S-task simulation builder framework as preventive work risk analysis

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Article Info

Article history:

Received Nov 24, 2023
Revised Feb 2, 2024
Accepted Feb 28, 2024

Keywords:

Biomechanics
Digital human modeling
Framework
Preventive
Rula

ABSTRACT

Computer methods in biomechanics are computer methods for solving biomechanics problems. Rula, Reba, Niosh, Owas is a method of analyzing work risks due to incorrect posture. Each method uses a worksheet on one posture to analyze risk. For dynamic work, a computer method is needed that can quickly calculate every change in posture. Virtual reality and Kinect as dynamic work analysis methods cannot be carried out preventively. Preventive measures are needed to prevent workers from risks resulting from work. For this reason, computer simulation methods are needed to create work stations and work processes so that they can be carried out preventively. The s-task simulation builder (S-TSB) framework provides a dynamic work analysis solution using simulation. The three processes carried out include surveying, creating simulations and processing posture data. Software validation was tested using the black box analysis method and the results were as expected. The dynamic working model is tested showing results in the form of graphs so it is easy to compare each change. The use of simulation also saves design costs because optimization can simply be done by changing the simulated work station data and/or work process.

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1. INTRODUCTION

Body posture determines the level of risk due to work [1]. Musculoskeletal disorders (MSDs) are occupational diseases [2]. The science that studies the physical interaction of a worker with machines, equipment and other materials, the aim of which is to maintain worker performance, and prevent injury or minimize the impact that will arise from physical activity, is work biomechanics [3]. Several work risk analysis methods include Niosh, Rula, Reba, and Owas [4]. The Rula method (rapid upper limb) is a work risk analysis method that examines upper body posture [5]. Rula is widely used because it does not require additional tools to carry out analysis [6]. Rula uses the Rula employee worksheet assessment to analyze the level of work risk as shown in Figure 1 [7]. Rula worksheet assessment only analyzes one posture during work so it is not efficient to use in analyzing risks in dynamic work. Dynamic work is work where changes in posture occur as a function of time [8]. Calculating the level of occupational risk by analyzing workers while working at a work station means that this method cannot be used preventively [9]. To stay healthy at work, workers must know the level of risk that may occur before working [10]. The work process must be biomechanically correct [11].

