Ergonomic Intervention for Improving Worker Efficiency: Using Adjustable Workstation in Garment Industry

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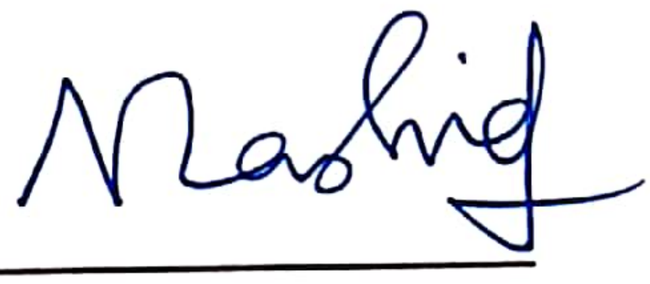

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Abstract

Current workstations of the RMG's are not ergonomically constructed, which results in less productivity in output. This paper aims to identify RMG's ergonomic factors (working posture and workers' perceptions) and to come up with an achievable solution. It is proposed that many ergonomic initiatives be introduced in the workplace so that workers can function with improved productivity in a healthy environment. Questionnaires on the chosen issues provide ample evidence that the working environment was harmful to employees' efficiency, health and safety. On basis of that, it was realized that seating arrangement is the most prominent factor of our study and we have worked on the improvements that it requires. Finally, an adjustable work-station was planned, testing the improved effectiveness. The improved efficiency was due to versatility and functionality of ergonomic design integrated into the workstation. The findings of this paper will enable the garment manufacturers improve the wellbeing and safety of the workforce.

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Chapter 1 Introduction

Bangladesh is considered as a nation of lower income concerning to the economy and job creation RMG are one of Bangladesh's most significant industries. The RMG segment has a great contribution in creating half of the country's income and also it is the most noteworthy in gaining foreign cash. It leads to annual exports of more than $30 billion, accounting for 83% of the country's total export earnings and also 4.4 million people work in the industry, with 85% of them being women [1]. The united hard work of purchasers, laborers, producers and government has succeeded this division.

Figure 1.1: Production Line of a RMG Factory

The greatest turner of this division is the laborers yet their contribution is scarcely acknowledged. The essence of work in a garment factory is sedentary, with a pattern of repetitive work. This type of job induces exhaustion, which can lead to a variety of health issues for the employees. The main determinant of exhaustion is the workers posture while at work and the postures are determined by spinal curvature, joint angles and the positions of the head, neck, arm, legs, and trunk. Employees are exposed to appalling working conditions, which involve poorly built workstations. The workstations given to garment workers do not adhere to any ergonomic design standards that could theoretically enhance worker comfort. As a result of factors such as inclined posture, prolonged sitting and repetitive movements, garment workers employed in poorly built workstations may develop work related musculoskeletal disorder and finally it leads to less productivity in output [1].

1.1 Background of the Study

Human, societal and economic damages result from hazards in workplace. Bangladesh garment industries on whole have very cheaply constructed workspace. Sewing desks, inspection desks, sitting equipment, work room limitations, and other things are not constructed ergonomically. Industry owners are preoccupied with fulfilling quota-based demands, and few are concerned with worker efficiency and welfare.

In Bangladesh, 11.7 thousand workers suffer from fatal diseases and 24.5 thousand die per year due to Work -Related Diseases across all the sectors [2]. Following the tragedies at Rana plaza Tazreen, Bangladeshi garment manufacturers are under enormous pressure from customers, consumers, and civil society to improve factory safety and working conditions [1].

ILO estimated that 2.3 million people die per year due to occupational hazard; 270 million people suffer from nonfatal injury; 160 million are affected from work related problems in all over the world [3]. Getting pressures from all corners, Bangladesh Garment Manufacturers and Exporters Association (BGMEA), along with the Accord and Alliance are now working to improve fire safety and building safety of the factories [1].

Figure 1.2 shows the current scenario of the RMG factories. The workstations are not ergonomically arranged and the production floor is overly crowded.

Figure 1.2: Present Garment scenario (Collected while conducting the survey)

Physical, chemical, architectural, fire, ergonomics and anthropological hazards exists in the workplace for garment workers [4].

Currently, garment factories are more concerned with health hazards and emergency situations than with working conditions, especially avoiding ergonomic hazards. No organization has any visible initiative to enhance ergonomic protection. The aim of this study is to reduce ergonomic risks and improve workplace safety through an ergonomic intervention.

1.2 Ergonomics

The ergonomics is known as the study of how people communicate with man-made artifacts. It's a general science that encompasses a wide range of working environments that have an effect on employees' comfort and wellbeing. So it can be stated as the analysis of man in relation to his profession. Ergonomics main concern is with the people's relation with goods, machinery, services and environment in which they function. To get the maximum productivity, the correlations between work space and body dimensions that cause body posture to be adapted must be considered [5].

Ergonomics is the study of how to make a workplace as efficient, secure and comfortable as possible. The use of ergonomics in the design of job systems will help to create a harmony between staff characteristics and mission demands. Workers' efficiency, work quality, wellbeing, physical and mental well-being and job satisfaction will all benefit from this.

Many research studies have shown positive effects of applying ergonomic principles in workplace design, machine and tool design, environment and facilities design.

1.3 Seating Posture

Workers are the backbone of an industry. To increase the production of an industry it is necessary for the workers to remain healthy and fit. For this all the necessary arrangement should be done so that workers feel comfortable while working.

The main determinant of exhaustion is worker's stance when at work. The postures are determined by spinal curvature, joint angles and the configurations of the head and curvature.

The requirement of the assignment, the nature of the work place and personal attributes all effect a worker's seating posture [6]. Correct body postures improve the worker productivity as well as worker moral a lot.

1.4 AHP as a Prioritization Tool

One of the most commonly used approaches in Multi-Attribute Decision Making in the Analytical Hierarchy Process (AHP) [7]. Saaty developed the AHP approach in an effort to solve difficult decision-making problems involving complexity and a lack of knowledge by integrating various hierarchical levels(Objectives, parameters, sub-criteria and decision alternatives) [8]. AHP expresses the factors involved in a problem in a hierarchical manner. It divides a dilemma into fractions and then prioritizes the factors accordingly by pairwise comparing them and represents the result in a statistical way.

Based in the theoretical and mathematical setting of the AHP method have been applied in many research papers [9] , along with presentation of scaling method for priorities in AHP [10], details of the AHP method and its application for various decision-making problems [11], manifesto of possible combined execution of the AHP and other decision-making techniques or fuzzy theory [12] etc.

The AHP method's key goal was to assist the policy-makers to make a decision based on the evidence available [13]. AHP method takes into account the subjectivity of the decision-making process [14] and enables decision-makers to transform subjective assessment into objective measures.

1.5 Adjustable Workstation

There is an undeniable correlation between proper work place design and ergonomics and workers' productivity [15].

Ergonomic workstations make sure that the desk and related equipment on it are arranged in such a way that they prevent injury and are well within reach and use. An ergonomic workstation also promotes good posture. An ergonomically designed workstation promotes good posture and helps to keep bones and joints in the correct alignment so that muscles are being used properly. A key reason for using a height-adjustable workstation intervention is that it may confer health benefits without having detrimental effects on work productivity [16].

