Application of Computer-Assisted System in Manufacturing Units of Communication Devices

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Abstract

In this paper the author has developed a computer assisted system which could help the Industrial engineers to practice ergonomics in the manufacturing industries in a more convenient manner. Development of ergonomics guidelines for particular industry has been a very meticulous task for most ergonomist. As it involves various components to understand and assess the work and workplace. In this paper, the authors have taken a step ahead to develop software which could guide the users in implementing ergonomics at their workplace. Also a case study of a small manufacturing unit of communication devices is made to present the implementation of ergonomic tools.

Keywords

Ergonomics, Computer-Assisted System, Ergonomic Assessment Tools.

1. Introduction

Growth and technological development in the industrial sector is a key prospectus for most developing countries. Human factors and ergonomics are helpful in designing the workplace thereby improving the safety of the workers in the industries. Designing the workplace is the major task for the design engineers and industrial engineers and they must have a very good knowledge about ergonomics to implement ergonomics to create hazard- free and safe working environment. Sonasale Priti.et.al (2016). A user-friendly platform is essential to provide the overall knowledge and guidance to the design engineers and industrial engineers to design and manage the work and the workplace. The author has developed software which can accomplish this task and provide better guidance for designing the work and the work environment to make it a more comfortable place to work. Sonasale Priti.et.al (2017). The author has given the glimpses of the software with a relevant case study for the better exposure of the software.

2. Literature Review

Various researchers have worked in the area of ergonomics aspects relevant to industries. Some have given the insights of the software which can be used by the ergonomist and industrial engineers to make improvements in the work and workplace. Issachar Gilad, Reuven Karni (1999) has worked on the development of an expert system (ERGOEX) for ameliorating the working conditions of worker and the work environment. Pavlovic Veselinovic,et. al (2010) has developed a expert system called SONEX, that is helpful in solving the musculoskeletal risk involved in the work and working postures. He has used around 150 questions from various resources and tried to train the system accordingly and developed an expert system. WANG Qiang (2020), Sonasale Priti, et.al (2021), have worked in the area of intelligent ergonomics, this is helpful in discussing a relationship between ergonomics in industrial design. Natasa Vujica Herzog & Gregor Harih (2019), have worked on the development of the decision support system for the worker with various types of disabilities. This system helps the user to make decision while performing the task which could reduce the risk of injuries. After reviewing the various articles from the literature, it was found that there is need for developing a computer assisted system for small and medium manufacturing sector in general. The developed system guides the user to understand the ergonomics and use the ergonomic assessment tools.

3. Methodology

The development of software interface is made using C# programming language of Microsoft Visual Studio. Using this software computer assisted system is developed. It consists of five sections as shown in the Figure 1.

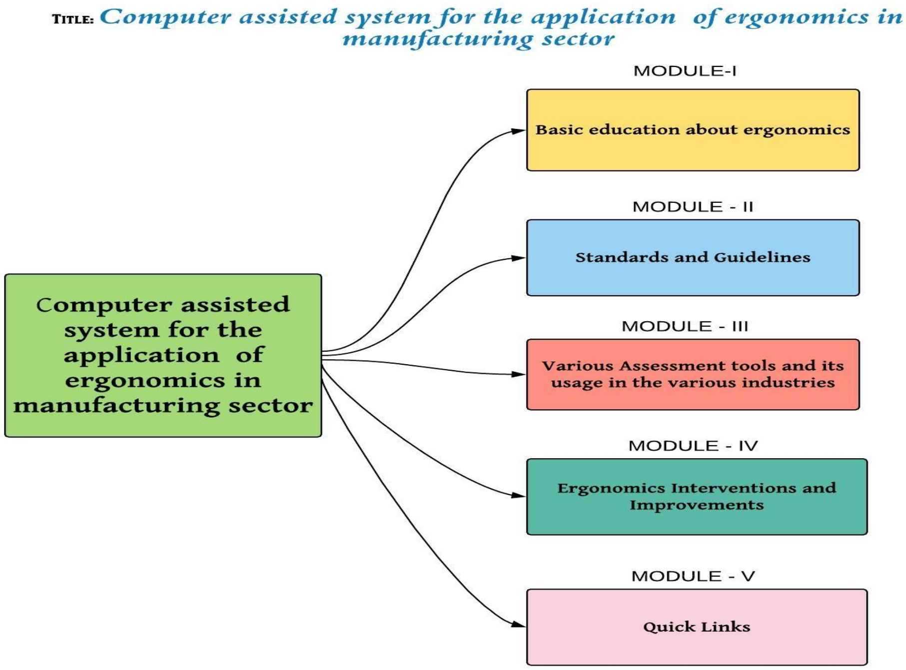

Figure1: Computer Assisted System for the application of ergonomics in manufacturing sector

