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Ergonomic analysis of handgrips on Suroboyo bus using the rapid upper limb assessment (RULA) method

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Abstract

Global technological developments continue along with the era of globalization. Apart from that, currently all our needs can be reached easily, including in the field of transportation technology. One mode of public transportation that is already operating in Surabaya is the Suroboyo Bus. The Suroboyo Bus offers various facilities including handgrips for passengers. However, in reality the handgrip is considered to lack ergonomics and many Suroboyo Bus passengers complain of discomfort when using it. This research distributed questionnaires, Of the 30 respondents, 40% of respondents have the potential to experience injury with a low risk level and 60% of respondents have the potential to experience injury with a moderate risk level. This research was carried out using the Rapid Upper Limb Assessment (RULA) method and simulated using jack software. It can be concluded that Suroboyo Bus needs to develop handgrips so that the height of the handgrip straps can be adjusted to the height of Suroboyo Bus passengers and their comfort level. In addition, the handgrip can be adjusted to the shape of human fingers and is coated with foam to minimize complaints or injuries such as muscle cramps, tingling and numbness.

Keywords

Rapid upper limb assessment (RULA), Handgrip, Ergonomic, Software jack, Injury

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Introduction

Transportation acts as a means to connect and move individuals from one location to another using vehicles operated by machines and humans. This shows that the role of transportation is very important in human life because it has contributed to development efforts and economic growth of the community in certain areas. The fairly rapid rate of economic growth in urban areas has attracted quite large urbanization, this is considered by some people as an opportunity to get wider jobs [1]. Therefore, it is necessary to be accompanied by the development of a transportation system that is in accordance with changes and community needs in order to achieve success in economic development efforts. Transportation has a major impact on a country's economy. All

areas of community life depend on this sector. The role of transportation includes as a driver, support, and motor of economic growth. If the management and implementation of the transportation sector are not optimal, then the uniformity and results of development cannot be utilized optimally by the community. One important component in the transportation system that involves many people is public transportation. The development of public transportation in urban areas of Indonesia aims to provide reliable and affordable services for various levels of society who use public transportation services.

Every company strives to provide adequate facilities for passengers to ensure a satisfying and enjoyable experience during their use [2]. Service quality is closely related to the level of passenger satisfaction. This quality has a significant value for passengers, with the aim of strengthening the bond between the company and its service users. Facilities relate to physical facilities provided to ensure user comfort, thus ensuring their needs are met. Thus, it can be concluded that work facilities act as a driving factor that helps increase productivity to achieve the Company's goals [3].

The availability of supporting facilities for Suroboyo Bus services is very important to ensure that services can be delivered efficiently to passengers. East Java Province is one of the areas with the second highest population density, which means that there is an increase in community activity every year. The impact of this high activity causes various problems, including congestion, difficulty in public transportation for passengers and traffic accidents. Traffic accidents are a serious problem in Indonesia. From a macroeconomic perspective, accidents are an inefficiency for transportation providers. This means that traffic accidents can result in losses that can reduce quantity and quality and increase the total cost of organizing transportation [4]. East Java provides a variety of public transportation options, such as city transportation, online motorcycle taxi services, taxis, and bus services. These transportation options give users the freedom to choose the type of transportation that suits their needs.

Suroboyo Bus is a public transportation owned by the Surabaya City Government. The Suroboyo Bus service has been operating since 2018 until now. The procurement of this transportation is based on a government program that aims to improve the quality of transportation services for the people of Surabaya. Suroboyo bus provides quite good facilities with a capacity of 67 people, with details of 41 seats and 26 standing areas equipped with handgrips or passenger handrails. However, in terms of ergonomics, there are several facilities on the Suroboyo Bus that do not fully meet ergonomic comfort standards. Ergonomics is related to optimization, efficiency, health, comfort and safety in the work environment [5]. One component that plays a very important role in the Suroboyo Bus is the handgrip or passenger handrail. The handgrip functions as a support or holds the weight of the passenger's body when they stand or move while on the bus. The existence of handgrip facilities has a high level of importance, if the seats are full, passengers are required to stand. Therefore, it is necessary to design or plan a

handgrip because this element ensures the comfort and safety of standing passengers during the journey [6].

As a result of this situation, many Suroboyo Bus passengers complained about discomfort in using handgrips, these complaints can be temporary or even permanent [7]. The parts of the body that often cause discomfort are the palms and shoulders, which increase the risk of injury such as muscle cramps, numbness, numbness or Musculoskeletal Disorders (MSDs). Musculoskeletal Disorders (MSDs) contribute as much as 42% - 58% of all occupational illnesses [8]. Therefore, the design of the handgrip or handrail is very important in considering ergonomic aspects during its design. The design of the handgrip must be adjusted to the anthropometry of the hands of Indonesians to ensure comfort and reduce the risk of health problems, one way is to measure the work posture, because improper hand placement can cause inflammation of the muscles and nerve tissue [9].