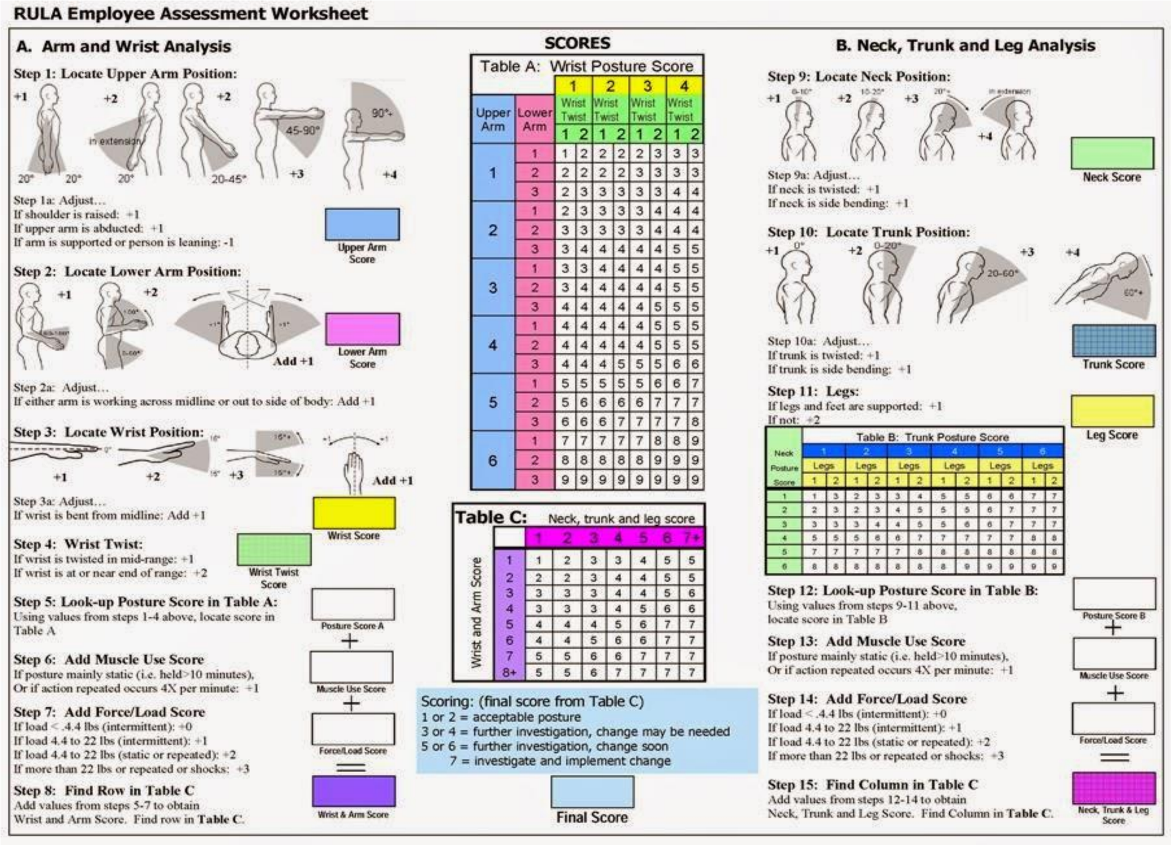


Figure 1. Rula employee assessment worksheet [7]

From this background, the problem is how to analyze the dynamic work risk level which can be used preventively. Computer technology is needed to solve this problem. Computer methods in biomechanics is an effort made to solve biomechanics problems using computer science [12]. Regarding computers in biomechanics, the focus of current research is still on efforts to obtain posture data that changes as a function of time [13]. Kinect technology has been applied to obtain posture data during work [14]. Kinect was refined into Kinect v2 to improve the capturing process in work processes [15]. Virtual reality (VR) technology is also developing to obtain posture data [16]. VR is a computer technology that can enable users to interact with environments in a simulated virtual world, so that they feel like they are in that environment [17]. However, Kinect, and VR cannot yet be applied preventively to obtain an analysis of work risk levels. To obtain preventive risk analysis requires humans, work stations, and simulated work processes. A number of studies show the development of digital human modeling (DHM) in the world [18], [19]. DHM developers include santos, HumanCAD, tecnomatix jack [20], [21]. Developments in computer software and hardware help the development of DHM today [22]. Currently DHM is able to simulate work processes well. Tecnomatix jack is a DHM developed by siemens software industries [23]. Tecnomatix jack provides grants to institutions in the form of free software license grants such as those obtained by the Faculty of Engineering Udayana University [24]. The task simulation builder menu is able to simulate work processes on workstations. On texnomatix jack anthropometric data can be obtained from measurement results, using secondary data, or using anthropometric data contained in the tecnomatix jack software [25]. Indonesian anthropometric data can be downloaded on the Indonesian anthropometric website [26]. This data can be input into the tecnomatix jack. The use of secondary data shows that risk analysis can be obtained preventively. Posture data will not be meaningful if there is no data processor to interpret the results. Data processing software is required. The PHP programming language [27] with the laravel framework [28] where results can be displayed in web form will make it easier for users and admins to use data processing applications. Apart from being a free license, the MysQL database is suitable for use and supports PHP programming which can be displayed on a web basis [29]. In displaying the results, using graphs of risk levels as a function of time will make it easier to compare risk levels when working dynamically.

The aim of this research is to obtain a dynamic work analysis method that is preventive in nature. With preventive methods, occupational risks can be avoided. The optimal design can be obtained by changing the simulation variables so that design costs can be saved. Displaying the frequency of risk levels means that optimization can be done simply by looking at the decrease in the frequency of risk levels. The benefit of dynamic work risk analysis which can be applied preventatively is that workers will avoid work-related risks and will save design costs.