The initial interface of the software is as shown in the figure 2

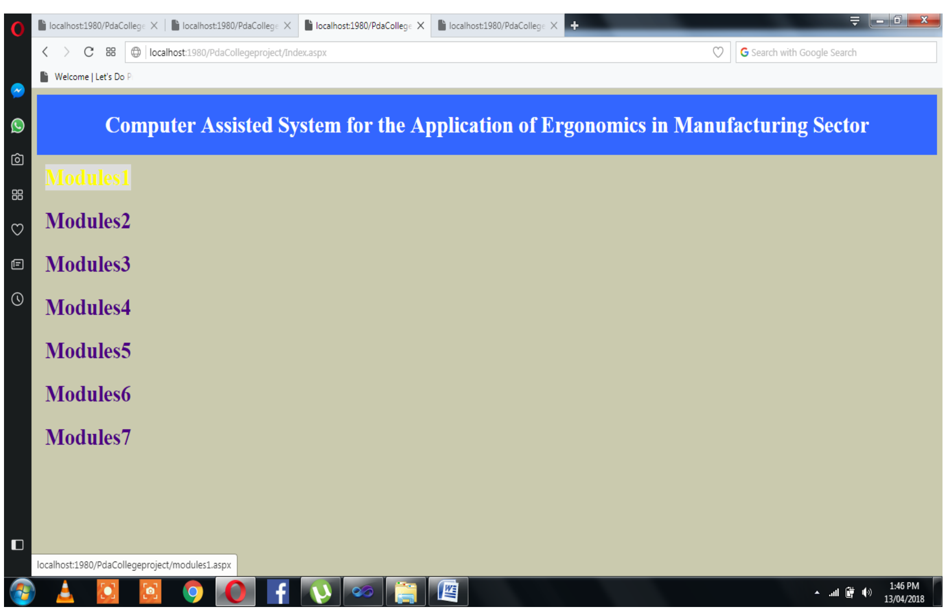

Figure2: Initial interface of the developed software

Once we click on the module 1, a new page will open as shown in the figure 3

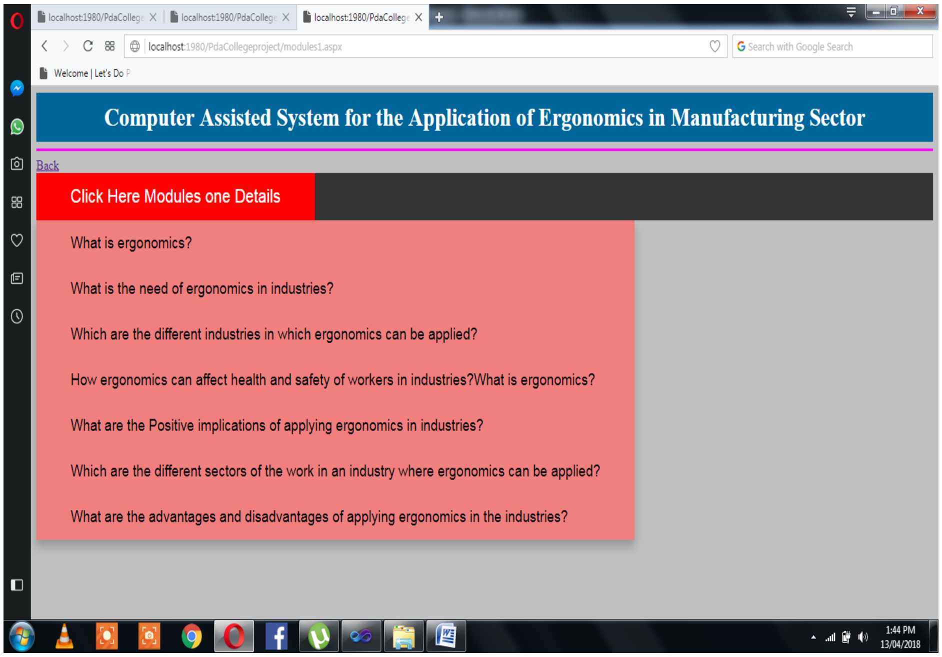

Figure3: Interface of Module 1

Similarly, various modules can be viewed through the interface and we can use the information from these modules for interpretation.

