Designing an adjustable height engine stand to reduce the risk of student's Musculoskeletal Disorders (MSDs) in engine tune up practice

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Abstract. This study aims to determine the description of a student's posture when practicing and make an engine stand according to the size or results of previous ergonomics analysis. The source of ergonomics risk is the design of practical tools that are less compatible with varied student postures. The ergonomics research method used is the Rapid Upper Limb Assessment (RULA). The participants of this research were automotive students of the mechanical engineering education department totaling 27 people, the reason for doing this research was because of the results of the Nordic Body Map (NBM) survey, almost all students who practiced on the Gasoline engine course complained of pain in the back, neck and arms. Therefore, an analysis of the level of ergonomics risk results is recommended to improve student work positions. Based on these recommendations, an adjustable height engine stand was designed and made. This research was conducted by beginning with a structured observation of student anthropometry, to provide design recommendations that can be accommodated by all student body postures. The results of the measurement of ergonomic risk level before using the adjustable height engine stand position of the student's body bent, neck bending, repeating for a long time, the results of RULA anthropometric analysis of the 5th percentile are 4, while the percentiles 50 and 95 are 6, which means that the position has a high level of ergonomic risk and action needs to be taken immediately to reduce risk. The level of ergonomics risk after using the adjustable height engine stand is 2, which means safe. Another result is the creation of an adjustable height engine stand whose height can adjust to the student's body posture.

1. Introduction
Students of the Department of Mechanical Engineering Education University of Indonesia (UPI DPTM) practiced engine tune-ups at UPI Automotive workshops, this practice was carried out on productive learning. UPI DPTM students practice using the engine stand. The varying engine dimensions cause the height of the practical tool to vary, the height of the student body also varies, it causes the body position...
to adjust to the practical tool. Empirically researchers see, students who are doing the practice of engine tune up forming the back posture of bending, neck bending, forearm bending position and students practicing in a long period of time and repeatedly. These activities have an ergonomic risk that disrupts comfort at work. Complaints of pain when doing work are often caused due to incompatibility of practice facilities with student anthropometry, thus affecting the performance of the practitioner.

The Nordic body map data of students who practice, showed significant complaints, namely neck, lower neck and waist pain, with an average percentage above 70%. Based on the background that the author has described above, regarding the problems that occur in the field, the authors intend to solve this problem by designing and making an engine stand that can be adjusted in height. Furthermore, researchers will analyze the level of ergonomic risk using the Rapid Upper Limb Assessment (RULA) method.

2. Method
Research on ergonomics analysis on the practice of engine tune up in the Department of Mechanical Engineering Education is a descriptive study with cross sectional approach. The method is used to study the dynamics of the correlation between risk factors and effects, by means of observation or data collection at a time [1].

3. Result
The research began by searching data of complaints from research subjects, complaints of skeletal, bone, joint and muscle complaints after they had practiced engine tune up, then measured subjectively. One of the subjective measurement methods for this problem uses the Nordic Body Map. The measurement results are processed and presented in the form of a percentage using a Likert scale.

The results of the research at UPT DPTM explained that significant body parts complained by students were the back, waist, upper neck, lower neck, right arm and left forearm, with an average percentage of 70%. These obstacles can endanger the health of students who practice engine tune up. Physical burdens that exceed the tolerant limits of the human body can carry the risk of musculoskeletal disorders. Musculoskeletal Disorders (MSDs) are "injuries to muscles, nerves, tendons, ligaments, joints, cartilage or spinal discs" [2].

Figure 1. Part of Nordic Body Map [3].

Therefore, it is necessary to improve the dimensions of practical tools in accordance with the anthropometry of the student body, then an adjustable engine stand is designed and made whose height can be adjusted to adjust the student's body posture. The mechanism for raising and lowering the height of the engine stand uses arms and power threads. Student users only need to adjust the height by turning the screw using a crank located on the front of the engine stand. The required height is between 100 cm to 110 cm.
Figure 2. Design drawings of the adjustable height engine stand.

Figure 3. An adjustable height engine stand has been created and is being tested in practice.

After the adjustable height engine stand was completed, it was continued with the anthropometry measurement of 26 students, the anthropometric calculation included the test a). Data uniformity b). Calculation of standard deviation of critical dimensions c). Test data sufficiency and d). Percentile calculations.

Figure 4. Ergonomics risk analysis before and after the adjustable height engine stand.
Practice tests are conducted on students who have average posture (50th percentile), above average (95th percentile) and below average (5th percentile). The student body position when the practice is analyzed using the RULA method. RULA (Rapid Upper Limb Assessment) is a method of measuring upper body ergonomic risk that can reveal how much ergonomic risk experienced by the practitioner. RULA was designed by Atamney and Corlett which provides a calculation of the level of musculoskeletal load in a job that has risk on the body from the abdomen to the neck or upper limbs [4].

This method does not require special equipment in determining the assessment of neck, back, and upper arm postures. Each move is given a predetermined score. RULA was developed as a method for detecting work posture which is an ergonomic risk factor. The method is designed to assess workers and determine the musculoskeletal burden that is likely to cause interference with the upper limbs. To facilitate the assessment of body posture, this method uses a diagram of body posture and is divided into 2 group segments, namely group A and group B.

Group A includes the angle formed by the movement of the upper arm, forearm, wrist and twisting around the wrist. Group B posture includes the angle formed by the neck, torso, leg position.

| Table 1. RULA calculation results before using the adjustable height engine stand. |
|----------------------------------|----------------|----------------|
| Individual                      | Score | Remark                  |
| Postur persentil 50 (Average)   | 6     | Further investigation, change soon |
| Postur persentil 95 (Above average) | 6     | Further investigation, change soon |
| Postur persentil 5 (Below average) | 4     | Further investigation, change may be needed |

| Table 2. RULA calculation results after using the adjustable height engine stand. |
|----------------------------------|----------------|----------------|
| Individual                      | Score | Remark                  |
| Postur persentil 50 (Average)   | 2     | Minimum risk, safe      |
| Postur persentil 95 (Above average) | 2     | Minimum risk, safe      |
| Postur persentil 5 (Below average) | 2     | Minimum risk, safe      |

4. Discussion

According to Kuswana, revealed that work activities are required with the abilities and limitations of workers [2]. Therefore, the designer conducts various analyzes related to the type of task, the required body movements and the limits on the ability to take the burden.

Student practice positions that were initially measured using the RULA method are included in category 6 and 4 scores, which means that it is necessary to improve work position design because it has a high ergonomic risk. Large and medium-sized individuals have a greater level of ergonomic risk, compared to smaller individuals. Based on the final score of the analysis Atamney and Corlett, that a score of 6-7 indicates a high level of ergonomic risk and changes in design and further research must be made, while 3-4 need to be changed if necessary [4]. After we design and create and use an adjustable height engine stand, the risk of ergonomics in practice students is reduced. High, low and medium students have a score of 2, which means a minimum and safe risk level. So the design and manufacture of the adjustable height engine stand can minimize the risk of musculoskeletal disorders (MSDs).

5. Conclusion

Obtain an engine stand that can be adjusted to height according to the student's body posture. Based on the results of trials and calculations using the RULA method, an adjustable height engine stand can reduce the risk of ergonomics in students who are practicing engine tune ups in the FPTK Department of Mechanical Engineering Education at Indonesian University of Education.
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