1.5.1 Interchangeable Workstation

Data from epidemiology shows that reducing sedentary activity is good for the wellbeing [17]. Working in both a sitting and standing pose was more effective and resulted in less upper-limb fatigue that working only in a sitting posture [18]. Sit-Stand workstations are one way to minimize sedentary activity and alter work postures during the day [19].

This study discussed the criteria and specification for ergonomically designed adjustable workstations. It describes the current state of Bangladesh's RMG factories and investigated the key factor that requires improvement.

Chapter 2 Methodology

For proper evaluation, a survey was conducted where a number of data were collected from two RMG factories. The data was based on the Adaptability of workers, Cost Effectiveness, Health/Safety Measurements and Productivity Efficiency. This data was used to finalize a decision for the optimization of productivity.

2.1 Data Accumulation

RMG workers' viewpoints on their physical workplace environment were accumulated using a questionnaire. The data used in the assessment is collected through interviews and surveys. An ergonomic factor questionnaire was used to conduct a subjective evaluation, among 20 workers from two individual RMG factories.

2.1.1 Data Input Method

The values of table 2.1 to 2.10 were filled on a scale of 1 to 9. After reading from left of a row with respect to column, value 1 was input if the row and column topic seemed equally important. Value 2 was input if row topic was twice more important than column topic and so on.

Table 2.1 shows the collected data from Manami Garments which was situated in Savar. The data represents the average value of 20 subjects.

Table 2.1: Factor Table: MANAMI Garments

	Adaptability of workers	Cost Effectiveness	Health/Safety Measurements	Production Efficiency
Adaptability of workers	1	1	3	2
Cost Effectiveness	1	1	3	1
Health/Safety Measurements	1/3	1/3	1	1

Table 2.2 represents the value of the factors: Seating arrangement, Machine design, Organizational ergonomic Intervention, Training from the view point Adaptability of the workers.

Table 2.2: Factor Table: Viewpoint of Adaptability of workers [MANAMI Garments]

	Seating arrangement	Machine Design	Organizational ergonomic interventions	Training
Seating arrangement	1	9	4	9
Machine Design	1/9	1	1	2
Organizational ergonomic interventions(e.g. break)	1/4	1	1	1
Training	1/9	½	1	1

Table 2.3 represents the value of the factors: Seating arrangement, Machine design, Organizational ergonomic Intervention, Training from the view point of Cost Effectiveness.

Table 2.3: Factor Table: Viewpoint of Cost Effectiveness [MANAMI Garments]

	Seating arrangement	Machine Design	Organizational ergonomic interventions	Training
Seating arrangement	1	8	4	3
Machine Design	1/8	1	1/2	1/2
Organizational ergonomic interventions(e.g. break)	1/4	2	1	1/2
Training	1/3	2	2	1

Table 2.4 represents the value of the factors: seating arrangement, Machine design, Organizational ergonomic Intervention, Training from the view point Health/Safety Measurements.

Table 2.4: Factor Table: Viewpoint of Health/Safety Measurements [MANAMI Garments]

	Seating Arrangement	Machine Design	Organizational ergonomic interventions(e.g. break)	Training
Seating Arrangement	1	6	2	6
Machine Design	1/6	1	1/5	¼
Organizational ergonomic interventions(e.g. break)	1/2	5	1	4
Training	1/6	4	1/4	1

Table 2.5 represents the value of the factors: Seating arrangement, Machine design, Organizational ergonomic Intervention, Training from the view point Production Efficiency.

Table 2.5: Factor Table: Viewpoint of Production Efficiency [MANAMI Garments]

	Seating arrangement	Machine Design	Organizational ergonomic interventions	Training
Seating arrangement	1	2	8	7
Machine Design	1/2	1	3	3
Organizational ergonomic interventions(e.g. break)	1/8	1/3	1	1/3
Training	1/7	1/3	3	1

Table 2.6 shows the collected data from MIM Garments which was situated in Cherag Ali. The data represents the average value of 20 subjects.

Table 2.6: Factor Table: MIM Garments

	Adaptability of workers	Cost Effectiveness	Health/Safety Measurements	Production Efficiency
Adaptability of workers	1	4	2	4
Cost Effectiveness	1/4	1	1/2	1/2
Health/Safety Measurements	1/2	2	1	2
Production Efficiency	1/4	2	1/2	1

Table 2.7 represents the value of the factors: Seating arrangement, Machine design, Organizational ergonomic Intervention, Training from the view point Adaptability of the workers.

Table 2.7: Factor Table: Viewpoint of Adaptability of workers [MIM Garments]

	Seating arrangement	Machine Design	Organizational ergonomic interventions	Training
Seating arrangement	1	5	4	6
Machine Design	1/5	1	1/2	1
Organizational ergonomic interventions(e.g. break)	1/4	2	1	3
Training	1/6	1	1/3	1

Table 2.8 represents the value of the factors: Seating arrangement, Machine design, Organizational ergonomic Intervention, Training from the view point Cost Effectiveness.

Table 2.8: Factor Table: Viewpoint of Cost Effectiveness [MIM Garments]

	Seating arrangement	Machine Design	Organizational ergonomic interventions	Training
Seating arrangement	1	2	6	8
Machine Design	1/2	1	6	4
Organizational ergonomic interventions(e.g. break)	1/6	1/6	1	1/2
Training	1/8	1/2	2	1

Table 2.9 represents the value of the factors: Seating arrangement, Machine design, Organizational ergonomic Intervention, Training from the view point Health/Safety Measurements.

Table 2.9: : Factor Table: Viewpoint of Health/Safety Measurements [MIM Garments]

	Seating Arrangement	Machine Design	Organizational ergonomic interventions(e.g. break)	Training
Seating Arrangement	1	3	6	9
Machine Design	1/3	1	6	7
Organizational ergonomic interventions(e.g. break)	1/6	1/6	1	2
Training	1/9	1/7	1/2	1

Table 2.10 represents the value of the factors: Seating arrangement, Machine design, Organizational ergonomic Intervention, Training from the view point Production Efficiency.

Table 2.10: Factor Table: Viewpoint of Production Efficiency [MIM Garments]

	Seating arrangement	Machine Design	Organizational ergonomic interventions	Training
Seating arrangement	1	5	6	9
Machine Design	1/5	1	1/2	4
Organizational ergonomic interventions(e.g. break)	1/6	2	1	3
Training	1/9	1/4	1/3	1

2.1.2 Calculating Priorities

Prioritization of factors help to define the most critical requirements for a system [20]. The priority of the factors was determined after deducing normalized matrix from the accumulated data.

Table 2.11 shows the calculated priorities of MANAMI and MIM factories respectively.

Table 2.11: Calculated Priority Table-1

	Priority	Priority
Adaptability of workers	35.7%	49.6%
Cost Effectiveness	30.8%	10.6%
Health/Safety Measurements	13.5%	24.8%
Production Efficiency	20.0%	15%

Table 2.12 represents the priority of Seating Arrangement, Machine Design, Organizational Ergonomic Interventions and Training from the point of view of Adaptability of workers, cost Effectiveness, Health/Safety Measurements and Production Efficiency based on the data collected from Manami Garments.