4. Case Study of a Manufacturing Unit in Communication Devices

In this work, an assembly line of a small scale manufacturing unit is considered to test the software implementation. In assembly communication equipment, the surface mount technology is used in sitting and standing position. There were a lot of complaints about MSDs in the workers of this unit. Hence it was planned to investigate the reason behind the MSDs using the developed software. To study the task, we are using the assessment tool module of the developed software.

Let us consider a research article in which the experimentation and interpretation were carried out manually Daneshmandi H. et. al (2018). In this work, an assembly line is taken in which 53 workers were performing the assembly operation of a communication device. Out of 53 workers, 44 were women and 9 were men. The anthropometry of all the workers was noted and the data related to MSDs were collected by using the Questionnaire. Most of the awkward postures in the assembly line lead to disorders in shoulders, hands, wrist and legs which are generally considered as MSDs. Qutubuddin S.M, (2013) Sanaulla .S et. al (2014). During the assembly operation, the upper limbs will encounter more exertion and this can be easily realized using the RULA Assessment tool. Also, the strain index chart is used to evaluate the strain on the hand and arms of the worker.

For the evaluation visual examination unit was considered. Video footage was taken while performing the assembly operation. One completed cycle of the assembly operation is taken into consideration to study the MSDs. From the footage, it was realized that a worker has to stand and bend her head forward to perform the inspection which in turn leads to stress on shoulder and neck portions as shown in figure 4

Figure 4: Working Posture of a worker in Assembly line Daneshmandi H. et. al (2018).

The risk analysis is carried out from the RULA excel sheet of the software. The action level of the score developed are given in the below Table1 McAtamney, E Nigel Corlett (1993)

Table1: RULA Action Score Table McAtamney, E Nigel Corlett (1993)

Case level	Score	Necessary Action
Case 1	1 -2	Acceptable Posture if it is not maintained or repeated for long periods
Case 2	3-4	Changes are necessary once investigated
Case 3	5-6	Soon changes have to be made once investigated
Case 4	7 +	Immediate changes have to made after investigation

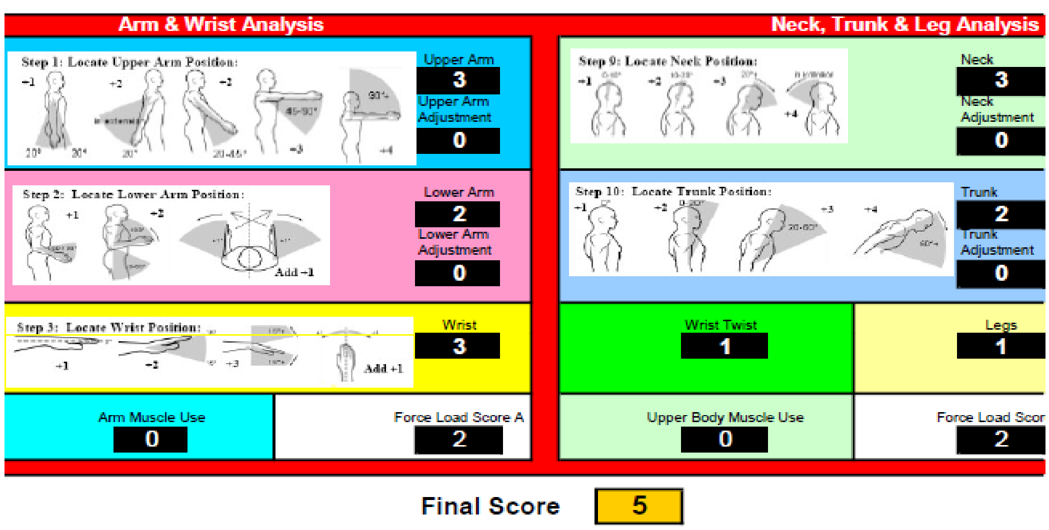

Figure 5: RULA Assessment Sheet based on the observations

Based on the postures and motions of limbs the RULA Assessment sheet is filled as shown in figure 5. Each action has some score which needs to be added in the form. Mobility of each arm and wrist, twist in the wrist are carefully observed and noted.

