Work Related Musculoskeletal Disorders in Sorting Process Area at Mariwasa Siam Ceramics Incorporated: An Assessment

Cake Fritzi Arsenio, Angel Loise Borja, Patrik Claude Garcia, Neil Harvey Maigue,
Dr. Ryan Jeffrey Curbano
Bachelor of Science in Industrial Engineering

Abstract

The study shows the significance of enhancing working area in the sorting process area at the Mariwasa Siam Ceramics Inc. to minimize injury or damage risk of the sorters. As technology change and arise, the need to guarantee that the tools that the workers access for their job are intended to meet their body demands and can put them away from risk. Rapid Upper Limb Assessment (RULA) and Nordic Musculoskeletal Questionnaire (NMQ) helps the researcher to identify which part of the workers body hurts and undergoes the most from musculoskeletal disorder. Anthropometry can be defined as the study which deals with body dimensions such as body size, shape, strength and working capacity for design purposes and body compositions. The researchers gathered anthropometric measurements from 20 workers. The findings from this research showed that the leading input of the incidence of MSD to the workers is their improper posture and insufficient workstation. MSDs caused pain or fatigue to the workers resulting in the workers ' absenteeism affecting the workers efficiency and productivity. Thus, it is necessary to develop an ergonomically designed workstation for the sorters chair and table in relation to the sorters tile conveyor.

Keywords: Ergonomics, Musculoskeletal Disorder (MSD), Rapid Upper Limb Assessment (RULA), Nordic Musculoskeletal Questionnaire (NMQ), Anthropometry

I. INTRODUCTION

Most of the companies here in the Philippines often refuse to give the best comfort that a worker can have because it costs them a lot of money but according to Environment, Health and Safety (EHS) today, ergonomics disorder is the fastest growing category in work related illness that affects the employees of the company [1]. Ergonomics is study of the interaction of the human body with the surrounding environment to achieve a balance between the workplace design and the human physical demands [2]. The employee's well-being in a workplace has become critical in ensuring that the employee performs to their best abilities. Ergonomics is created to provide safety and comfort to the workers. Ergonomically design workplace can lessen the workers stress in their workload and can give them comfort that leads to efficiency and reliability. Ergonomics avoid disorders that can cause pain and injuries such as musculoskeletal disorders that affect the human body. Musculoskeletal disorder symptoms can be experienced by the workers performing their tasks in bad work postures which are largely static and therefore these are associated with long term risks and injuries [3].

After inoculating the researchers to the problem, the proponents aim to solve and gather data by using Nordic Musculoskeletal Questionnaire (NMQ) and Rapid Upper Limb Assessment (RULA). This study will focus on giving the employees stress-free environment by improving their workstation that is ergonomically designed for them to avoid MSD and improve their productivity. This research will emphasize the ergonomics safety culture of Mariwasa and their employees' productivity and work quality.

This study is beneficial to both the employees and the employer because health hazards like injury, accident, MSD, and other illness will be avoided.

The main purpose of the study was to address the work-related disorder such as neck and back pains of the employees by giving them an ergonomically designed workplace. This includes correct layout of the chair and desk in relation to the tile conveyor with adequate spacing to each other to achieve good work posture.

Figure 1. Conceptual Framework

Objectives of the Study

The focus of the study was to assess work-related musculoskeletal disorders in the sorting process area at Mariwasa Siam Ceramics Incorporated. Specifically, the study sought to identify the physical condition experienced by the workers; assess the work posture of the workers using RULA (Rapid Upper Limb Assessment); identify the root cause of physical discomfort; develop an ergonomically designed workstation for the workers; and evaluate the effectiveness of the design for the workers.

II. METHODOLOGY

This study used applied research as it aims at finding a solution for an immediate problem facing a society or a business organization, whereas fundamental research is mainly concerned with generalizations and with the formulation of a theory. Since the researchers used applied research; improvements are implemented in the company. Mariwasa Siam Ceramics is located at Brgy. San Antonio, Santo Tomas, Batangas and was founded in March 1966. Established by brothers Emerson and Edison Coseteng, the company was founded on the vision of producing ceramic products that would meet world standards for beauty and durability.