Table 2.12: Calculated Priority Table [Manami]

	Adaptability of workers	Cost Effectiveness	Health/Safety Measurements	Production Efficiency
Seating arrangement	69.3%	58.4%	51.5%	57.0%
Machine Design	11.2%	7.9%	5.5%	25.6%
Organizational ergonomic interventions(e.g. break)	11.6%	13.3%	31.1%	6.2%
Training	7.9%	20.4%	11.9%	11.2%

Table 2.13 represents the calculated priorities based on the data collected from MIM Garments.

Table 2.13: Calculated Priority Table [MIM]

	Adaptability of workers	Cost Effectiveness	Health/Safety Measurements	Production Efficiency
Seating arrangement	60.6%	54.0%	57.0%	65.6%
Machine Design	10.2%	31.4%	30.8%	13.0%
Organizational ergonomic interventions(e.g. break)	20.3%	6.0%	7.6%	16.4%
Training	8.9%	8.6%	4.6%	5.0%

2.2 Problem analysis of using existing workstations

Workers in the garment industry work in clothes designing, sewing or cutting services, and clothes wholesaling [21]. Due to the nature of these jobs, the prevalence of work-related musculoskeletal disorders has been high [22].

The majority of workers in garments industries fined the seat and table heights to be too high and also the hand seat depths are too long and seat widths are too narrow for female workers [23] and this is due to the design of the equipment's without taking ergonomic factors into consideration.

Figure 2.1: Current Workstation in RMG Factory

The operators who operate in a seated position, the chair are an essential piece of equipment. It can have a significant effect on the workers comfort as well as the risk of muscle pain and injury[24].

Employees must conform to work environments that were not planned for them due to a lack of preparation in the construction of workstations[25].

2.2.1 Design adoptability and criteria

To improve this current seating arrangement, we proposed using an adjustable workstation. An adjustable workstation lets users move from a seated to standing position when working. The solutions suggested in this study are:

1. Manually adjustable workstation

2. Switch-controlled workstation

3. Interchangeable workstation

2.2.2 Manually adjustable workstation

In this design a knob is provided beside the footrest rotating which the actuator mechanism starts and the table can be moved up and down. A footrest was provided for the worker that could be used while working in a sitting posture. The worker had the flexibility to adjust the table height to his comfort.

2.2.3 Switch-controlled workstation

It is quite similar to the manual adjustable workstation the only difference is that the ECU Controls the height adjustment and it needs an operator to operate the whole process.

2.2.4 Interchangeable workstation

Two tables have been constructed with difference in height.one for working in standing position and other is for working in sitting position. Workers can select low-sitting, high-sitting, and standing postures according to their needs and tasks and adjust the work station height easily.

2.2.5 Dimensions Considered

The three major factors that needs to be considered while specifying the dimensions of a workstation are sex, age and race or ethnicity [26]. Here the data was collected from a research work done on the Malaysian people. For the manually adjustable workstation the range of height adjustment was from 65cm to 85cm from ground level [26].

The sitting table height can be adjusted between 65cm to 75 cm and standing table height can be adjusted between 95 cm to 105 cm [18].

The length and width were taken as 400mm and 900mm respectively.

2.2.6 Design Using SolidWorks

The adjustable workstation's design was done in SolidWoks 2018.

2.2.6.1 3D view of the parts

Figure 2.2 shows the 3D view from the top plane of the table top in SolidWorks 2018.

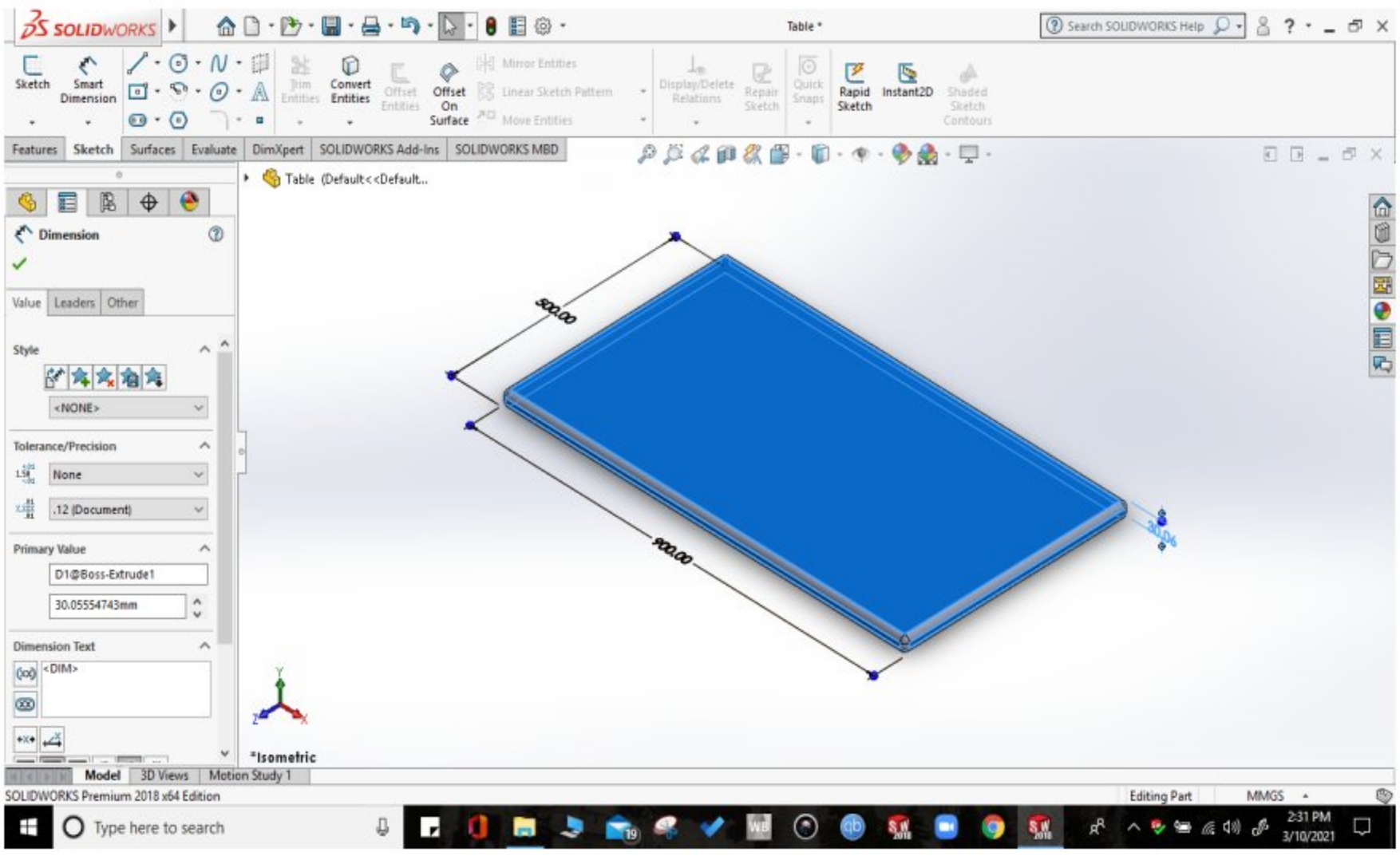

Figure 2.2: Table Top 3D

Figure 2.3 shows the isometric view of the upper leg in SolidWorks.