The RULA Excel sheet gives clear and concise information about the approach of analysis. It minimizes the work by automating the calculations part, thereby reducing the efforts for the evaluation process.

The obtained final report generated gives the data in red colour, which indicates that there is an urgent need for changing the postures of the work so as to prevent MSDs.

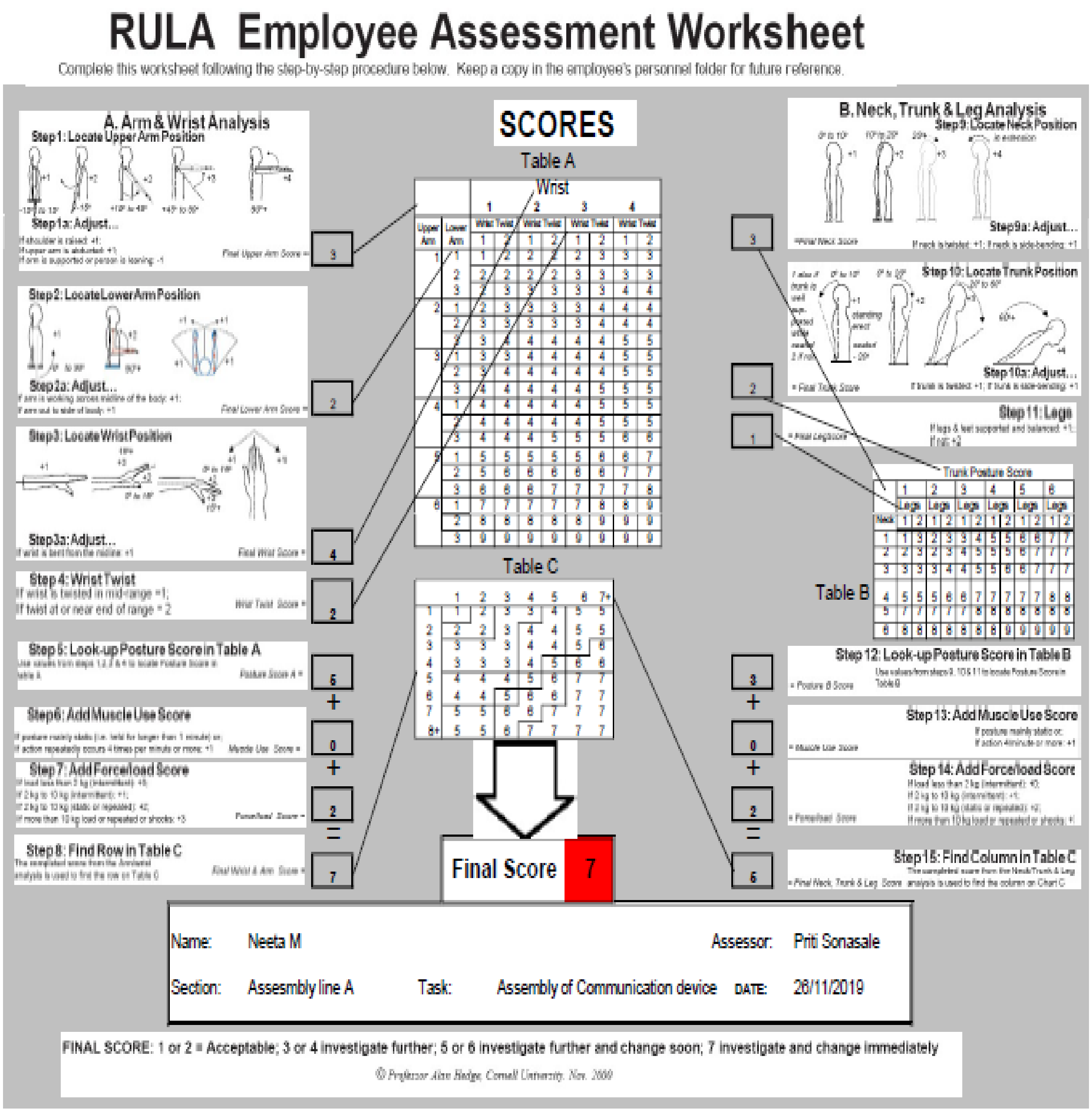

Figure 6: RULA Assessment report generated after observation

Once the final score is obtained we can include the necessary changes that need to be incorporated in the assembly line so as to reduce the risk of MSDs. To overcome this issue we can use the guidelines for postures. These guidelines are available in the module “Standards and guidelines” of the software. Considering the “Postures” section of guidelines we can look for the guidelines for postures that need to be implemented in the work. As it is an assembly inspection operation where no manual work is required, we can implement the guidelines given as shown in the figure 6. “In tasks that require no manual work, such as reading, bending the head and trunk forward can be reduced by using a sloping work surface of at least 45 degrees for viewing.”

