers, 80.7%for the accountants, and 80.3%for insurance sales agents spending an average of their workday sitting in 2016 [6].

Guidelines provided by the Department of Safety and Health (DOSH) on Standing Workstations have stated that it involves work that is carried out in a standing position with leg movements that are either dynamic, static, or a combination of both [7]. Work assignments at standing workstations can be categorized as light, average and heavy. It also depends on the worker and his or her ability to manipulate the power or force placed on the weight of the object that is being lifted. Standing workstations require the movements of the upper part of the body to distribute the load and the lower part of the body is used as a momentum to distribute the weight of the load lifted equally. Workers also require body movements such as bending and twisting their hands while their feet remain in a stationary position. The main purpose of ergonomics standing workstations is to minimize the discomfort experienced by the workers caused by uncomfortable working environments and to avoid designs that can cause stress to users.

Das and Sengupta [8] conducted a study that focuses on various problems related to ergonomics, specifically related to static body posture and its effects on the body of workers such as cumulative trauma disorders (CTDs). In addition, they also discussed about the ergonomic and systematic guidelines for implementation of effective designs to be applied at standing workstations in industries, which are appropriate with the population anthropometric data. Procedures to determine the workspace size for workstations and its importance in designing prototypes to evaluate the subject's effectiveness in performing the tasks. In this modern era workstations in the industrial sector are often categorized as light but require repeated movements.

Rampal and Chee [9] focused on the health levels and types of pain experienced by workers due to the work assigned to them and determined the relationship between working postures and repetitive movements that can lead to musculoskeletal diseases. Based on the results obtained, the highest ergonomics exposure effects were detected in the arm and wrist region at 68.8%, followed by standing, at 55.1%, and lifting weights using hands at 51.2%. Meanwhile, the highest degree of pain was discovered in the shoulder region at 42.8%, followed by pain in the calves, upper back, and the shoulder or wrist regions. This indicates that most pain experienced by the workers is concentrated in their shoulder region.

Messing and Kilbom[10] conducted a survey on ten sales personnel and kitchen workers and found they had to stand for long hours while at work and this had caused them to be in uncomfortable positions for long periods of time. Their pains mostly involved the lower regions of the body, the neck, shoulder, upper back, and wrist regions, mainly caused by work with inappropriate working positions and techniques. Poor standing working systems can cause pain, especially in the lower waist, neck, and shoulder regions. Pain in the upper region of the body is caused by work that involves climbing stairs and ladders, while pain in the arms and wrists region is often caused by work involving lifting heavyweights. The best method to design workstations is by reducing physical pressure on workers which may cause lethargy, pain, and discomfort while they are at work. To reduce and minimize pressure, several design principles can be applied, for instance, redesigning or rearranging the work structure to enable workers to sit and stand according to their needs. This also includes avoiding work assignments that require long periods of standing in static positions and providing chairs and tables for seating or standing at work. In addition, preparing workstation work accessories such as soft surfaces to stand on by using an anti-fatigue mat, suitable working shoes with ample space for feet as well as station work surfaces that can be adjusted according to the height of the workers.

Hsiao and Chen [11] believe ergonomic workstation designs are based on factors such as the trend, emotion, complexity, and work potential. These techniques will allow workers to perform various tasks freely and reduce static burden. Work and assignments can also be done in turns. In addition, the application of the "resting a while" system can also reduce the lethargy of workers while working. Common tasks performed while in the standing position are frequent handling of heavy items; frequent reachable and continuous movement using heavy force; frequent mobility to and from the workstation; and frequent force exertion, which required more energy [12, 13].

Anthropometric principles as well as the proper training and awareness of workers of how to use these ergonomic facilities [14]. However, despite what has been said about the importance of having ergonomic designs forworkplace facilities, it is still not enough to prevent the prevalence and complaints of work-relatedmusculoskeletal disorders. Thus, providing workers with ergonomic facilities as a classical approach to ergonomic intervention is not an end in itself. It is also important to discuss the level of ergonomic awareness of the workers which is also a risk factor associated with the cases of musculoskeletal disorders.