The participants of the study are the collaborative team of the company, Engr. Enriquez the Assistant Vice President in the Operations Department, Engr. Kristel Mendoza, and the 20 sorters from the sorting process area of Mariwasa Inc. The sorting process caught the attention of the researchers because of the worker's working posture and workstation that makes them uncomfortable. After observing the company, the researchers discussed and proposed the alleged problem about workstation and work posture of the sorters to the team leader and manager. The study had its main objective of reducing the risk factor of workers. The data gathered were analyzed using different tools. RULA worksheet and Nordic Musculoskeletal Questionnaire were used to define the risk factor affecting quality and productivity. The researchers used to assess anthropometric measures to help evaluate workers' growth and nutritional status. The researchers compared the concepts and applications of percentiles and Z - scores and their strengths and limitations.

III. RESULTS AND DISCUSSIONS

Level of Physical Condition Experienced by Workers

Table 1. Physical condition of the body

	Body Dimensions	Mean	Interpretation	Rank
Left	Upper Arm	3.20	Moderate Pain	11
	Lower Arm	3.20	Moderate Pain	11
	Wrist	3.75	Strong Pain	4
	Trunk	3.55	Strong Pain	6.5
	Leg	3.35	Strong Pain	8.5
Right	Upper Arm	3.20	Moderate Pain	11
	Lower Arm	3.15	Moderate Pain	13
	Wrist	3.60	Strong Pain	5
	Trunk	3.55	Strong Pain	6.5
	Leg	3.35	Strong Pain	8.5
	Neck	3.85	Strong Pain	3
	Upper Back	4.25	Severe Pain	2
	Lower Back	4.45	Severe Pain	1

Table 4 shows that lower back had the highest assessment with the mean of 4.45 which described as severe pain. Lower right arm had the lowest assessment with a mean of 3.15 and described as moderate pain. These results are from the 20 sorters that the researchers surveyed. According to the National Institute of Neurological Disorders and Stroke (NINDS), low back pain is the most common cause of job-related disability. Due to various sudden movements or poor body mechanics while lifting heavy objects, most low back pain is the result of injury, such as muscle sprains or strains [4].

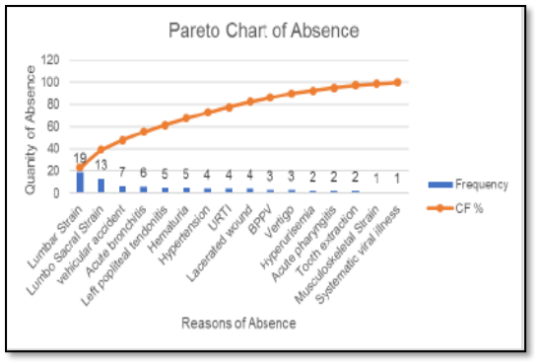

Figure 2. Pareto analysis of sick leaves as of April and May 2019

According to the International Journal of Industrial Ergonomics, various lumbar postures and individual flexibilities can cause musculoskeletal disorders when sitting. While performing seated tasks, people should exercise caution about lumbar posture [5].

Figure 2 displays that the most to the least reason of sick leaves. The bars represent individual values which are arranged in descending order while the line represents the cumulative frequency in percent. Through the Pareto Chart, it was recognized that the lumbar strain is the most occurring reason of absence of workers which is the priority in this study.

Work Posture Analysis

Figure 3. Workers' current work posture

Figure 3 demonstrates the workers' current work posture. Normally, workers do not consciously maintain normal posture. Poor posture can lead to excessive strain on postural muscles and may even cause them to relax, when held in certain positions for long periods of time [6].

Table 5. Assessment on the posture of sitting workers using rapid upper limb body assessment (RULA)

Group A	Body Part	Score	Comments
Left	Upper Arms	2	Shoulder is raised up to 45° on marking the tiles
	Lower Arms	1+1	Lower arm is ranging 60° to 100° across the midline of the body and out to the side
	Wrist	2	Wrist bends away from the midline
	Wrist Twist	1	No wrist twisting is required
Score Left A: 3			
Right	Upper Arms	3	Shoulder is raised from 45° to 90 ° on marking the tiles
	Lower Arms	2+1	Lower arm is ranging 60° and more than 100° across the midline of the body and out to the side
	Wrist	2	Wrist bends away from the midline
	Wrist Twist	1	No wrist twisting is required
Score Right A: 4			
Group B	Neck	2+1+1	The neck bends down from 10 ° to 20 ° as well as twisted and side-bent
	Trunk	2+1	The trunk is twisted and bends from 0 to 20
	Legs	2	The positions of the lower limbs are appropriate for the sorters
Score B: 6			
Group A	Force	0	There is no handling of materials
	Muscle Use	1	Action is repeated more than 4 times per minute
Posture Score A: (3+0) = 3			
	Force	0	There is no handling of materials
	Muscle Use	1	Action is repeated more than 4 times per minute
Posture Score B: (4+1) = 5			
Grand Total Score: 7			