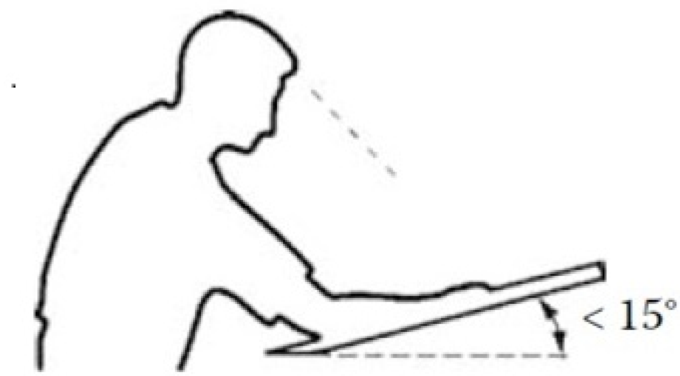

Figure 7: Postures for non-manual works

Also, consider the issue of hand and arm postures while performing a repetitive task for a long period of time we can find the solution in the guidelines “Postures” section of the software. To overcome the problem we can consider putting into practice a sit-stand workplace and implementing to make use of pedestal stood for intermediate sitting. In this inspection task to improve the workplace, some changes are made by making the variation in the table position by referring figure 8 and providing a pedestal stool for intermediate sitting and standing postures. Titling the table from 0º to 15º will reduce the pain in the neck. Also, it provides support to the arms thereby minimizing the chances of risk. The pedestal stool helps the worker to relax during the transitional period.

Figure 8: Working Postures after implementation of Software Daneshmandi H. et. al (2018).

After the ergonomics is implemented at the work, once again the RULA assessment tool is used to evaluate the risk involved in performing the assembly task.

Figure 9 shows the RULA assessment carried out after observing the worker and the relevant observations are noted in an excel sheet. From the observation assessment sheet, it can be viewed that the risk involved in performing the assembly operation of a communication device has been reduced. Before implementation of ergonomics there was a high risk of about 7 score which has now reduced to 3 score after implementation of ergonomics in the workplace.