The provision and installation of various models of office ergonomic facilities in form of ergonomic computers, adjustable chairs, ergonomic work stations, etc., must be followed by an effective ergonomic awareness campaign as previous experiments have shown a significant reduction in the cases of musculoskeletal pains as a result of effective office ergonomic education and awareness campaigns through training, education, and guidelines [15, 16].

Ergonomics principles and ergonomics workstationsare the most important things to consider by the worker and company. Ergonomics means the science of fitting the workplace conditions and job demands to the capabilities of the working population. Besides, ergonomics also can be defined as a science of design [17, 18]. Ergonomics aims to design appliances, technical systems, and tasks in such a way as to improve the safety of humans, health, comfort, and performance.

The improvement of musculoskeletal health at work is one of the most important objectives of ergonomics [19]. According to the International Ergonomics Association, physical ergonomics issues include "working postures, materials handling, repetitive movements, work-related musculoskeletal disorders, workplace layout, safety and health" [20]. Musculoskeletal health can be maintained by controlling for risk factors.

III. RESEARCH METHODOLOGY

A. Research FrameWork

The approach to this research is essentially a quantitative approach. It is thus a research approach within the positivist paradigm. It involves a quantitative opinion survey of the secretaries'/photocopier machine operators' concerning their level of ergonomic awareness. Thus, an ergonomic awareness survey questionnaire was used to study the prevailing photocopier machineopinion of photocopier machine operators concerning their awareness of the issue of office ergonomics and table design as a branch of workplace safety, health, and enhancing the life of the machine. However, in order to corroborate the findings, an unobtrusive observation was conducted which observed the standing posture of the photocopier machine operators, which informs their level of ergonomic awareness and suitable table design followed by fabrication of table.

B. Area, Population,and Sample of the Study

The area of this study is HH Campus, Ambo University, Ambo, Ethiopia. The secretariats, office staff and the photocopier machine operators are randomly selected subjects for the research survey. The research was conducted from the period of June 2021 to July 2021.

The population of the study is the subjects of the research interest. In other words, they are the subjects of the observation. The populations of the study in this research are secretariats office staff and the photocopier machine operators/users.

To determine the sample of the population, 34 secretariats/photocopier machine operators are randomly selected. The adequate sample for the survey based on statistical analysis is 30.

C. Method of Data Analysis

The stages to be conducted in this study were as follows:

- Preliminary studies and identification of problems,
- Collecting data from secretaries'/photocopier machine operators',
- Anthropometric measured data analysis,
- Design of photocopier machine table based on anthropometric data,
- Material selection for the design of photocopier machine table
- Design of photocopier machine by using AUTOCAD.

1) Mean and Median*:* The mean (average) of all the scores will fall at the approximate middle of the bell curve. The mean represents the 50th percentile, where half of all scores are above that measure, and half are below. In normally distributed data, the median score will also fall at the center of the bell curve, representing the most occurrences.

2) Standard Deviations (SD) and Variance:Standard deviations and varianceare the measures of dispersion or deviation about the mean or average value. In normally distributed sets of data, a measure can be described as being a certain number of SD away

from the mean.SD is a measure of variance,or how dispersed, or spread out, the data is from the mean. If measures have a lot of variances, the bell curve is spread out; if they have little variance, the bell curve is narrow. The more SD away the score is, the less likely the score is to occur in nature.

3) Percentiles and Empirical Rule:When looking at a bell curve, 68% of the measures lie within one SDs of the mean. 95% of the distribution lies within two SDs of the mean. A whopping 99.7% of the measures fall within three SDs of it. These percentages, termed the empirical rule, are the foundation of statistical analysis of naturally occurring phenomena.

D. EthicalConsideration of the Methodology

Due process was followed in conducting this study. Formal permission was sought before conducting the observation on the respondents from the HH Campus, AU, Ambo,to conduct the research.