2. METHOD

The s-task simulation builder (S-TSB) framework uses the Rula employee worksheet assessment to obtain work risk calculations as in Figure 1. In this research, a survey was conducted in the computer technician's room at PT Baliyoni Saguna to see the work process of moving 3 central processing unit (CPU) units from the rack to the work desk. To show that the process can be carried out preventively, anthropometry uses secondary data from Indonesians on the website https://anthropometriindonesia.org [26]. Simulation using the TSB menu on DHM tecnomatix jack version 9 at the FT Unud Electrical Engineering Laboratory [30]. DHM Software is a software grant received by the Faculty of Engineering, Udayana University from Siemens Software Industry. The analysis software was created using the PHP programming language with the laravel framework and MySQL database which is published at https://kerjadinamis.web.id [31]. The process flowchart for the analysis software is shown in Figure 2. Testing of the analysis software using the black box method [32]. S-TSB framework analysis and testing was carried out on a number of dynamic jobs. In this paper, the work of moving computers in the technician room of PT Baliyoni Saguna is analyzed. The workstation design optimization process using the S-TSB framework is also presented.

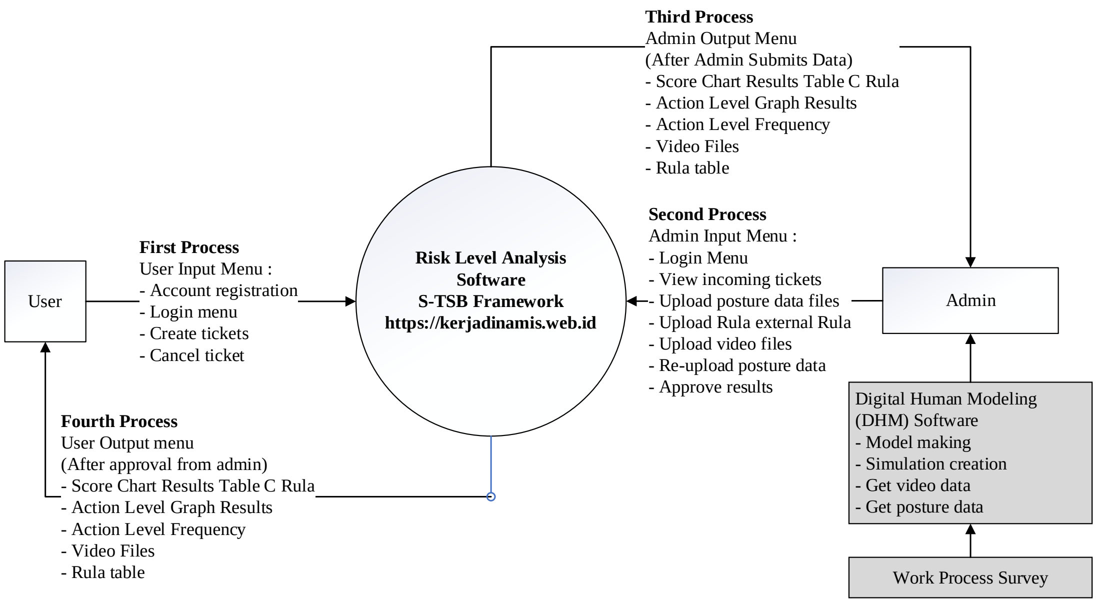


Figure 2. Risk level analysis software S-TSB framework

3. RESULTS AND DISCUSSION

Results and discussion began with a survey process to see the work process. The survey results will be used as a guide in creating simulations. At the survey location, you can measure anthropometric data if you want to simulate according to worker data, but you can also use secondary anthropometric data for preventive purposes. From the survey results, a simulation model and simulation process was created using DHM tecnomatix jack. Before testing the work process, the risk level analysis software is tested using the black box analysis method. If the results are as expected then the S-TSB framework testing on dynamic work continues. The test results were analyzed to see the suitability of the results with the Rula method which uses a worksheet. In the discussion, the advantages, and disadvantages of the S-TSB framework will be discussed.

3.1. Survey to see the work process

The survey was carried out in the computer technician's work room at PT Baliyoni Saguna as shown in Figure 3. The technician simulates the process of moving 3 CPU units from inventory to the workbench. Anthropometric data uses secondary data from Indonesian anthropometry. The work process was recorded using handycam to make it easier to compare with the simulation model. Anthropometrics uses secondary data to show that the process can be carried out preventively.

