Solving Office Ergonomics Problem Using Rapid Upper Limb Assessment (RULA)

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Abstract. This research took place in the Industrial computation laboratory, where the main function of the laboratory as a place of practical activity related to industrial engineering software for students. From the results of the Nordic Body Map preliminary questionnaire (NBM) showed that the highest percentage after students doing computer practically for 2 hours was the pain in the sitting position when operating the computer (typing and holding the mouse). Based on the analysis that has been used with the RULA method for positions at the time of computer operation, the results of risk level 3 to 4 are obtained (long-term action is needed) and the risk level is 5 - 6 (immediate action is required). To reduce the level of student injury risk during the learning process, this research proposes a redesign work desk position and seat position with a work station design approach based on student's anthropometric data by utilizing RULA. The three results of work station design proposals, computer desks namely table mat height 78 cm, 83 cm wide, and 45 cm long, 68 cm height keyboard and for chairs namely 49 cm seat height, 42 cm seat base width, 46 cm pedestal length, width of backrest 42 cm, height of backrest 58 cm with a slope of 5^{o} degree. By paying concern to the student's posture, the design proposal should appropriate and decrease the risk level of students who operating computer into level 1 – 2 (acceptance posture)

Introduction

Industrial Computation Laboratory (ICL) is a place for basic computer practices (MS Office Applications), information management system practices, Industrial Simulation practices, and AutoCAD practice. In ICL there are facilities including 18 computers for students and 1 computer for lecturers. At present, the practitioner who conducts lab activities in the laboratory takes around 2 hours per day for one meeting and during implementation often students experience discomfort especially at the computer desk. Based on the results of the preliminary survey through interviews with students, complaints were felt when using computational laboratory among them; interference on the hands and arms when the hand position is not straight; when holding the keyboard, fatigue in the neck when the position is facing the monitor screen; interference on the shoulder & elbow position when stepping foot. From the results of the distribution of preliminary questionnaires to 50 respondents, namely students when after performing Basic Computer Practices and AutoCAD Practices for around 2 hours, students experience pain (in a sitting position) on neck 80%, shoulder 60%, 66% back, upper arm 62%, forearm 58%, legs 56%, thighs 56%, buttocks 76%, and wrists 58%. It can be concluded that most of the student body parts feel unwell or uncomfortable when doing practices in the ICL. Specific biomechanical risk factors are associated with the occurrence of work-related musculoskeletal disorders in each body region. Some of the body regions outlined,

includes the shoulder, which highly demanding physical work dan monotonous work, the wrist which highly demanding physical work; awkward static & dynamic working postures; and repetitive work. The hips (regular lifting and carrying of heavy loads) and the knee (highly demanding physical work, sustained kneeling or squatting, prolonged standing, everyday climbing, and repeated lifting loads and carrying of heavy loads) [1]. This research purpose is to find out the work posture of students in carrying out activities in the ICL using Office Ergonomics approach by utilizing the RULA method. Another purpose is to find out the results of the proposed computer desk design and seat position in accordance with the anthropometric dimensions of students. To find out the results of the comparison of the dimensions of the old workstation with the work station that has been proposed. The assumption in this research is the body condition of students in normal or healthy condition. The results of the RULA score after the proposed design of a computational laboratory workstation are based on a simulation from the angle of the posture (range).

Literature Review

RULA (Rapid Upper Limb Assessment). According to Putera [2], RULA (Rapid Upper Limb Assessment) is a tool in the survey form to identify occupations, which can cause cumulative trauma disorders risk (CTD) through posture analysis, muscle load and muscle exertion. This tool is a detailed screening tool for testing workers' tendency to risk injury posture, muscle load, muscle exertion, and worker's movement when doing their work. This method uses a body posture diagram and three score tables in determining the evaluation of injury risk factors. In facilitating the posture assessment, the body posture maps are divided into 2 group segments, namely group A and group B. Then, the two scores are combined to get the final value using table C so that the posture score will be formed and show how the risks that occur in the movement which already done. Therefore, this method is very useful for showing how the risk of workers while doing work.
According to Ramdhani [3], The development of the RULA consists of three stages, namely:

1. Identifying work postures,
2. Scoring system,
3. Action level scales that provide a guideline on the level of risk that exists and is needed to encourage assessments, which exceed details relating to the analysis obtained.