Table 5 indicates the posture score of the workers. The researchers evaluated each body part using the RULA worksheet, for the group A, the left upper and lower arms, as well as the wrist, scores with 2, and 1 for wrist twist. For the right upper and lower arms, the score is 3, the wrist with a score of 2 and wrist twist with 1. For group B, the neck, trunk, and legs were evaluated with scores of 4, 2, and 1 respectively. Based on the total score, four action levels, indicating the level of intervention required to reduce the risk of injury, are suggested: action level 1, posture is acceptable; action level 2, further investigation is needed, and changes may be needed; action level 3, investigation and changes are required soon; and action level 4, investigation and changes are required immediately [7].

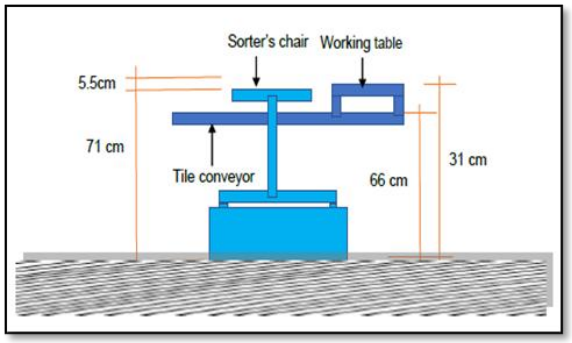

Figure 4. Current sorter's workstation (back view)

According to Niebel's Methods, Standards, and Work Design, the primary guideline is to design the workplace to accommodate most individuals about structural size of the human body [8].

The current workstation of a sorter from the back point of view is shown in Figure 4. Measuring from the edge of the conveyor to the floor, the height is 66cm. The height of the chair from the floor to the seat pan is 71cm so that the sorter can see the tiles for inspection in the conveyor. The materials of the chair are made of mild steel.

Figure 5. Actual current chair and table

Figure 5 shows the actual current chair and table used by sorters in the workplace. The chair has no backrest, and the table is too low, making sorters uncomfortable while working.

Figure 6. Current table and chair with the sorters

As shown in Figure 6, the work posture of the sorters is uncomfortable using the former chair and table.

Root Cause Analysis

Table 6. Why-why analysis of musculoskeletal disorder

Problem	1st Why	2nd Why	3rd Why	Corrective Action
Musculoskeletal disorder	Frequent twisting and bending of the body in the workplace	Unbalanced proportion of the body and table	Poor workplace design	Developed an ergonomically-designed chair and table

Table 6 shows the breakdown of different minor problems to solve and determined the root cause of MSD. It also shows that the cause of MSD is repetitive twisting and bending in the workplace because of the awkward working posture due to poor design of workplace. Why-why analysis is a great tool to analyze and identify the root cause of the problem while connecting it to minor problems. According to the Department of Industrial Engineering and Operations Research, having an ergonomically designed chair and table allows workers to work comfortably and decreases the chance of suffering back injuries such as unbalanced proportion of workers' body [9].

Ergonomically Designed Chair and Table

Table 7. Anthropometric measurements for sitting

Anthropometric Measurements (cm)	n = 20				
	Mean (cm)	Std. Dev. (cm)	5th Percentile	50th Percentile	95th Percentile
Popliteal Height	35.90	4.37	28.73	35.90	43.07
Shoulder Height	24.64	4.29	17.60	24.64	31.68
Hip Breadth	33.85	3.25	28.52	33.85	39.18
Elbow-to-Elbow Breadth	33.92	2.95	29.08	33.92	38.76
Buttock Popliteal Depth	42.96	3.42	37.35	42.96	48.57
Thigh Clearance	12.86	3.00	7.94	12.86	17.78
Sitting Elbow Height	21.84	4.53	14.41	26.37	29.27
Functional Forward Reach	70.04	6.28	59.74	76.32	80.34
Buttock-Knee Depth	52.65	4.11	45.91	56.76	59.39
Sitting Eye Height	72.08	5.28	63.42	77.36	80.74
Sitting Height	77.73	6.02	67.86	83.75	87.60
Knee Height	48.75	7.25	36.86	56.00	60.64

The anthropometric measurements of the worker at the sorting processing area are in Table 7. It shows that the sitting height is the highest mean of 77.73cm. and the knee height for the standard deviation with the value of 7.25cm. Also, the sitting height has the highest measurement for the 5th percentile, 50th percentile, and 95th percentile with measures of 67.86cm., 83.75cm., and 87.60cm., respectively.