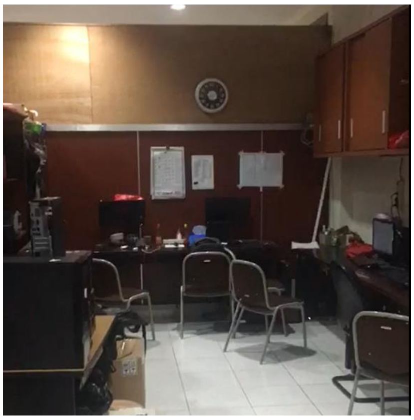


Figure 3. PT Baliyoni Saguna workspace

3.2. Making work process simulations

Creating a work process simulation begins with creating models of humans, objects and the environment using DHM tecnomatix jack Ver.9. Human anthropometric data obtained from Indonesian anthropometry is included as input for the human model. Object and environment models are taken from survey data. The model is used as a simulation using the task simulation builder menu. The simulation results used in the data processing software are posture data as a function of time which is stored in the ssp.csv file and work process video files. This process requires the operator's ability to create simulations using DHM software. The simulation results are shown in Figure 4.

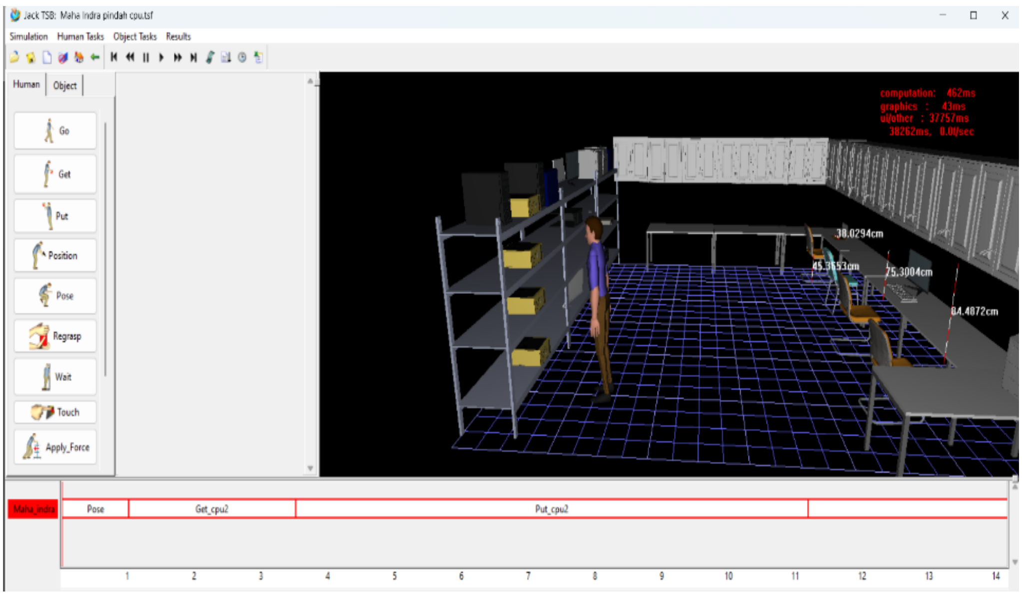


Figure 4. Dynamic work process simulation

3.3. Job risk analysis software validation test

At this stage, the validity of the software created will be tested. Testing of the validity of work risk level analysis software uses the black box analysis method. The testing stages are in accordance with Figure 2. There are 4 test tables on the user input, admin input, admin output, and user output sides. The validation results on the admin output are shown in Table 1. The results obtained are all as expected. All tests also show results that are as expected. The test results show that the work risk level analysis software is declared valid.

Table 1. Test items: admin output menu

	User acceptance test document	Doc no: 4	
	Posture data processing software	Tester: software developer	
		Test items: user output menu	
ID	Output menu		Results
	Test description	Results obtained	Received
4.1	Displaying analyzed work process data	Analyzed work process data	Received
4.2	Displaying Reba graphics	Reba graphics	Received
4.3	Displaying action level graphics	Action level graphics	Received
4.4	Displays action level frequency	Action level frequency	Received
4.5	Showing simulation video	Video simulation	Received
4.6	Displaying Reba table	Reba table and action level filters	Received
4.7	Displaying ssp.csv	Ssp.csv table	Received