Anthropometry is a science that studies the measurement of the human body, especially the dimensions of the human body. Anthropometry is one part that can support ergonomics, especially in designing work equipment based on ergonomic principles. Anthropometric data can also be used in designing effective, safe, comfortable, healthy and efficient work systems [10]. Anthropometry is divided into two parts, namely static anthropometry and dynamic anthropometry. Static anthropometry is an activity carried out while still, while dynamic anthropometry is an activity carried out while moving so that it is more complex and more difficult when measured [11]. In this case, Suroboyo Bus must pay special attention to passenger service facilities as one of the determining factors for service quality. Service providers are expected to be responsive in dealing with passenger complaints by providing the best facilities and services, while ensuring comfort for Suroboyo Bus passengers, this is done in order to improve the quality of life for the better [7].

This study will analyze the design of passenger handgrips to achieve a better level of ergonomics. The Rapid Upper Body Assessment (RULA) method will be used as an assessment or evaluation tool to identify and overcome potential health problems that may arise in the upper body of passengers and are related to the use of handgrips in the Suroboyo Bus. The Rapid Upper Limb Assessment (RULA) method is a principle used in ergonomics that can be used to examine human posture by observing or paying attention to the upper body of humans, this method does not require a complicated method in the measurement process [12]. In accordance with the Rapid Upper Limb Assessment (RULA) measurement method, data collection is carried out in several stages, namely recording body posture, grouping values, and adding up the total values obtained from each table [13]. In addition, an analysis was also carried out using Jack Software which functions to simulate virtual human modeling. This study is also supported by the Nordic Body Map (NBM) questionnaire which aims to collect information from respondents through written questions. Nordic Body Map (NBM) is a questionnaire used to assess the level of discomfort or pain in the body. Respondents

who fill out the questionnaire are asked to indicate whether or not there is a disturbance in the body area [14]. The Nordic Body Map (NBM) questionnaire has been standardized as a form of ergonomic checklist that can be used [15].

Methods

In the study of ergonomic analysis of passenger handgrip on Suroboyo Bus using Rapid Upper Limb Assessment (RULA) method, qualitative descriptive research has been conducted. The subjects of the study were Suroboyo Bus passengers with categories of students and the general public. The total sample was 30 people, divided into 15 students and 15 general public. The sampling technique used purposive sampling.

The method of data collection uses data triangulation, namely observation, documentation and questionnaires. The observation data will be documented in the form of images for each respondent's posture. The documentation is carried out using a cellphone camera with the help of a tripod, the image is taken from the right side of the respondent's body by showing the posture when using the passenger handgrip. The documentation will be used as basic material for simulation using jack software. The data analyzed using the Rapid Upper Limb Assessment (RULA) method by giving a score for each movement. The Rapid Upper Limb Assessment (RULA) method consists of group a and group b, group a contains the angle of the hand while group b contains the angle of the neck and back. Each value from group a and b will be entered into a table to get the final value of the Rapid Upper Limb Assessment (RULA) and can determine the level of risk that occurs in the posture. Meanwhile, the questionnaire will be distributed to 30 respondents to find out the complaints felt by the passengers, in the questionnaire there are several questions about passenger comfort regarding the use of the Suroboyo Bus passenger handgrip.

Results and Discussion

Identification of passenger handgrips is based on observations and measurements that have been carried out previously on the Suroboyo Bus passenger handgrips. Measurements were carried out on Suroboyo bus passengers and Suroboyo Bus passenger handgrips. The dimensions and sizes of the passenger handgrips were obtained through direct measurements using a goniometer, cellphone camera, and tripod. Respondents were divided into 2 categories, namely, 15 students and 15 general public.

Ergonomic risk analysis was carried out using the Rapid Upper Limb Assessment (RULA) method. Measurements were carried out through several stages, namely: Finding the average value of the Lower Back Analysis (LBA), finding the Ovako Working Posture Analysis (OWAS) value, finding the Rapid Upper Limb Assessment (RULA) value and the last was the calculation results using the Posture Evaluation Index (PEI).

Stage 1

Measurements of the posture angle of Suroboyo Bus passengers when using the passenger handgrip facility were carried out using a goniometer measuring instrument. Table 1 shows the results of posture measurements on Suroboyo Bus passengers.