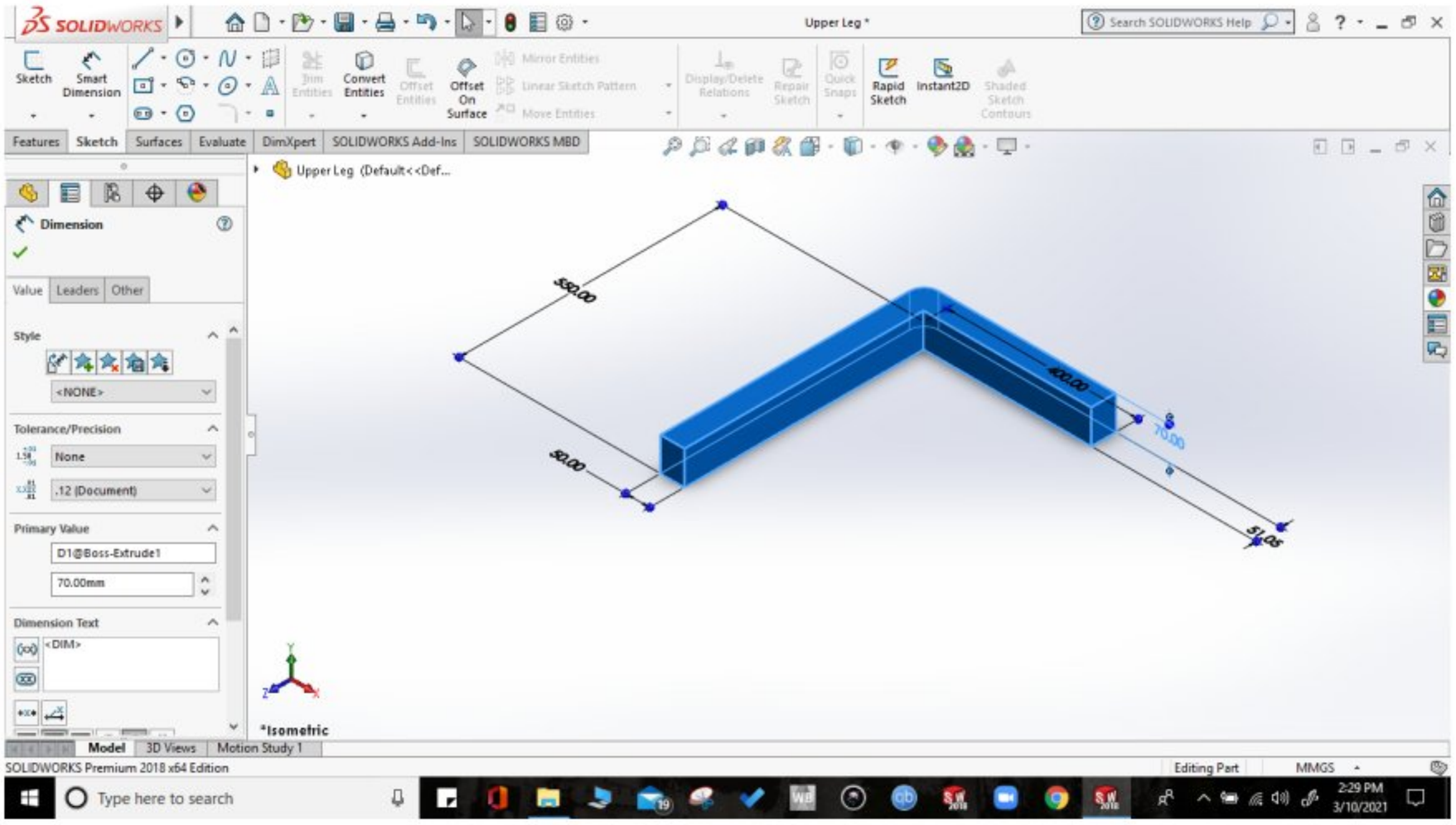

Figure 2.3: Upper Leg 3D

Figure 2.4 shows the 3D view of the lower leg in SolidWorks.

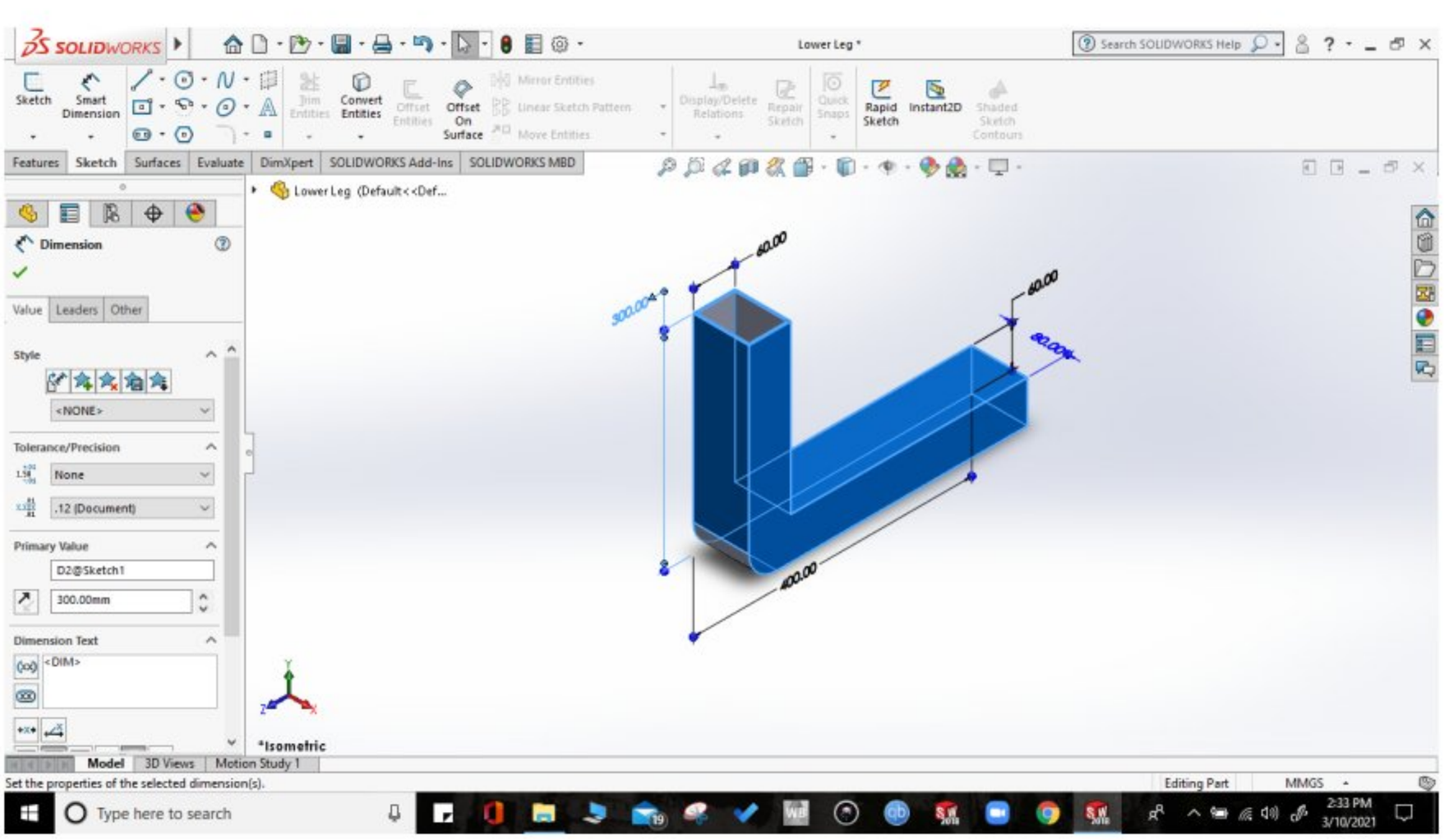

Figure 2.4: Lower Leg 3D

2.2.6.1.1 Table Top(2D View):

The table top has a standard height and width of 500mm and 900mm respectively.