IV. RESULTS AND ANALYSIS

A. Materials and Methods

A sample of 34 female secretaries, randomly selected, between the ages of 18 - 38 years, working in the Institute of Technology (IoT) in HachaluHundessa Campus, Ambo University, Ambo, Ethiopia is considered for the anthropometric study

All anthropometric measurements were collected while each secretary was standing in an erect position, with straight knees on a horizontal surface and with the elbow bent at 90º. Measurements were taken in centimeters. During the measurements, the secretaries/ photocopier machine operators were wearing shoes and normal clothing, and all the dimensions were taken only from the right side of their body.

Two anthropometric measurements of secretaries (total height and height of the elbow when it is parallel to the horizontal surface) were recorded during a single session, and four table dimensions (table height, underneath table height, table width, table depth) from the existing furniture were measured. Illustrations of the selected anthropometric variables were shown in Fig.2.

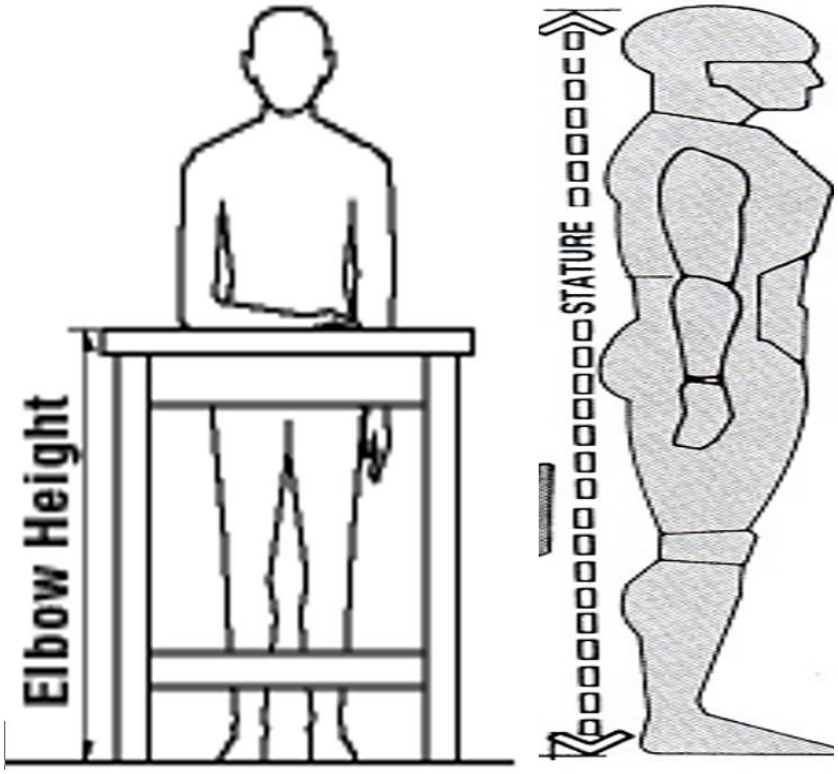

FIGURE 2

ANTHROPOMETRIC VARIABLES

The measurement equipment consisted of set squares, a bevel protractor, ruler, vernier caliper, a measuring tape, and a fixed measurement scale for stature. The measurements (including two anthropometric measures and four table dimensions of the table) were taken by three members.

B. Results and Discussion

There are enormous variations in body size among individuals. The body dimension should match the photo copier. On the other hand, any mismatch in the work environment leads to users' discomfort, low productivity, work hazards, and accidents. So, it can be said that the body dimensions of secretaries are important for the design of the table for the copier, particularly are used in academic institutions.