There are four main applications of the RULA, namely to:

1. Measuring musculoskeletal risk; usually as part of a wider improvement of ergonomics aspect.
2. Comparing musculoskeletal load, between the original design of the workstation with the modified one.
3. Evaluate output such as productivity or appropriateness of equipment use.
4. Train workers about musculoskeletal loads due to differences in work posture.

Group A Body Posture Assessment. The first step in the RULA method is to calculate the group A body posture score consisting of the upper arm, lower arm, wrist and wrist twist.

a. Upper Arm, the process of the assessment carried out on the body of the upper arm (upper arm) is an assessment carried out on the angle formed by the upper arm when doing work activities. The angle formed by the upper arm is measured according to the torso position.
b. Lower Arm, the assessment process carried out on the lower arm body is an assessment made on the angle formed by the forearm when doing work activities. The angle formed by the forearm is measured according to the position of the torso. The appearance of the forearm posture can be seen in the picture below.
c. Wrist, the process of assessing the wrist is an assessment made on the angle formed by the wrist when doing work activities. The angle formed by the wrist is measured according to the position of the forearm.
d. Round Wrist, for a neutral wrist twist the posture is scored:
   1 = middle position of the round

2 = at or near the round
The values of the posture of the upper arm, forearm, wrist and wrist rotation are included in the group A body posture table to obtain a temporary score and continue at the next stage.

e. Activity Score Addition
f. Added Load Score

Group B Posture Assessment. After evaluating the group A, the next step is to calculate the group B posture score. Group B body posture consists of the neck, trunk, and legs.

a. Neck, assessment of the neck (trunk), is an assessment of what is done on the neck when doing work activities. The neck posture can be seen in the picture below.
b. Torso, trunk evaluation is an assessment of the angle formed by the body's spine when doing sloped work activities that have been classified.
c. Legs, an assessment of legs is an assessment of the position of the foot when doing work activities whether the operator works in a normal position or rests on one straight leg.
d. Activity Score Addition
e. Added Load Score

To get a grand score, the scores obtained for group A and B body postures are combined into the table by referring to RULA Worksheet [4].

Prior Research. Here are some research related to RULA tools, which are the main references in this study. According to Torik [5], a problem that often arises in administrative work is monotonous work activities, among others, checking the completeness of documents submitting a permit application and then inputting and processing the entry request data with a long sitting position and transporting the document to the supervisor room which is 20 m. Nauli [6], Designing tables and chairs. The incompatibility of study tables and chairs with student body dimensions occurred in SLTPN 6 Wonogiri. Based on observations of case studies using a questionnaire at SLTPN 6 Wonogiri, 80% of respondents stated that their sitting position was uncomfortable. Based on the Nordic Body Map questionnaire, which was distributed to 90 respondents in the preliminary study, the discomfort caused complaints of bodily pain including 88.89% of the neck, 66.67% back, 66.67% shoulder, 88.89% waist, 77 buttocks, 78%. Namwongsa [7] try to utilizing RULA tool on smartphone users, The RULA scores identified ergonomics risks from using smartphones to text, it is indicating the need for further investigation and changes (Action Level 3). Notably, no participants had acceptable RULA Grand Scores of 1 or 2. The correlation between musculoskeletal disorders and the ergonomic risk among smartphone users was determined using the Chi-Square test and Fisher's exact test; $p < 0.05$ was considered statistically significant. The RULA results identified the high ergonomics risk of smartphone users; this resulted from two key risk factors: posture and muscle use. The neck, trunk and leg postures had a combined effect on neck musculoskeletal disorders. Yusuf [8], try to make Improvement of Work Posture Using RULA (Rapid Upper Limb Assessment) Analysis to Decrease Subjective Disorders of Strawberry Farmers in Bali. Their research can be concluded that the improvement of work posture using RULA analysis decreases work risk level and subjective disorders of strawberry farmers in Bali around 28,5%. This is in line with the lean manufacturing concept, which aims to minimize waste and improve work efficiency [9]. This research concept is also in line with the concept expressed by Fahrianta [10].