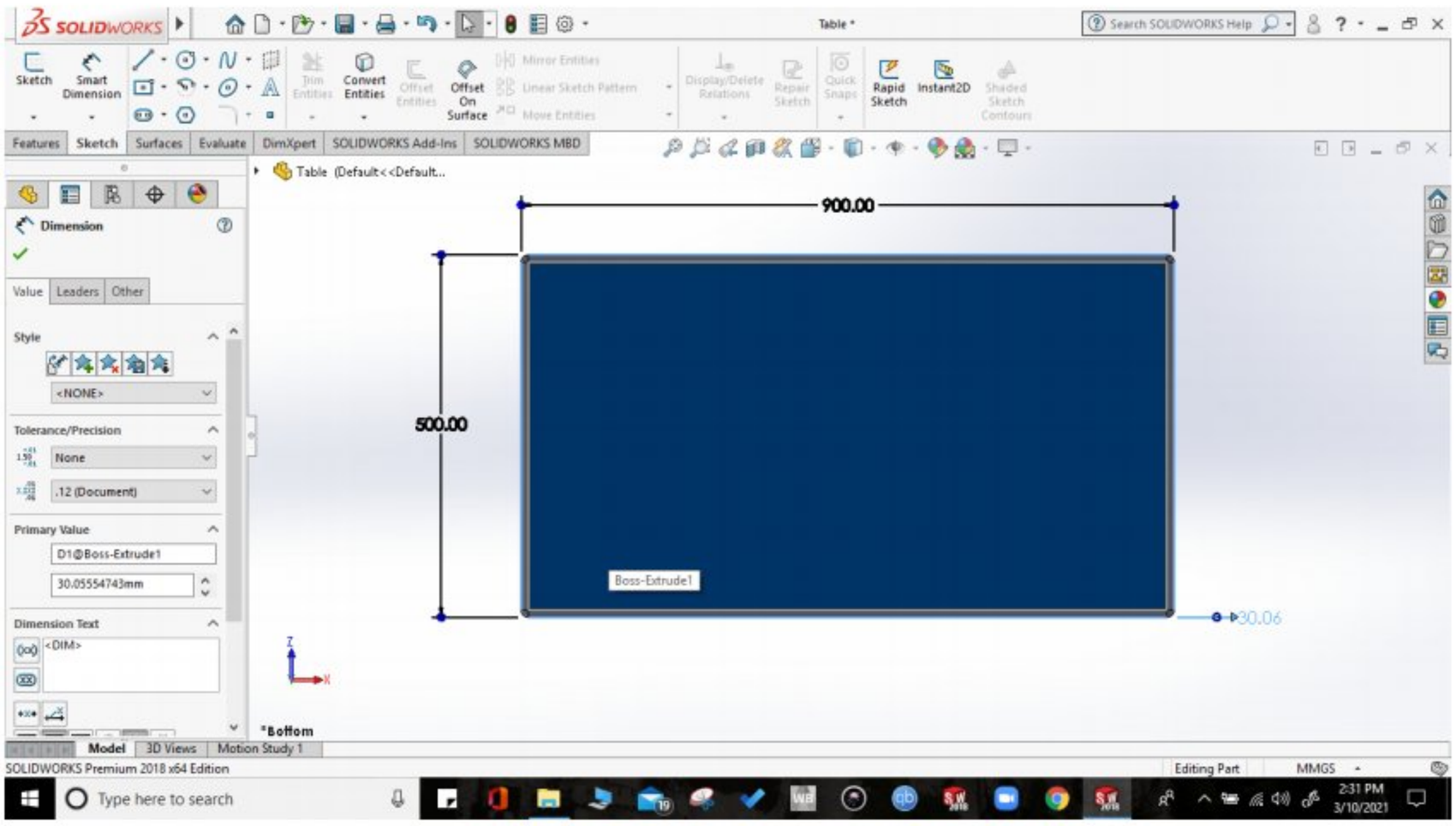

Figure 2.5: Top View

The table top has a depth of 30.06mm.