Table 8. Measurement of the relevant dimensions of table and chair

Dimensions	Actual Measurement (cm)	Measurement	Anthropometric Measurement (cm)
Seat Height	30 – 55	5th to 95th percentile of the popliteal height + shoe allowance	29.39 – 45.40
Seat Depth	43	95th percentile of the hip breadth	39.15
Back Rest Height	37	95th percentile of the sitting shoulder height	31.68
Back Rest Width	41	95th percentile of the hip breadth	39.18

Table 8 shows that the seat height adjustable from 30cm to 55cm is sufficient for the 5th percentile and the 95th percentile to evaluate each chair measurement in the workstation. Consequently, it may be convenient for both percentiles to sit for the seat height and the sorter's legs to strongly touch the galvanized iron plate. The seat height allows a suitable footrest to support the feet of the sorter comfortably [10].

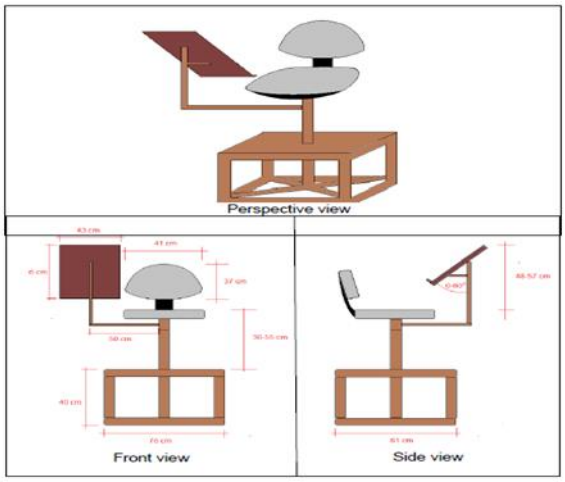

Figure 7. Proposed chair with desk

The proposed working chair with desk in the sorter's workstation is shown in Figure 7. From the seat pan that is made of round mild steel with a diameter of 37cm to a foamed seat pan measuring 46x43cm2 with a foamed backrest measuring 41x37cm2. The height of the seat is adjustable from minimum of 130cm to maximum 150cm with respect to the floor. A desk made of stainless-steel measuring 30x40cm2 is attached to the chair that is also adjustable depending on the sorter's convenience. The height of the desk can be adjusted ranging from 48cm to 57cm with respect to the top of the seat pan. The angle of the desk is adjustable from 0o to 60o. The horizontal distance of the desk to the backrest is 50cm.

Ergonomically Designed Chair and Desk Work Posture Analysis

Table 9. Physical condition of the body

	Body Dimensions	Mean	Interpretation	Rank
Left	Upper Arm	1.80	Slight Pain	11
	Lower Arm	1.90	Slight Pain	8
	Wrist	2.10	Slight Pain	7
	Trunk	2.40	Slight Pain	4
	Leg	1.85	Slight Pain	9.5
Right	Upper Arm	1.85	Slight Pain	9.5
	Lower Arm	1.50	No Pain	13
	Wrist	1.55	No Pain	12
	Trunk	2.55	Slight Pain	3
	Leg	2.65	Moderate Pain	1
	Neck	2.60	Moderate Pain	2
	Upper Back	2.25	Slight Pain	6
	Lower Back	2.30	Slight Pain	5

Table 9 indicates the worker's body parts' physical condition after they used the ergonomically designed chair and table. It has an evaluation of 1.80 and 1.85 for the left and right upper arm with an interpretation of slight pain. As well as for the left and right lower arm with an interpretation of slight pain that has an evaluation of 1.90 and 1.50. The left and right wrist, both with an interpretation of slight pain and evaluation of 2.10 and 1.55. Left trunk with 2.40 and right trunk with 2.55 with the interpretation of slight pain and moderate pain, respectively. Slight pain for the left leg with 1.85 and moderate pain with 2.65. For the upper back, lower back, and neck all with interpretations of slight pain and with evaluations of 2.25, 2.30, and 2.60, respectively. These results are from the 20 sorters that the researchers surveyed.