For selecting the design dimension of the photocopier table, different percentile values of the measured body dimensions of the secretaries were calculated. Three percentile values, 5th, 50th, and 95th, for each body dimension, were computed. The descriptive statistics (including minimum, maximum, mean, standard deviation (SD), and 5th, 50^{th}, and 95th percentile values) of the secretaries'/photocopier machine operators' anthropometric measurements are presented in Tables 1 and 2 respectively.The existing photocopier machines models and dimensions in the IoT, HH Campus, AU, Ambo are measured. The dimensions (height, width, and depth) are tabulated in Table 3. The existing photocopier machine support table dimensions are presented in Table 4.The mismatch between the existing copier machine table dimensions and the anthropometric characteristics of the university secretaries is very high.

Therefore, these results suggest that the design of a copier support table for university secretaries based on anthropometric data is a major consideration to promote a correct working posture and consequently reduce musculoskeletal problems among this group and improvethe life span of photocopier machine.

Thus, the findings from this study provide some useful contributions to our understanding of secretaries' anthropometry that can be used as a basis for designing copier tables. It has been noted that the table height should be considered the most important variable and the starting point for the design of the copper table.

The results showed that the table height mismatch in our study was mainly due to available table heights that were too high and too low. This means that photocopier operators have to bend while working or cannot see the operation as it is not at eye level. This situation may lead to increased tissue pressure on the posterior surface of the knee and spinal cord and consequently may cause serious discomfort or possible injury.Most of the machines are kept on the ground height on the wooden platform (pallets) which came as packing support or on a general working table (Fig. 2) having a standard height of 75cm.

Both of these arrangements made the photocopier display not at a convenient height level for the secretaries who are operating the copier machines. For this reason, new tables are designed and fabricated to address this problem.

TABLE 1

SECRETARIES'/PHOTOCOPIER MACHINE OPERATORS' ANTHROPOMETRIC MEASUREMENTS (CM)

Subject No.	Total Height	Elbow Height	Subject No.	Total Height	Elbow Height
1	160	102	18	158	105
2	156	97	19	171	112
3	155	99	20	158	105
4	156	99	21	159	107
5	160	97	22	158	103
6	154	96	23	162	104
7	165	104	24	169	103
8	156	99	25	157	104
9	159	96	26	157	103
10	160	99	27	166	108
11	161	101	28	163	106
12	156	100	29	165	110
13	158	103	30	165	108
14	157	105	31	160	102
15	161	104	32	175	111
16	167	106	33	166	108
17	158	100	34	165	108

TABLE 2

STATISTICS OF THE MACHINE OPERATORS' ANTHROPOMETRIC MEASUREMENTS (CM)

Items	Total Height (TH)	Elbow Height (EH)
Mean	160.97	103.35
SD	4.93	4.25
Minimum	154	96
Maximum	175	112
Range	21	16
5 Percentile	155.65	96.65
50 Percentile	160	103.5
95 Percentile	169.7	110.35

TABLE 3

MACHINE MODELS DIMENSIONS MEASUREMENTS

Sharp Machine Models	No. ofDraws	Height(cm)	Width(cm)	Depth(cm)
MX-M354U	2	68.58	58.42	49.53
MX-M464	1	72.39	58.42	58.42

TABLE 4

EXISTING COPIER MACHINE TABLE HEIGHTS(CM)

Machine	Height
1	8
2	75

C. Design of Photocopier Machine Table

The design procedure and material selection for the new table are explained in this section. The average elbow height (EH) of the 34 secretaries/photocopier machine operators is found to be 103.35cm. The elbow height at the 5 percentile is 96.65cm, at the 50 percentileis 103.5cm and at the 95 percentile is 110.35cm.

The average machine height (MH1) for model 1 copier machine (Sharp MX-M354U) is found to be 68.58cm and the average machine height (MH2) for model 2 copier machine (Sharp MX-M464) is found to be 72.39cm. The photocopier table height (TH) is calculated by using Eq. 1.

$$TH = EH - MH \quad (1)$$

According to Eq. 1, two table heights are calculated.

TH1 = EH - MH1

TH1 = 103.35 - 68.58; (= 34.77) ≈ 35cm

TH2 = 103.35-72.39; (=30.91) ≈ 31cm

The table height of 35cm is selected. The other dimensions (width and depth) are calculated for the two different machines by using the following equations.