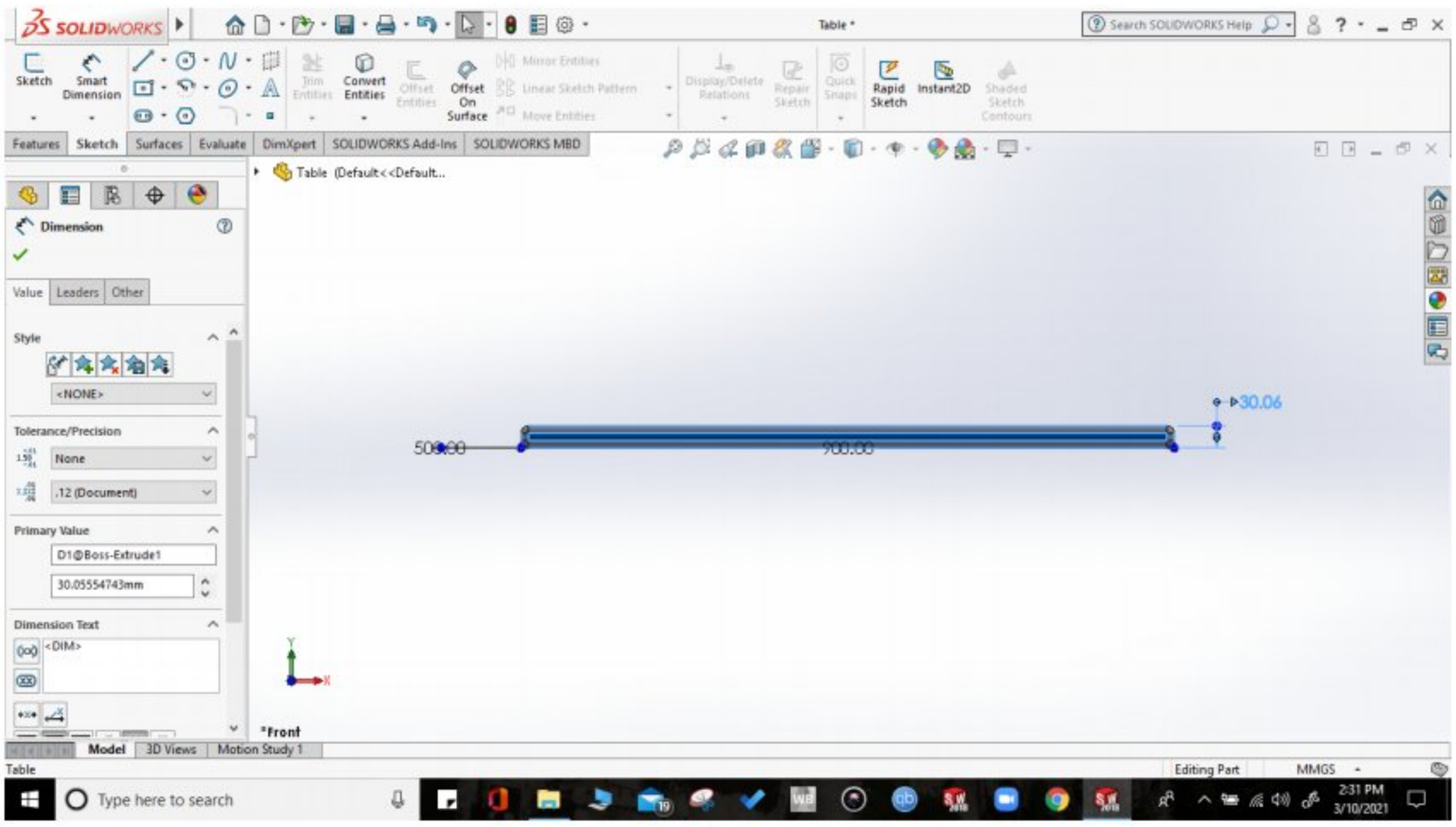

Figure 2.6: Side View

2.2.6.1.2 Upper Leg[2D View]

The Upper leg has a standard height and width of 550mm and 400mm respectively.

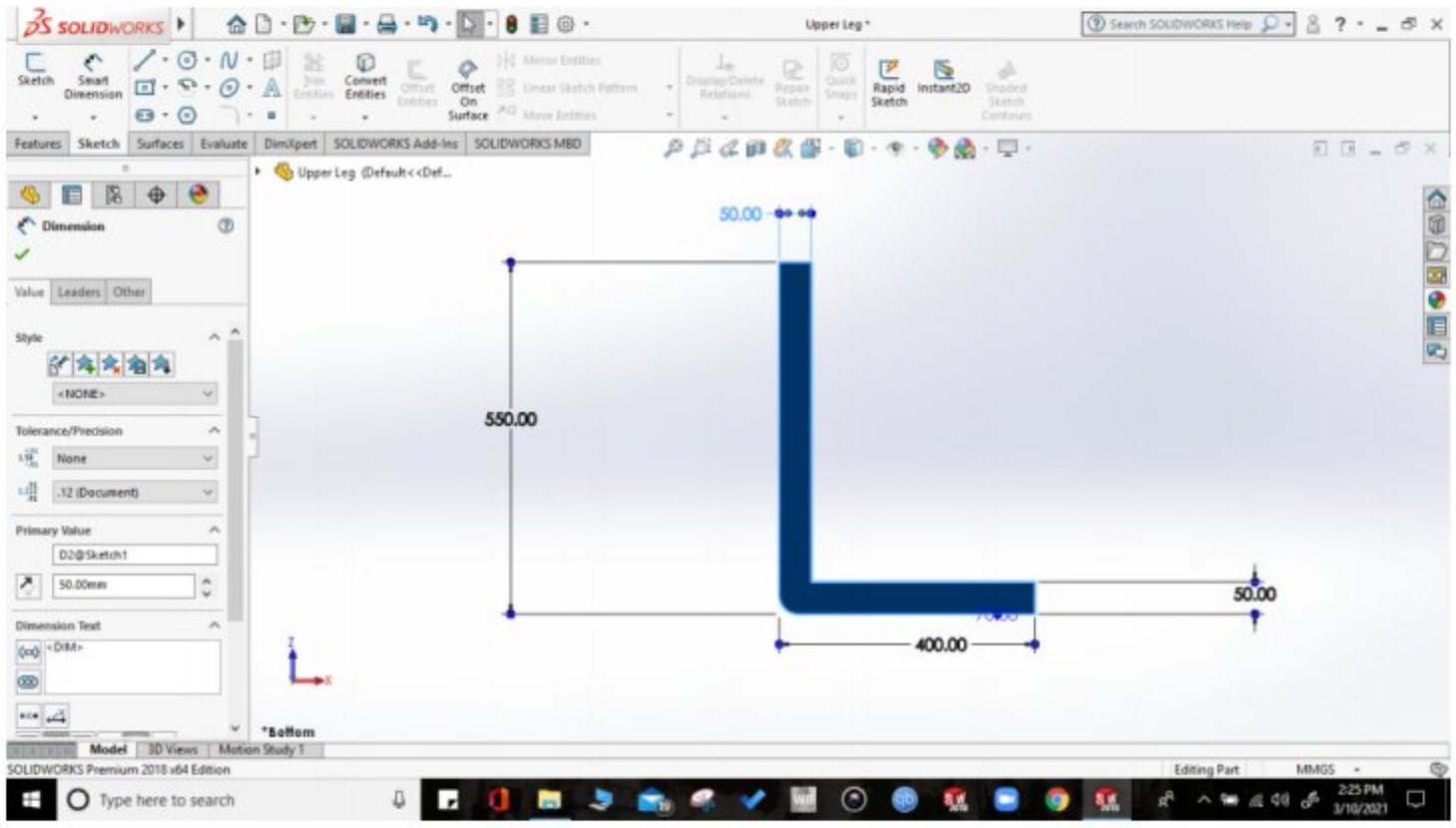

Figure 2.7: Side View

2.2.6.1.3 Lower Leg[2D View]

The lower leg has a standard height and width of 300mm and 400mm respectively.