Table 10. Assessment on the posture of sitting workers using rapid upper limb body assessment (RULA)

	Body Part	Score	Comments
Left	Upper Arms	2	Shoulder is raised up to 45º on marking the tiles
	Lower Arms	1+1	Lower arm is ranging 60º to 100º across the midline of the body and out to the side
	Wrist	2	Wrist bends away from the midline
	Wrist Twist	1	No wrist twisting is required
Score Left A: 3			
Right	Upper Arms	2	Shoulder is raised from 45º to 90 º on marking the tiles
	Lower Arms	1+1	Lower arm is ranging 60º and more than 100º across the midline of the body and out to the side
	Wrist	2	Wrist bends away from the midline
	Wrist Twist	1	No wrist twisting is required
Score Right A: 3			
Group B	Neck	1	The neck bends down from 0º to 10º.
	Trunk	1	The trunk is not bending at all.
	Legs	1	The positions of the lower limbs are appropriate for the sorters.
Score B: 1			
Group A	Force	0	There is no handling of materials.
	Muscle Use	1	Action is repeated more than 4 times per minute.
Posture Score A: (3+1) = 4			
Group B	Force	0	There is no handling of materials.
	Muscle Use	1	Action is repeated more than 4 times per minute.
Posture Score B: (3+1) = 4			
Grand Total Score: 2			

Table 10 indicates the posture score of the workers. The researchers evaluate each body part using the RULA worksheet. For the group A, the left upper and lower arms as well as the wrist scored with 2, and 1 for wrist twist. For the right upper and lower arms, the score is 3, the wrist scores 2 and wrist twist, 1. For group B, the neck, trunk, and legs are all evaluated with the same score of 1. For force and muscle used for both groups, they have a grand total score of 7, thus, investigation and changes are required immediately.

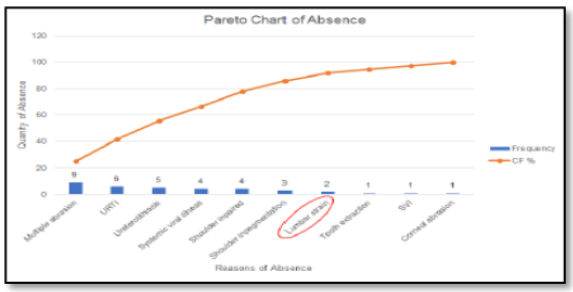

Figure 8. Pareto analysis of sick leaves as of June and July 2019

Based on the data from Figure 8, 80 percent of the reason for sick leave is due to multiple abrasions, URTI, ureterolithiasis, systemic viral illness, and shoulder impairment. On the other hand, shoulder in pigmentation, lumbar strain, tooth extraction, SVI, and corneal abrasion are reasons that belong to 20 percent or the useful many. The data is from June 14, 2019 to July 14, 2019.

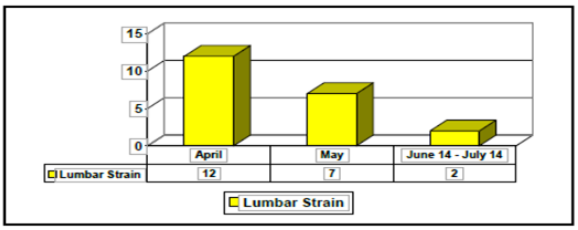

Figure 9. Frequency of lumbar strain

Figure 9 indicates the frequency of lumbar strain of sorters from April to June 2019. The incidence of lumbar strain was reduced to two as of June 2019 because the sorters started to utilize the new ergonomically designed chair with table on June 14, 2019. This shows the effectiveness of the researchers' proposed design for sorters' chair and table.

Figure 10. Actual proposed chair with table

Figure 10 shows the actual proposed chair with table that is ergonomically designed for sorters which was built last June 13, 2019.

Figure 11. Table and chair with sorters (after)

Figure 11 shows the comfortable work posture of the sorters using the new ergonomically designed chair and table. The researchers surveyed 20 sorters who got to experience to sit on the ergonomically designed chair with table.