Table width (TW) = Machine width + Allowance

Table depth (TW) = Machine depth + Allowance

TW1 = 58.42+ Allowance

TW2 = 58.42+ Allowance

TD1 = 49.53+ Allowance

TD2 = 58.42+ Allowance

D. Material Selection and Fabrication of Table

For the selected two table dimensions the selection of material is done and is presented in this section. For the base of the table mild steel (MS) square bars of cross-sectional dimension, 40mm x 40mm are selected. MS is corrosion resistive, has relatively high strength, is easily available, and is less expensive. These reasons made it the best material for the frame of the table. Different square bars of cross-sectional area (20mm x 20mm, 30mm x 30mm, and 40mm x 40mm) are available in the workshop. Considering the weight of the machine (65kgs) mild steel bars of the highest cross-sectional area (40mm x 40mm) are selected. Plywood of thickness of 2.54cm is selected and used for the top surface. Wood being electric resistant is selected for the top surface of the table. The table is designed in sketch up AUTOCAD software and the 2D and 3D views are shown in Fig. 3 and finally manufactured as shown in Fig. 4.

The ergonomic and life enhancement photocopier design of the two tables had dimensions of height 35cm, length and width of 50x50cm andheight 35cm, length and width of 60x50cm that could be suitable as per anthropometry data collected, with the calculation of mean, standard deviation, and 50^{th} percentiles. The manufactured photocopier machine table prototype as per design dimensions is shown in Fig. 4.