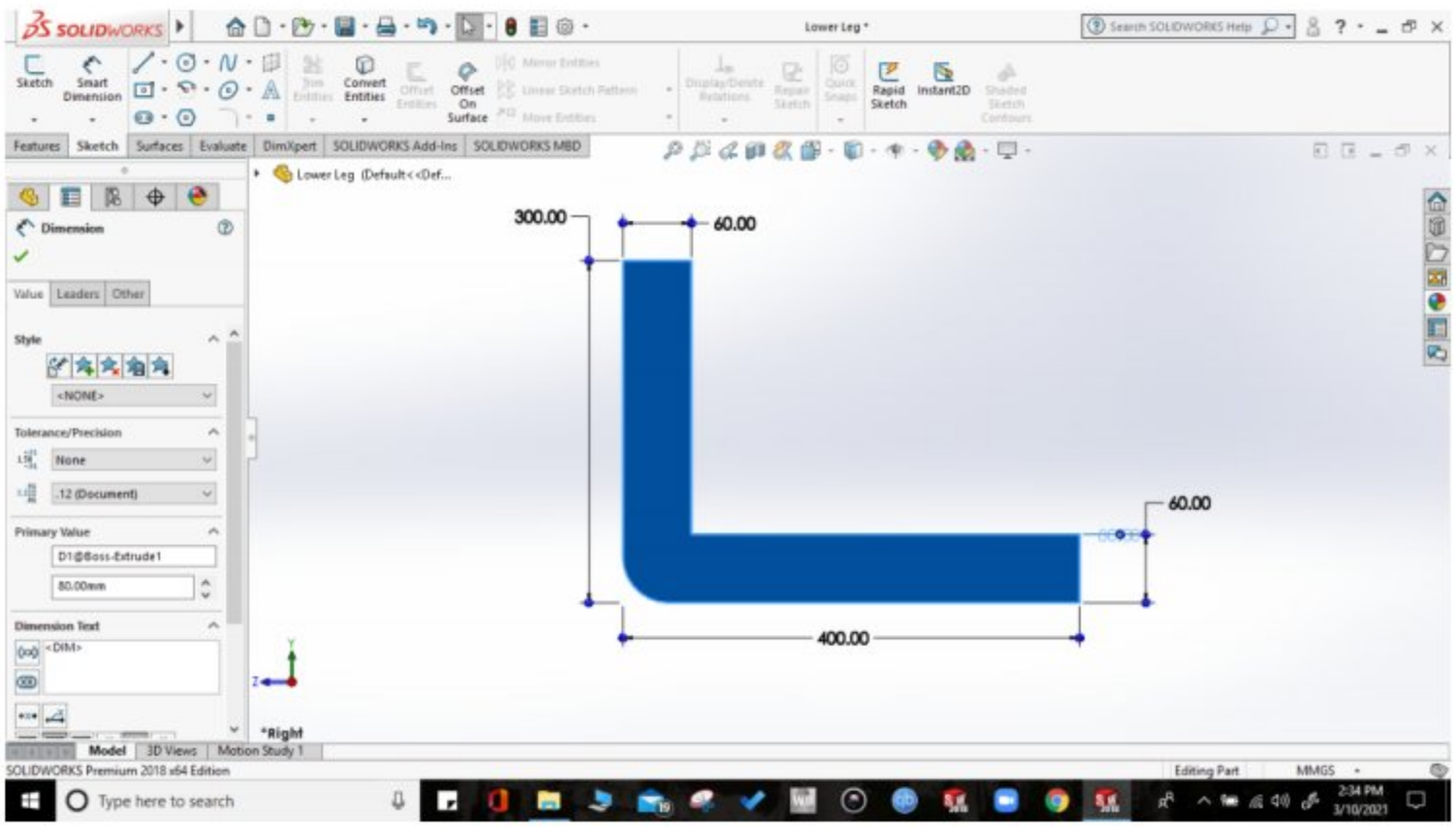

Figure 2.8: Side View

2.2.7 3D View of Assembly

Figure 2.9 shows the final assembly of the manually adjustable workstation.

Figure 2.9: Manually adjustable Workstation [3D View]

Figure 2.10 represents the sit-stand workstation assembly.

Figure 2.10: Interchangeable Workstation[3D View]

Chapter 3 Result and Discussion

An ergonomic factor questionnaire was used to conduct a subjective evaluation, among 20 workers from two individual RMG factories. The questionnaire is used to evaluate the ergonomic risk factors that are the leading cause of musculoskeletal problems amongst which the seating setup is the most crucial component of our research findings, and we have aimed to develop it. The majority of the participants were young, ranging in age from 20 to 35 years. They were untrained and had only been on the job for a limited timeframe. The collected data, which suggest massive change in seating position, are typical of most of the South East Asian apparel as most of the workplace conditions were stressful, involving long work hours with poor safety and labor relations, and that work equipment and the physical workplace design were acceptable ergonomic practices[22].

3.1 Ergonomic Factors Questionnaire

The research project was carried out in order to look at the ergonomic risk factors that cause discomfort.

Table 3.1 shows the priority of factors. It is seen that the adaptability of the workers is the most prioritized factor amongst the other, cost effectiveness, health/Safety measurements, and production efficiency.

Table 3.1: Priority Table-1

	Priority(X)	Priority(Y)	Average
Adaptability of workers	35.7%	49.6%	42.65%
Cost Effectiveness	30.8%	10.6%	20.70%
Health/Safety Measurements	13.5%	24.8%	19.15%
Production Efficiency	20.0%	15%	17.50%

Figure 3.1 shows a bar chart of factors by percentage of priority. As is visible from the chart adaptability has the maximum priority. To compound to that second specimen gives higher percentage requiring the most improvement.

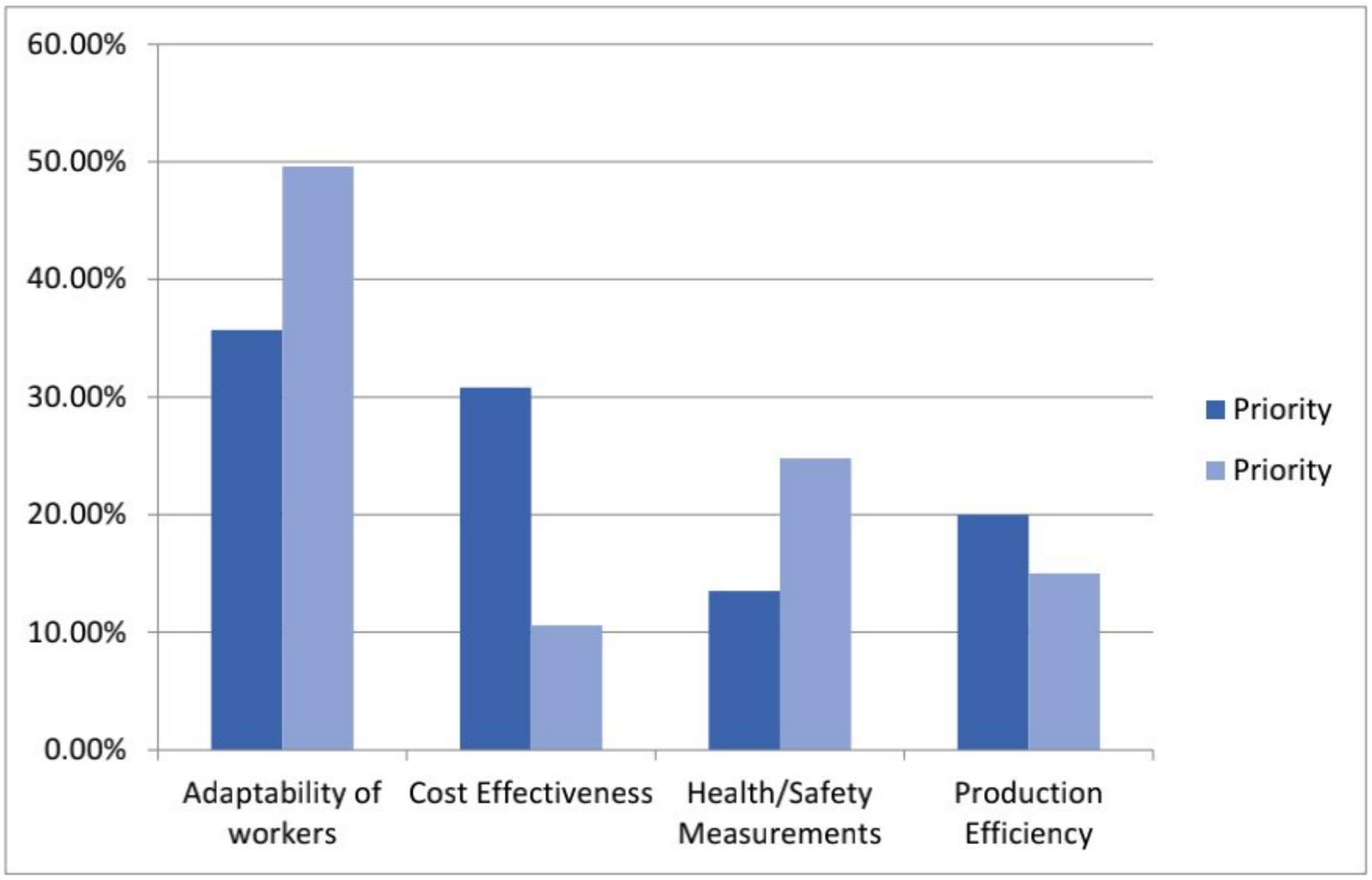

Figure 3.1: Bar Chart of Factors

Upon further analysis we have curated a table consisting of these factors calculated priority. Table 3.2 and table 3.3 represent the calculated priorities.