Table 11. Effectiveness summary of the proposed chair with table

	Physical Condition (Mean)	Rapid Upper Limb Assessment (Mean)	Sick leave (Lumbar Strain)
Before	3.57 Strong pain	6.45 Investigation and changes are required soon	April – 12 cases May – 7 cases
After	2.10 Slight pain	2.45 Posture acceptable	June to July – 2 cases
T-value	13.90	12.65	
P-value	0.00	0.00	
Interpretation	Significant	Significant	

The summary of the effectiveness of the proposed chair with table is indicated in Table 11. For physical condition, the overall mean has an assessment of 3.57 with the interpretation of strong pain, then, after they used the proposed

chair with table, the physical condition is 2.10 with the interpretation of slight pain with a T-value and P-value of 13.90 and 0.00, respectively and with an interpretation of significant. While for RULA, before, the researchers evaluated the sorters with an overall mean of 6.45 with an interpretation of investigation and changes are required soon, after the sorters used the proposed chair with table, the researchers evaluated them with an overall mean of 2.45 with an interpretation of posture acceptable and T-value and P-value of 12.65 and 0.00, respectively, with an interpretation of significant.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The survey result from the Nordic Musculoskeletal Questionnaire shows that the sorters are currently experiencing strong pain particularly on their necks, lower backs, upper backs, and legs. The Pareto Chart of sick leaves also shows that the top reason of absence is due to lumbar strain next is lumbosacral strain. In the many days of observing the working posture of the sorters at the sorting process area, the researchers evaluated their upper body by using the RULA (rapid upper limb assessment). Using the why-why analysis, the researchers determined that the main cause of physical discomfort among sorters is the poor design of their workstation in relation to their chair and desk with respect to the tile conveyor machine that leads to musculoskeletal disorders. The sorters need the right mix of workspace to be productive while working comfortably so the researchers focused on planning an ergonomically designed workstation for the sorters by improving the sorter's chair and desk in relation with their respective tile conveyor machine. The researchers used anthropometry to help them in designing an ergonomic workstation. With the newly designed ergonomic chair and table, the incident of lumbar strain of sorters is reduced to two as of June to July 2019 from 12 in April and seven in May. This shows the effectiveness of the researchers' design for the sorters' chair and table.

Recommendations

The researchers suggest further conducting ergonomic analysis on other areas of the company which can easily highlight possible risks in the workstation. The researchers recommend that the company change the remaining workstations of sorters that are still using the old chair and table into the ergonomically designed chair and table for them to feel comfortable in doing their job and reducing the chances of MSD. The researchers recommend the company to use stainless steel as their material in making an ergonomic chair and desk because stainless steel is less expensive long term when total life cost is considered due to its remarkable properties such as versatility, high corrosion resistance, and strength. The researchers recommend future researchers in line with this study to find different aspects that affect workers while performing their tasks.

REFERENCES

[1] C. Roth, (2011). "The importance of ergonomics for the safety professional," [Online]. Available: https://www.ehstoday.com/news/importance-ergonomics-safety-3009

[2] J. Thomas, (2012). "Ergonomics and workplace design," [Online]. Available: https://workdesign.com/2012/08/ergonomics-and-workplace-design/ [Accessed 25 May 2019].

[3] Canadian Center for Occupational Health and Safety, (2014). "Work-related musculoskeletal disorders (WMSDs)," [Online]. Available: https://www.ccohs.ca/oshanswers/diseases/rmirsi.html. [Accessed 25 May 2019].

[4] Dr. W. Morrison, (2019). "What You Should Know About Low Back Pain," [Online]. Available: https://www.healthline.com/health/low-back-pain-acute

[5] Y.-L. Chen, Y. Chen, W.-C. Lin, Y.-H. Liao, & C.-J. Lin, (2019). "Lumbar posture and individual flexibility influence back muscle flexion-relaxation phenomenon while sitting," International Journal of Industrial

Ergonomics, 74, November 2019, 102840. [Online]. Available: doi.org/10.1016/j.ergon.2019.102840.

[6] Freivalds, A. "Niebels Methods, Standards, and Work Design," 13th Edition

[7] G. Badfar, (2017). "Evaluation and correlation of the rapid upper limb assessment and rapid office strain assessment methods for predicting the risk of musculoskeletal disorders," Internal Medicine and Medical Investigation Journal, 2(4):155, October 2017. 10.24200/imminv.v2i4.87

[8] Freivalds, A. "Niebels Methods, Standards, and Work Design," 13th Edition.

[9] R. Alojado, B. Custodio, K. M. Lasala, & P. L. Marigomen, (2015). "Designing an ergonomic chair for pedicurists and manicurists in Quezon City, Philippines," Procedia Manufacturing, 3; 1812-1816, 2015doi.org/10.1016/j.promfg.2015.07.220

[10] Salvendy, G. (2015). Handbook of Human Factors and Ergonomics 4th Edition.