Research Methodology

The research was carried out through several stages. The first stage is problem formulation and research objectives. Observations were carried out with the aim of finding out the problems being experienced at the ICL. The next stage is data collection and processing. The first data collection was distributing questionnaires to students after conducting practicum for 2 hours. Of the majority of students felt unwell or uncomfortable when practicing at the ICL. Then there needs to be a new work

station improvement action for convenience in activities in ICL by students. The next step is collecting data needed to carry out this research. The data taken is exclusive and is a characteristic of the problem. The data taken is as follows:

1. Anthropometric data of the students
2. Documentation of student posture during computer operation
3. Dimensions of old computer Office Ergonomics data

Furthermore, the data processing stage which aims to find out the results of data collection that have been obtained. Data processed in this study are as follows:

1. Calculating the percentile of Anthropometry data
2. Calculating the RULA score
3. Calculate the risk level of the RULA score

Moreover, the last stage is proposed designs are addressed at the level of risk. This stage is the advanced stage of processing data in this study. The results of the discussion will find a proposed improvement in the design of computer workstations that are ergonomic. Based on the RULA risk level and anthropometric approach, the proposed workstation was designed to meet the objectives set at the start of the study. The analysis is based on the initial form of ICL's ergonomics. Then, from the proposals re-designed based on the anthropometric approach, an analysis was carried out to meet the objectives set at the beginning of the study. The analysis will be based on changes in the dimensions of the initial workstation to more ergonomic and safe forms and uses.

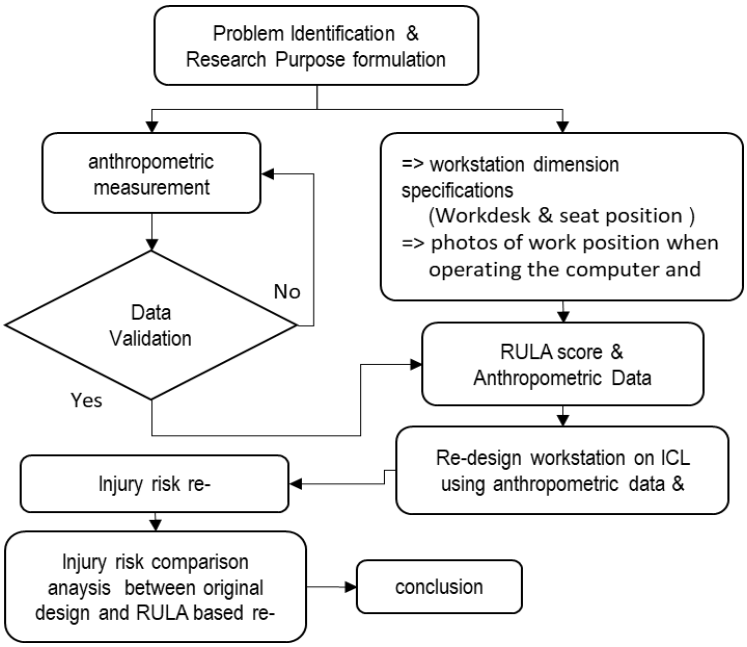

Fig. 1. Research Flowchart

Result and Discussion

The image of student's posture was taken while they are operating computers (based on usual activities), and measured by using the RULA method. If there are similarities in the shape of the body's angle when operating a computer, then one is taken, the process of retrieving documentation can be stopped or taking documentation of different body angles. Angle measurements are formed by the neck, back, upper arms, forearms, and wrists using the RULA method. The score was given from the body angles of 42 students which operating computer in ICL. So of the 42 students who carried out the operation of the computer 6 photos of posture based on height (the shortest, medium, & high) were chosen because they represented 42 students during the operation of the computer. Steps in carrying out work posture analysis using the RULA method: a) Taking student posture data using photo help,

b) Observation and selected posture to be analyzed, c) Determine the angle of posture on student photos when doing activities in ICL with a bow. d) Posture scoring and e) Posture analysis.

Fig. 2 The image below shows the working position when holding the mouse (left) and when typing with the keyboard (right)

Fig. 2, is activities of the student holding a mouse and typing with a computer keyboard during practicum and while Fig. 3, the original design dimensions were measured before a comparative analysis of the original Office Ergonomics design and new design, as follows:

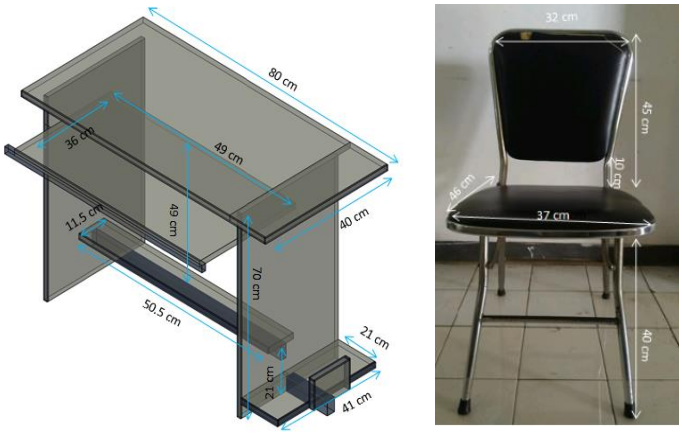

Fig. 3 Specifications for Size of original Tables and Chairs

The following is the result of a homogeneity test of the data and a test of the adequacy of data from sampling data taken for each body part observed in Table 1. All sampling data are homogeneous and sufficient for the next research stage. Percentile is a value that states that a certain percentage of a group of people whose dimensions are equal to or lower than that value. For example, 95% of the population is equal to or lower than 95 percentiles, and 5% of the population is equal to or lower than 5 percentiles. Percentile calculations can be seen in Table 2. The percentile data and the RULA results will be used to redesign the ICL workstation. Subsequently risk of injury will be measured when using the redesign ICL workstation. The results of the risk level analyze the student's work posture when holding the mouse, and when typing with the keyboard as can be seen in table 3.

The position of the student carried out during the activity in the laboratory is a sitting position. This resulted in students often experiencing cramps in the legs, shoulders, spine, and others due to incompatible anthropometry of student body dimensions.

From the results of the assessment using the RULA method, 50% of students produce moderate risk level scores that need change action in the near future and 50% of the remaining students produce small risk level scores that require action in the future. Therefore, in an analysis that uses the original workstation design has a small risk and moderate risk. Then it is necessary to redesign the workstation, which is a table and chairs that are intended to reduce the risk to the body and make the

work position more comfortable and safe. Through the anthropometric measurements of the students' bodies, a workstation design dimension can be proposed to make students more comfortable. As the redesigned for computer desks and chairs can be seen in figure 4. It can be inferred from the calculation of the risk level score, which shows the proposed improvement of a computer workstation with an anthropometric approach has a small level and action for some time to come.

Table 1. Data Homogeneity Test and Sufficiency Test

No	Body Dimension When Sitting [cm]	Average	St.Dev	UCL	LCL	Uniformity	N	N'	sufficiency
1	Maximum body width	44,99	6,00	62,99	26,98	Uniform	42	2,01	sufficient
2	Forward reach	71,23	8,43	96,53	45,93	Uniform	42	1,93	sufficient
3	Shoulder width	41,75	4,09	54,02	29,49	Uniform	42	1,29	sufficient
4	Eye height when sitting	76,30	4,28	89,15	63,45	Uniform	42	0,83	sufficient
5	Thigh height	44,65	3,02	53,70	35,61	Uniform	42	1,00	sufficient
6	Knee height	52,44	4,46	65,82	39,06	Uniform	42	1,26	sufficient
7	Shoulder height	58,54	4,74	72,75	44,32	Uniform	42	1,20	sufficient
8	Elbow height	24,18	3,74	35, 41	12,95	Uniform	42	2,41	sufficient
9	Height	86,65	8,65	112,60	60,70	Uniform	42	0,73	sufficient
10	Butt - knee length	54,64	4,51	68,18	41,11	Uniform	42	1,22	sufficient
11	Hip width	35,60	4,19	48,18	23,01	Uniform	42	1,75	sufficient
12	Elbow width to elbow	39,96	6,79	60,34	19,58	Uniform	42	2,09	sufficient
13	Long buttocks - groin	47,02	4,75	61,27	32,78	Uniform	42	1,50	sufficient

Note: UCL = Upper Control Limit; LCL = Lower Control Limit; N = Number of Original Data; N' = Number of Data which is sufficient to conduct the research

Table 2. Percentile Table

No	Body Dimension When Sitting	P5	P10	P50	P90	P95
1	Maximum body width	35,1156	37,306	44,99	52,67	54,86
2	Forward reach	57,353	60,431	71,23	82,02	85,1
3	Shoulder width	35,0306	36,523	41,75	46,99	48,48
4	Eye height when sitting	69,2524	70,816	76,30	81,78	83,34
5	Thigh height	39,6948	40,795	44,65	48,51	49,61
6	Knee height	45,1036	46,732	52,44	58,15	59,78
7	Shoulder height	50,7404	52,47	58,54	64,60	66,33
8	Elbow height	18,0213	19,388	24,18	28,97	30,34
9	Height	72,4198	75,577	86,65	97,72	100,9
10	Butt - knee length	47,2208	48,868	54,64	60,42	62,06
11	Hip width	28,6964	30,227	35,60	40,96	42,49
12	Elbow width to elbow	28,789	31,269	39,96	48,66	51,14
13	Long buttocks – groin	39,2125	40,946	47,02	53,10	54,84