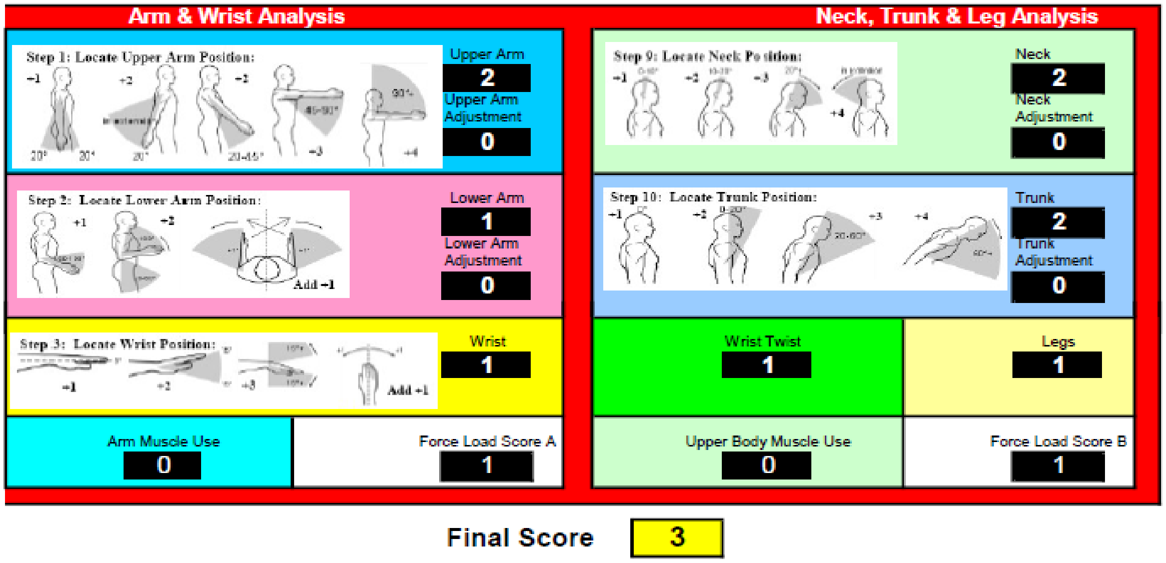

Figure 9: RULA Assessment sheet after analysis

Figure 10 shows the RULA Assessment sheet generated after analysis of the workplace. This report shows that after implementation of ergonomics in the workplace the risk has been abridged and now the worker can perform the work satisfactorily.