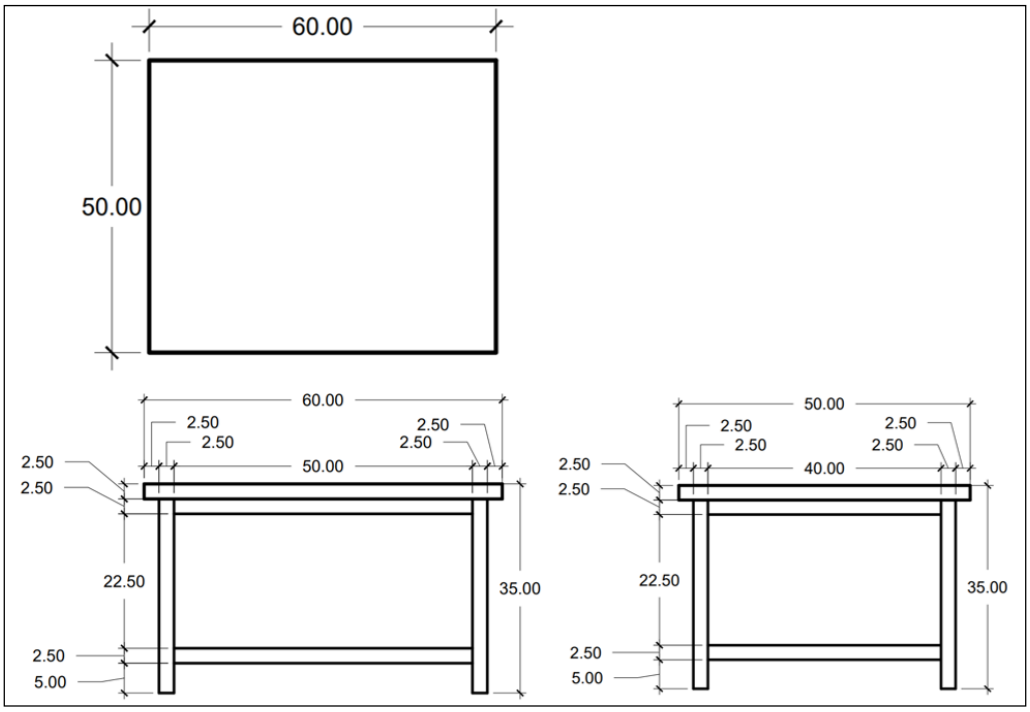

FIGURE 3

DESIGNEDPHOTOCOPIER MACHINE TABLE

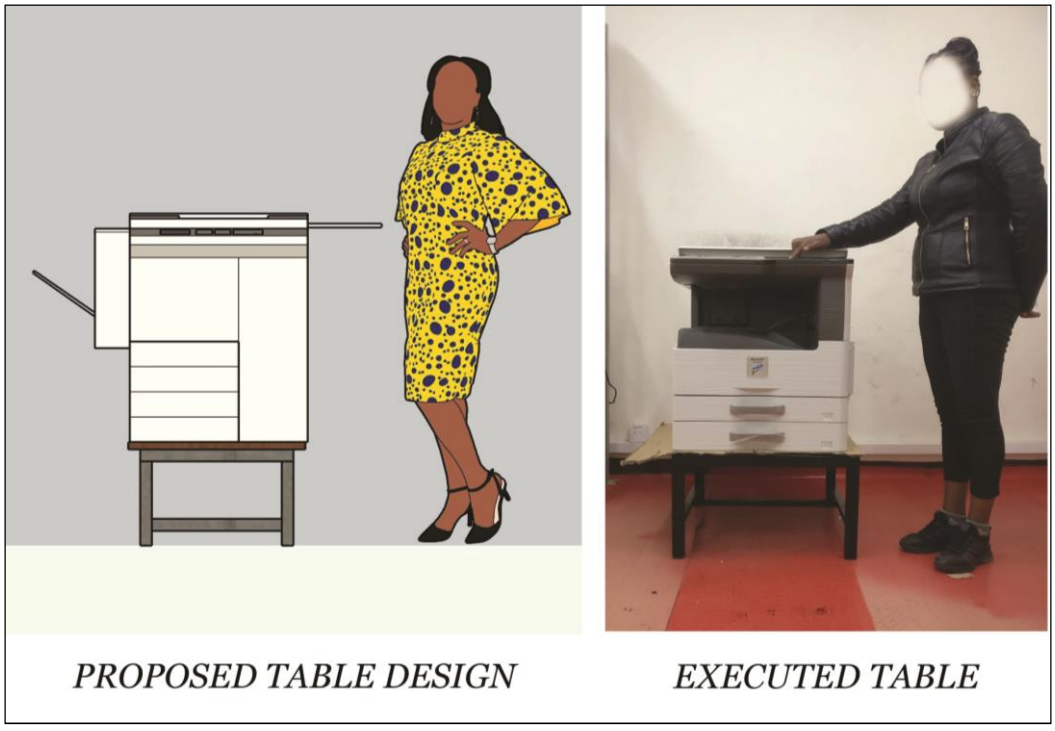

FIGURE 4

FABRICATED PHOTOCOPIER MACHINE TABLE

V. CONCLUSION

From the analysis of both quantitative and qualitative data which reveals the workspace design and work postures of the photocopier machine operators, it could be concluded that the photocopier machine operators are lacking in workspace design and ergonomic awareness which leads to photocopier machine malfunction.

Due to inappropriate placement of photocopier machine on lower floor level location (on wooden pallets),problems occur like employee backbone pain, hitting employee forehead to nearby objects (cupboard, metal self) during cleaning floor dust particles and water drops go easily inside the machine. While placing the machines on the standard table of 75cm high leads to problems

like wrong photocopy, and incomplete photocopy. These problems can be easily solved by designing a proper support table for the photocopier machine. The photocopier machine's life span can also be improved.

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REFERENCES

[1] GUIDANCE/5/wd/98. Health and Safety Guidance, Workstation Design. The University of Birmingham, (March 1998).

[2] S.R. Agha, School Furniture Match to Students' Anthropometry in the Gaza Strip. Ergonomics, 53, (2010) 344-354.

[3] K.D. Kelley, An Ergonomic Evaluation and Analysis for Identifying Cumulative Trauma Exposures in the Office Work Place. http://digital.library.wisc.edu/1793/39245 (1999).