3.4. Testing the S-TSB framework in dynamic work

Testing of the S-TSB framework is carried out on a number of dynamic jobs. In this paper, testing was carried out on the job of moving 3 CPU units from the inventory shelf to the workbench. After the survey of work stations and work processes, the simulation was continued. The simulation results in the form of a posture file as a function of time are stored in the ssp.csv file and the video file is uploaded to the risk level analysis software. The software also includes other variables according to Rula's method, including the weight of the object carried and the type of work. After all variables are sent, the software will automatically display the results. The first result that appears is a graph of of Rula as a function of time as shown in Figure 5. The x-axis shows the measurement time and the y-axis shows the results of the Rula method. Displays a graph of the level of work risk as a function of time as shown in Figure 6. In the graph the x-axis shows time and the y-axis shows the level of risk. The larger the number displayed, the higher the risk level. This graph is an interpretation of the level of risk due to work from each posture while working. There are 4 levels of risk according to the Rula method. Figure 6 cannot show the entire process when moving 3 CPUs because the graph size is relatively long. The increase in risk level in the graph shows the posture when taking the CPU from the inventory shelf. This is appropriate when compared with calculations using the Rula worksheet.

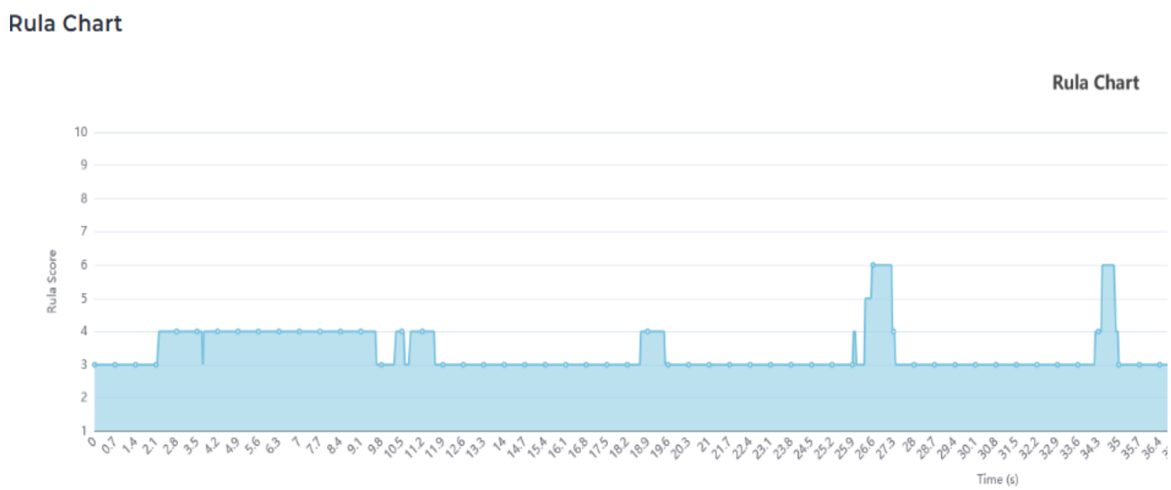


Figure 5. Dynamic work process simulation

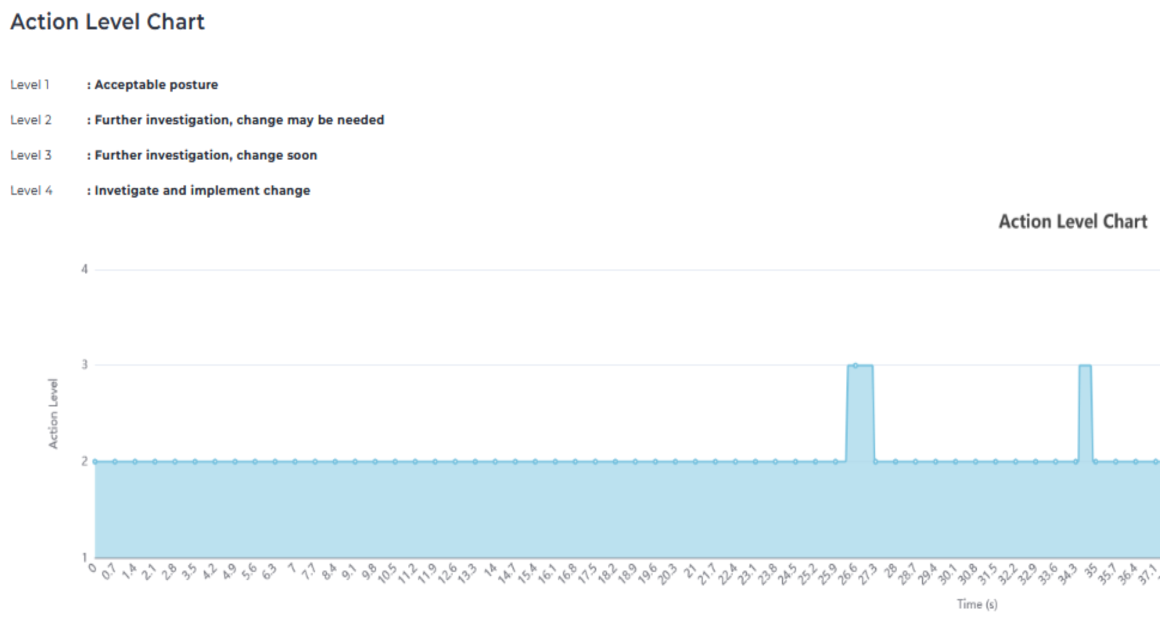


Figure 6. Graphic action level

For optimization purposes, the results menu displays the frequency of occurrence of each risk level as shown in Figure 7. Reducing the frequency of each risk level, especially at high value risk levels, will produce more optimal design results. The analysis process also displays the Action level score along with its variables which can be compared with the video showing the posture at that time as shown in Figure 8. This is very useful to see when the score obtained is high.