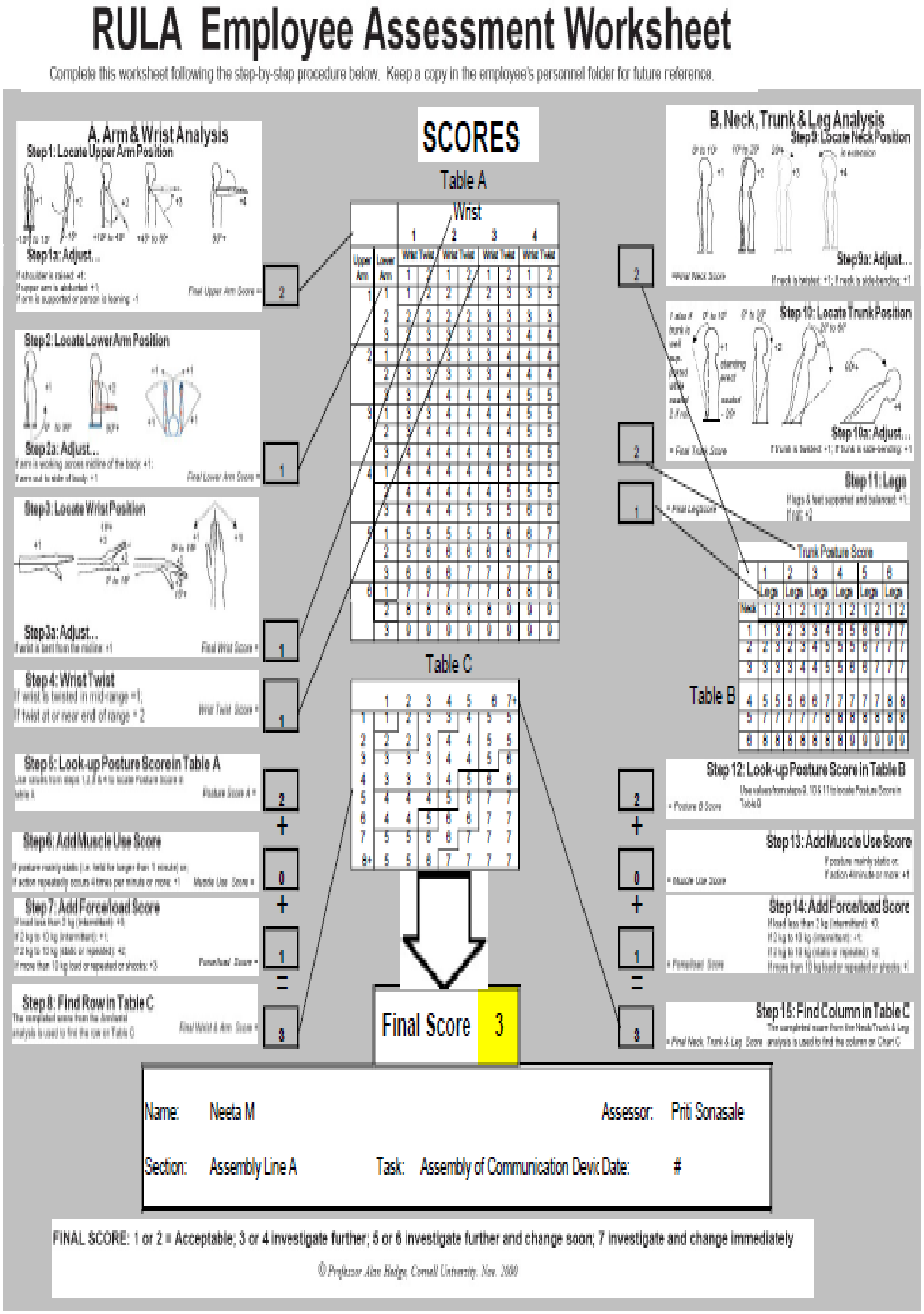

Figure 10: RULA Report generated after analysis

Furthermore, the strain on the hands and arms of the worker is evaluated using a strain index (SI) parameter. This can be evaluated manually by using the steps given in the software or via an excel sheet provided in the software. Using the excel sheet provided in the software we can easily perform the evaluation task. Below mentioned is the excel sheet used for evaluation of strain index (SI) for inspection of a communication device after assembly.

Strain Index Scoring Sheet

Date:	26/11/2019	Task:	Inspection task
Company:		Supervisor:	Neeta M
Dept:	Assembly line	Evaluator:	Priti Sonasale

Risk Factor	Rating Criterion	Observation			Multiplier	Left	Right
Intensity of Exertion (Borg Scale - BS)	Light	Barely noticeable or relaxed effort (BS: 0-2)			1	1	3
	Somewhat Hard	Noticeable or definite effort (BS: 3)			3		
	Hard	Obvious effort; Unchanged facial expression (BS: 4-5)			6		
	Very Hard	Substantial effort; Changes expression (BS: 6-7)			9		
	Near Maximal	Uses shoulder or trunk for force (BS: 8-10)			13		
Duration of Exertion (% of Cycle)	< 10%	**Calculated Duration of Exertion** (from inputs below)			0.5	0.5	1.5
	10-29%	**User Inputs**	**Left**	**Right**	1.0		
	30-49%	Total observation time (sec.)	60	60	1.5		
	50-79%	Single exertion time (sec.)	2	5	2.0		
	≥ 80%	Number of exertions during observation time	2	4	3.0		
	Calculated Duration of Exertion (%)		6.7 %	33.3 %			
Efforts Per Minute	< 4	**Calculated Efforts Per Minute** (from inputs above)			0.5	0.5	1
	4 - 8		**Left**	**Right**	1.0		
	9 - 14		2.00	4.00	1.5		
	15 - 19				2.0		
	≥ 20				3.0		
Hand/Wrist Posture	Very Good	Perfectly Neutral			1.0	1	1.5
	Good	Near Neutral			1.0		
	Fair	Non-Neutral			1.5		
	Bad	Marked Deviation			2.0		
	Very Bad	Near Extreme			3.0		
Speed of Work	Very Slow	Extremely relaxed pace			1.0	1	1
	Slow	Taking one's own time			1.0		
	Fair	Normal speed of motion			1.0		
	Fast	Rushed, but able to keep up			1.5		
	Very Fast	Rushed and barely/unable to keep up			2.0		
Duration of Task Per Day (hours)	<1				0.25	1	1
	1 < 2				0.50		
	2 < 4				0.75		
	4 ≤ 8				1.00		
	> 8				1.50		
Results Key	SI ≤ 3	Job is probably safe				0.3	6.8
	3 < SI < 7	Job may place individual at increased risk for distal upper extremity disorders					
	7 ≤ SI	Job is probably hazardous					

Figure 11: Strain Index (SI) sheet used for evaluation

By using the Strain Index (SI) excel sheet from the software we can easily determine the level of strain a worker is facing while performing inspection operation in the assembly line unit. The above mentioned figure 11 shown the sheet in which the details of strain exerted on the worker while inspecting the communication device are noted. Once the data is filled, this sheet will calculate the strain Index (SI).

The risk factors such as the intensity of exertion, duration of exertion, efforts per min, hand and postures, speed of work, duration of task per day in hrs are considered while determining strain index. The rating criteria, observations and multipliers are used as per J. Steven Moore & Arun Garg, (1995) the developer of the chart.

In the task of inspection of the communication device, the intensity of exertion on the part of worker's left hand is barely plain insight, whereas right-hand exertion is somewhat hard and can be easily noticed.

The working shift was of 6 hrs. Duration of exertion is measured as % of the cycle in which, the total observation time for left and right hand is 60sec. The single exertion time for left hand is 2 sec and for right-hand, it is 5 sec. There are 2 such exertions in the observation cycle for left hand and 5 for right-hand. The duration of exertion on the left hand is 6.7%, whereas for right-hand it is 33.3%. The effort on the left and right hand are 2 and 4 respectively and the speed of work was normal for both the hands.