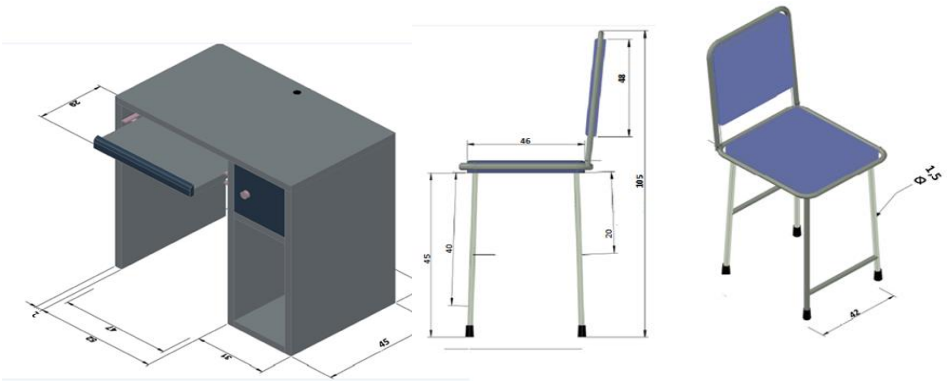

Fig. 4 Design proposal for computer desk and chair

In calculating the RULA level score, tables 3 is generated based on student anthropometry. In addition, the RULA score uses a posture angle approach with the specified range in the RULA method. There is a significant effect of nonneutral body posture on the risk of MSDs especially at shoulder/arm and wrist/hand [11]. By minimizing the risk of injury from the work position, the learning process at ICL can be further improved. As has been stated from several studies, by minimizing constraints, work productivity can be increased [12]. Thus, the implementation of productive learning can be carried out by minimizing the risk of injury in ICL.

Table 3. Risk analysis Work posture with the RULA method

No	Parts of body	Resp. holding the Mouse Position				Resp. typing Position (keyboard)			
		1	2	3	improv.	1	2	3	improv.
Body Part of Group A									
1	Upper arm	2	3	2	1	2	2	2	1
2	Forearm	2	1	1	1	2	1	2	1
3	Wrist	3	3	3	1	3	3	3	1
4	Wrist Round near the round	1	1	1	1	1	1	2	1
	Group Score	3	4	3	1	3	3	4	1
5	Activity (static)	1	1	1	1	1	1	1	1
6	Load Score <2 kg	0	0	0	0	0	0	0	0
	Group A score	4	5	4	2	4	4	5	2
Body Part of Group B									
1	Neck	3	2	2	1	3	2	3	1
2	Torso	3	2	2	1	3	2	3	1
3	Legs Are Balanced Position	1	1	1	1	1	1	1	1
	Group Score	4	2	2	1	4	2	4	1
5	Add activity score (static)	1	1	1	1	1	1	1	1
	Group B score	5	3	3	2	5	3	5	2
	Final Score	4	4	3	2	5	3	6	2
	Level of risk	Small	Small	Small	Safe	Medium	Small	Medium	Safe

Conclusions

The conclusions that can be drawn from this study include; From the assessment of the student work posture in carrying out activities in the ICL when using the original work station based on the RULA method there are 6 students who show different risk scores, namely 3 students showing level 5 - 6 (Medium) and 3 students showed risk levels 3 - 4 (Small).

Proposal for designing computer work stations using the anthropometric dimensions in the ICL as follows: (a) Computer Desk, The original dimension table height 70 cm, length 80 cm, and width 41 cm; after redesign the table height 78 cm, length 83 cm, and width 45cm. (b) Computer Chair, The original the dimension the seat height 42 cm, length 34 cm, shoulder back width 33 cm, and shoulder height 45; after redesign the seat height 49 cm, length 46 cm, and width 45cm, shoulder back width 42 cm, and shoulder height 58 cm a slope of 5^{o}. By paying concern to the student's posture, the design

proposal should appropriate and decrease the risk level of students who operating computer into level 1 – 2 (acceptance posture).

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