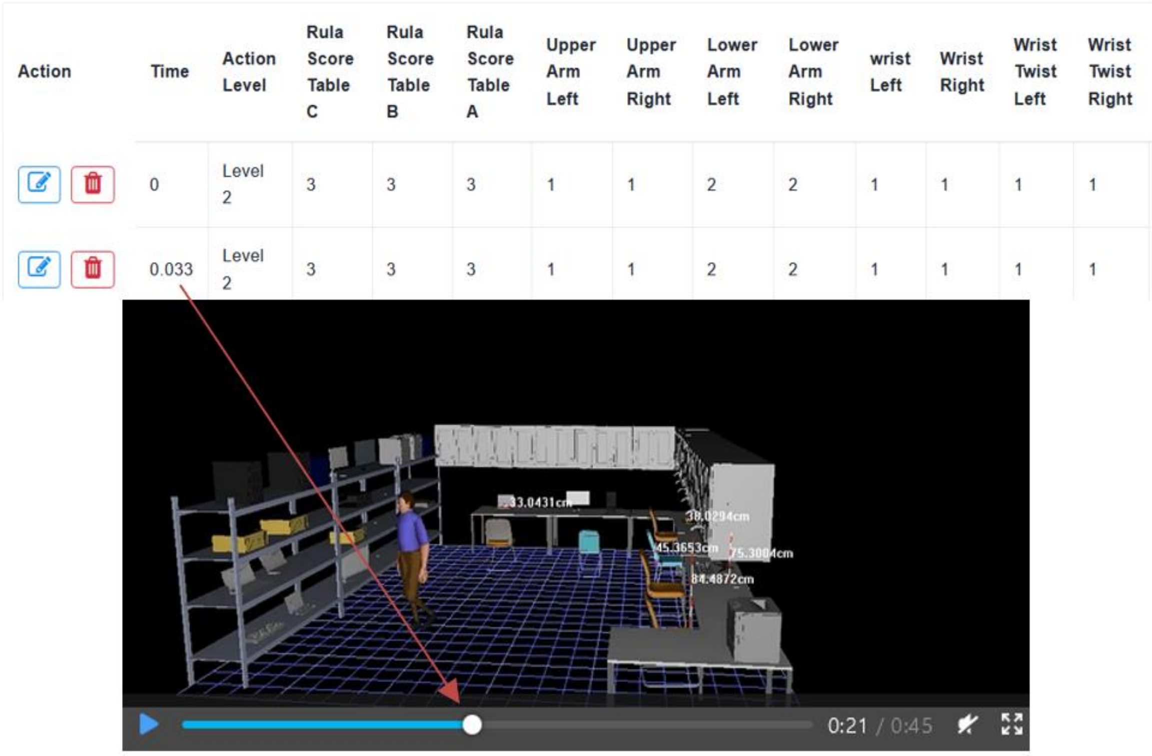
3.5. Design optimization

The optimization process in design can be done by looking at high risk scores. As in the dynamic work example of moving the computer to the work desk, when taking the CPU to the bottom shelf there was an incorrect work process on the part of the worker. In the simulation, the worker can be seen picking up the CPU by bending over. This will increase the risk of injury to workers as shown in Figure 9(a). In the optimization process, changing the posture when taking the CPU with the posture as in figure 9(b) will reduce the risk of work accidents. Workers should do this by squatting so that the risk factor will be reduced. Different postures at work will provide different levels of risk [33]. The analysis process can be carried out only by improving the simulation process. This can certainly save production costs, especially in design. Optimization is carried out by changing the work process simulation. Anthropometric data in the form of an ssv.csv file is re-uploaded to the data processing application. Optimization results are shown by reducing the frequency of risk occurrence as in Figure 7. A decrease in the score that has a high risk indicates an increase in the optimization results obtained. The reduction in risk is also shown by the Rula chart or action level chart. After optimization is carried out, the admin will declare that the design created is optimal and the user will automatically receive the design results.

Action Level Frequency

Score	Frequency
1	0
2	1673
3	136
4	44

Figure 7. Action level frequency



Action	Time	Action Level	Rula Score Table C	Rula Score Table B	Rula Score Table A	Upper Arm Left	Upper Arm Right	Lower Arm Left	Lower Arm Right	wrist Left	Wrist Right	Wrist Twist Left	Wrist Twist Right
	0	Level 2	3	3	3	1	1	2	2	1	1	1	1
	0.033	Level 2	3	3	3	1	1	2	2	1	1	1	1

Figure 8. Compare risk scores and posture videos

(a) (b)

Figure 9. Posture when taking CPU (a) wrong posture and (b) correct posture

3.6. Discussion

The results of testing the S-TSB framework on the software created have shown valid results and testing the dynamic work model shows that this method can be applied preventively. This is important because workers know the risks that may occur before working. The use of simulation allows workers to know how to work correctly. When compared to the use of Kinect or virtual reality technology in work risk analysis, the workstation must already be present when carrying out the analysis, so it cannot be used preventively. Designing workstations using simulation also saves design costs because the optimization process can be done quickly just by changing the posture and/or work station using simulation, as shown in subchapter 3.5. Simulation optimization saves production costs