Table 3.2: Priority Table-2

	Adaptability of workers		Average	Cost Effectiveness		Average	Health/Safety Measurements		Average	Production Efficiency		Average
Seating arrangement	69.3%	60.6%	64.95%	58.4%	54.0%	56.20%	51.5%	57.0%	54.25%	57.0%	65.6%	61.30%
Machine Design	11.2%	10.2%	10.70%	7.9%	31.4%	19.65%	5.5%	30.8%	18.15%	25.6%	13.0%	19.30%

Table 3.3: Priority table-3

	Adaptability of workers		Average	Cost Effectiveness		Average	Health/Safety Measurements		Average	Production Efficiency		Average
Organizational ergonomic interventions(e.g. break)	11.6%	20.3%	15.95%	13.3%	6.0%	9.65%	31.1%	7.6%	19.35%	6.2%	16.4%	11.30%
Training	7.9%	8.9%	8.4%	20.4%	8.6%	14.5%	11.9%	4.6%	8.25%	11.2%	5.0%	8.10%

And the values of each were used to plot a line diagram depicted in the following figure 3.2.

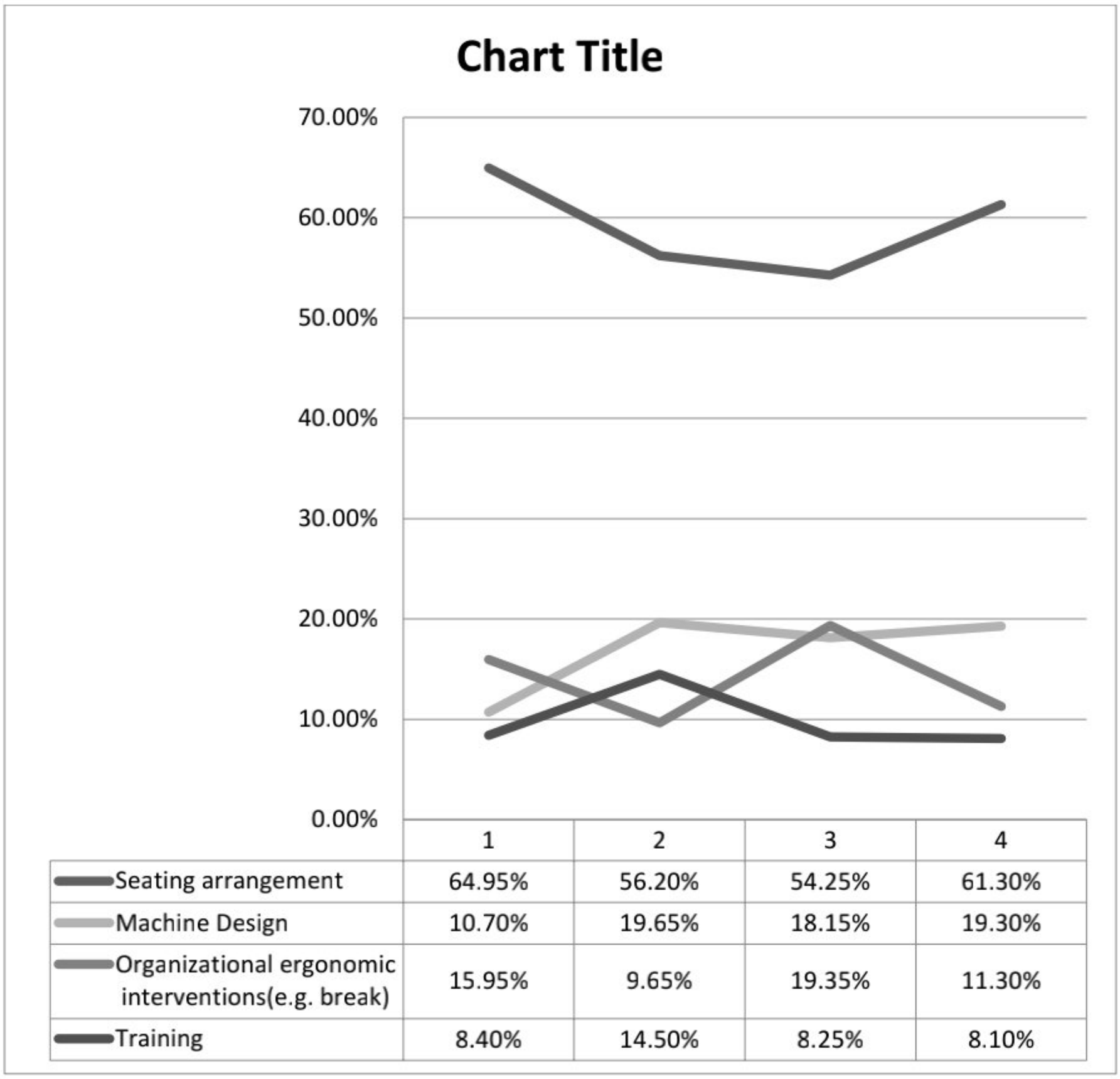

Figure 3.2: Line Diagram of Priority of the Factors

From the priority percentage data it was realized that seating arrangement is the most prominent factor of the study. This research aims to improve the seating arrangement of the workers for which three different designs were generated. To improve the seating arrangement adjustable workstation was proposed by this study.

The manually adjustable workstation functions through an actuator mechanism that in turn, can be used to move the table up and down. A footrest was provided for the worker that could be used while working in a sitting posture. The worker had the flexibility to adjust the table height to his comfort. Workstation should be laid out such that it minimizes the working area so that it reduces fatigue [27]. The switch controlled adjustable workstation is quite similar to the manual adjustable which is controlled by an ECU. Another solution offered by this research work was to use an interchangeable workstation, where the works use the sit-stand workstations.

Chapter 4 Conclusion

Bangladesh's Occupational Safety and Health (OSH) service is in the early stages of growth [28]. The responsibility of health and safety is forced upon the employees, when the RMGs should be the one responsible for the workers' health and safety regulations. It is high time the RMG factories start taking necessary steps to improve worker adaptability.

This study showed that the seating arrangement in current RMG factories needs massive improvement. To improve the existing seating arrangement, adjustable workstations were suggested. Three possible solutions were suggested and each of them was ergonomically designed considering the anthropometric data. Working both in sitting and standing postures offer more work productivity than traditional sitting postures.

Business owners who are starting new RMG factories should use the design instructions provided in this paper to reduce workers' postural discomfort. Existing RMG factories can improve their seating arrangement by installing ergonomically designed workstations; let it be an adjustable workstation or an interchangeable workstation as both of them offer improved productivity along with reduced workers' postural stress.

Since this study only represents the design and a theoretical outlook, in the future building a prototype and implementing it in a RMG factory may benefit the sector.

Chapter 5 Reference

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