Applying the multipliers for various criteria we can determine the Strain Index (SI) of both left and right hand. For left-hand SI is 0.3 and is indicated with the green colour of the sheet which reveals that the job is safe to proceed whereas SI on right hand 6.8 in yellow colour implies that there is risk involved while performing the task as shown in figure 11

Strain Index Scoring Sheet

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	Near Maximal	Uses shoulder or trunk for force (BS: 8-10)			13		
Duration of Exertion (% of Cycle)	< 10%	Calculated Duration of Exertion (from inputs below)			0.5	0.5	1
	10-29%	User Inputs	Left	Right	1.0		
	30-49%	Total observation time (sec.)	60	60	1.5		
	50-79%	Single exertion time (sec.)	2	4	2.0		
	≥ 80%	Number of exertions during observation time	2	4	3.0		
	Calculated Duration of Exertion (%)		6.7 %	26.7 %			
Efforts Per Minute	< 4	Calculated Efforts Per Minute (from inputs above)			0.5	0.5	1
	4 - 8		Left	Right	1.0		
	9 - 14		2.00	4.00	1.5		
	15 - 19				2.0		
	≥ 20				3.0		
Hand/Wrist Posture	Very Good	Perfectly Neutral			1.0	1	1
	Good	Near Neutral			1.0		
	Fair	Non-Neutral			1.5		
	Bad	Marked Deviation			2.0		
	Very Bad	Near Extreme			3.0		
Speed of Work	Very Slow	Extremely relaxed pace			1.0	1	1
	Slow	Taking one's own time			1.0		
	Fair	Normal speed of motion			1.0		
	Fast	Rushed, but able to keep up			1.5		
	Very Fast	Rushed and barely/unable to keep up			2.0		
Duration of Task Per Day (hours)	<1				0.25	1	1
	1 < 2				0.50		
	2 < 4				0.75		
	4 ≤ 8				1.00		
	> 8				1.50		
Results Key		SI ≤ 3	Job is probably safe			0.3	3
		3 < SI < 7	Job may place individual at increased risk for distal upper extremity disorders				
		7 ≤ SI	Job is probably hazardous				

Figure 12: Strain Index after implementation of ergonomics

After the implementation of the changes in the workplace again the observations are made and filled in the strain index sheet as shown in figure 12. The Strain on right hand has drastically changed from 6.8 to 3 by titling the table provided support to the arms and thereby reducing the exertion on the right hand. The SI on left and right hand are 0.3 and 3 which indicates that the task is safe to progress.

In this case study, we have considered only one task of the work and it tried to convert into automated form by using software which minimizes the time, increases accuracy and provides error-free results when compared to manual methods of inspection in an assembly line. This software not only identifies the risk but also guides the user to adopt some better methods of performing the task thereby reducing the risk of injury on the part of the worker.

5. Conclusion

Ergonomics is a science that deals with designing a workplace and the task as per the requirements of the user and the task, so that user can work comfortably and safely. Ergonomics can be applied in many ways at different levels in an organization in order to grow ergonomics culture in the work place. . To facilitate the implementation of ergonomics in more-and more industries can be achieved by using resources which can be easily implemented at work place and can improve the productivity of the industry. In regards to this, user-friendly software is developed that is helpful for small and medium scale manufacturing organization to implement ergonomics principles smoothly at work. this software includes some assessment tools necessary for day-to-day activities in industries. The validation of the software is made by using it in assembly operation of communication devices, which is proved to be successful as it could help to maintain the proper posture and comfort for the worker. It also identifies the strain at performing the task and guides the worker to maintain proper postures so as to reduce the strain at work.The software can also provide the suggestions for the user to take corrective actions to avoid the work related issues prevailing in the industries.

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Biography

Miss Sonasale Priti is presently working as a research scholar, Industrial and Production Engineering Department, P.D. A. College of Engineering, Gulbarga. She has completed her M. Tech in Production Engineering and BE in Industrial and Production Engineering. She has 7 years of teaching experience at university level. She has published around 8 research articles in international journals and presented papers in various international and national conferences. She has attended various refreshers courses, short-term courses and workshops. She is a life member of professional societies such as ISTE, ISRD, IAENG, and senior member of IRED. She is a reviewer of Science Alerts and International journal for research in mechanical engineering.

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