[4] C.W. Lee, and D.J. Hsu, Measurements of Fine and Ultrafine Particles Formation in Photocopy Centers in Taiwan. Atmospheric Environment, 41(2007) 6598-6609.

[5] S.M. Siivola, S. Levoska, K. Latvala, E. Hoskio, H. Vanharanta, and S. Keinänen-Kiukaanniemi, Predictive Factors for Neck and Shoulder Pain: A Longitudinal Study in Young Adults, Spine, 29 (15) (2004) 1662-1669.

[6] Bureau of Labor Statistics, U.S. Department of Labor. The Economics Daily. Standing or Walking Versus Sitting on the Job. https://www.bls.gov/opub/ted/2017/standing-or-walking-versus-sitting-on-the-job-in2016.html(2016).

[7] DOSH, Department of Safety & Health, Malaysia, Guidelines on Occupational Safety & Health for Standing at Work. Ministry of Human Resources, Department of Safety & Health, Malaysia(2012).

[8] B. Das, and A. K. Sengupta, Industrial Workstation Design: A Systematic Ergonomics Approach. Applied Ergonomics, 27 (3), (1996) 157-163.

[9] K.G. Rampal, and H.L. Chee, Work-Related Musculoskeletal Problems among Women Workers in the Semiconductor Industry in Peninsular Malaysia. International Journal of Occupational and Environmental Health, 1 (2004) 63-71.

[10] K. Messing, and A. Kilbom, Standing and Very Slow Walking: Foot Pain Pressure Threshold, Subjective Pain Experience and Work Activity. Applied Ergonomics, 32 (1) (2001) 81-90.

[11] K.A. Hsiao, and L.L. Chen, Fundamental Dimension of Affective Responses to Product Shapes. International Journal of Industrial Ergonomics, 36 (6)(2006) 553-564.

[12] B.M. Deros, N.K. Khamis, J.A. Ghani, A.R.M., Yusoff, and C. Salleh, A Study On Common Risks and Body Parts Complaints by Standing Workstation Female Operators in an Electronics Product Manufacturing Company. Proceedings of the 11th Global Congress on Manufacturing and Management (GCMM2012), 28-30 November 2012, School of Engineering, AUT University, Auckland, New Zealand(2012).

[13] A.R.M. Yusof, Designing Ergonomic Workstation for Standing Work System in an Electronic Manufacturing Company. Master of Science Dissertation, Faculty of Engineering & Built Environment, UniversitiKebangsaan, Malaysia(2011).

[14] Cavalho, M. A. et al. Anthropometric Data Collection for Occupational Ergonomic. Occupational Safety and Hygiene Journal, Vol. II, Taylor and Francis Group, London (2014).

[15] A.A. Kalla, The Bone and Joint Decade l 2000-2010-for Prevention and Treatment of Musculo-Skeletal Disorders Press Release-October 11, 2000(2010).

[16] C.C. Menéndez, Benjamin C Amick 3rd, Michelle Robertson, LiannaBazzani, Kelly DeRango, Ted Rooney, Anne Moore, A Replicated Field Intervention Study Evaluating the Impact of a Highly Adjustable Chair and Office Ergonomic Training on Visual Symptoms. Journal of Applied Ergonomics, 43, (2012) 639-644.

[17] J. Brennan, Workspace Design, Ergonomics and Gender. Paper presented at the Technology and Society, 1999. Women and Technology: Historical, Societal, and Professional Perspectives Proceedings (1999).

[18] A. Saptari, S. R. Kamat, W.H.W. Mahmud, and I. Halim, A Plug Assembly Line: An Assessment of Work Design and Working Posture. Journal of Biomechanics, 40 (2007).

[19] R.H. Westgaard, and J. Winkel, Ergonomic Intervention Research for Improved Musculoskeletal Health: A Critical Review. International Journal of Industrial Ergonomics, 20(1997)463-500.

[20] International Ergonomics Association (IEA) (Feb. 12, 2003). http://www.iea.cc/ergonomics/