because mock-ups are not required repeatedly to test design results. It is hoped that the implementation of the S-TSB framework can be included in policy regulations where work stations created in industry should have been tested for risk factors using the S-TSB Framework before being implemented. This is to prevent workers from work accidents. Research needs to be developed to be able to analyze the risks if work is carried out by more than one person simultaneously. Besides that, the DHM used cannot provide information on when the load is carried or released by the worker. It is necessary to test other DHMs so that data processing software can also be developed. The ability of the simulation maker also greatly influences the analysis results obtained. Testing also needs to be done for dynamic work that is difficult for admins to simulate, such as simulating art workers dancing. Dynamic changes in anthropometry and all five senses require the ability to create simulations from the admin. Simulation creators must understand human factors related to industry 4.0 to be able to produce optimal work stations according to current needs [34].

4. CONCLUSION

Workers avoid the risk of work accidents if the work risk analysis method can be applied preventively. The S-TSB framework uses simulators in work station design, uses digital humans, and simulated work processes making this method can be applied preventively. The process stages include a survey to get an overview of the work process, creating a model and simulating the work process using DHM, and obtaining the level of work risk using software created with the PHP programming language. Software output includes: Rula graphs, action level graphs, work process videos as a function of the action level table, and frequency of occurrence of risk levels. Optimizing work station design and work processes can be achieved by changing variables in work stations and/or work processes in a simulated manner to obtain the lowest risk level frequency using posture data processing software. The validity of the posture data processing software has been tested using the black box analysis method and shows results that are in accordance with the expected output. The S-TSB framework was tested on a dynamic work process with results in accordance with the Rula method. By optimizing the design using a simulator, design costs can be saved.

ACKNOWLEDGEMENTS

The DHM software used in this research is tecnomatix jack Version 9. I would like to thank Joyce as Academic Manager of South East Asia Siemens Industry Software who has facilitated the Faculty of Engineering, Udayana University, to receive a free license grant for the software used in laboratory as a LAB facility by researchers.

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