Table 1. Surabaya Bus Passenger Posture Measurement Results

Respondent	Upper Arm	Lower Arm	Wrist
1	110	114	150
2	104	105	166
3	120	115	168
4	119	113	164
5	91	100	134
6	89	101	140
7	109	106	165
8	94	99	166
9	101	106	147
10	100	108	146
11	121	119	156
12	124	125	154
13	119	111	153
14	110	120	159
15	103	105	146
16	102	110	145
17	122	114	149
18	101	109	156
19	105	100	149
20	106	104	139
21	103	108	155
22	106	119	164
23	121	120	149
24	114	109	154
25	99	111	144
26	95	109	134
27	105	101	137
28	112	116	140
29	105	118	155
30	114	120	143

Stage 2

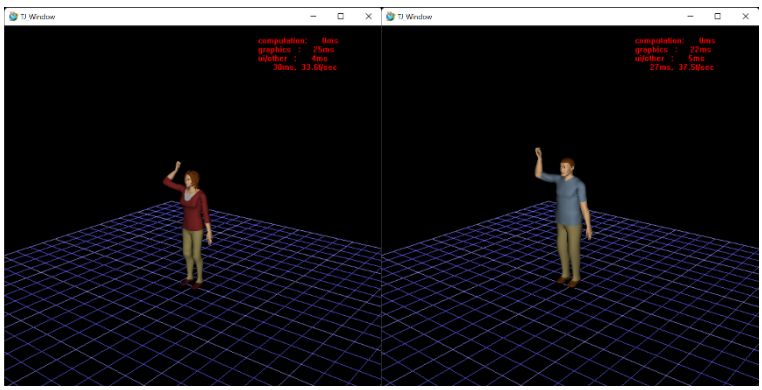

Figure 1. Human Model

A simulation is carried out using Jack Software. This simulation is also used to see the Lower Back Analysis (LBA) and Ovako Working Posture Analysis (OWAS) values (Figure

1). LBA is a tool that allows for evaluating the strength of the spine simulated in the human model according to the body posture of each action performed. The resulting pressure value will be compared with the NIOSH standard limit of 3400 N. While OWAS is used to evaluate the level of operator comfort while working.

Stage 3

The Lower Back Analysis (LBA) value is calculated using the jack software application. The Lower Back Analysis (LBA) measurement is used to determine how much pressure is experienced on the spine. Factors that influence the Lower Back Analysis (LBA) are the work posture formed by the worker and the weight of the load during the activity. Table 2 is the results of the Lower Back Analysis (LBA) value calculation.

Table 2. Result of LBA Score

Respondent	LBA score
1	291
2	294
3	288
4	274
5	503
6	445
7	288
8	462
9	349
10	366
11	285
12	272
13	274
14	355
15	364
16	392
17	282
18	533
19	439
20	470
21	324
22	296
23	349
24	304
25	439
26	412
27	433
28	419
29	315
30	348

Based on the average value obtained in the Lower Back Analysis (LBA) which is 362, it means that the final value obtained is below the NIOSH standard limit of 3400N. So that the pressure received on the worker's spine does not pose a high risk.

Stage 4

The Ovako Working Posture Analysis (OWAS) value is calculated. Ovako Working Posture Analysis (OWAS) is used in the evaluation of work postures in Suroboyo Bus

passengers that have the potential to cause Musculoskeletal Disorders (MSDs) (Karhu et al., 1981). Ovako Working Posture Analysis (OWAS) determines the work posture of the back, legs, hands, and weight of the load. The results of the Ovako Working Posture Analysis (OWAS) posture analysis are divided into 4 category levels. Based on the Ovako Working Posture Analysis (OWAS) attitude code obtained, namely 2. Category value 2 means that the category action needs to be improved in the future. If improvements are not made, there is a possibility that Suroboyo Bus passengers will experience Musculoskeletal Disorders (MSDs).

Stage 5

The Rapid Upper Limb Assessment (RULA) assessment is carried out. This calculation is carried out in 2 ways, namely manually and using Jack Software, for the results obtained from both methods are the same. Table 3 contains the results of the Rapid Upper Limb Assessment (RULA).

Table 3. Result of RULA

Respondent	Final Score	Risk Level
1	5	low
2	5	low
3	5	Medium
4	5	Medium
5	5	Medium
6	4	Low
7	5	Medium
8	4	Low
9	5	Medium
10	5	Medium
11	5	Medium
12	4	Low
13	4	Low
14	5	Medium
15	5	Medium
16	5	Medium
17	5	Medium
18	4	Low
19	4	Low
20	4	Low
21	5	Medium
22	5	Medium
23	5	Medium
24	5	Medium
25	4	Low
26	4	Low
27	4	Low
28	5	Medium
29	4	Low
30	4	Low

Based on the risk level of the table above, it can be seen that each category has different actions, namely:

1. Low risk level requires further investigation and possible changes.

2. Medium risk level requires further investigation and changes as soon as possible.
3. High risk level requires further investigation and changes are made now.

Stage 6

The Posture Evaluation Index (PEI) is calculated. The Posture Evaluation Index (PEI) is an approach by calculating three ergonomic assessment methods, namely the Lower Back Analysis (LBA) calculation method, Ovako Working Posture Analysis (OWAS), Rapid Upper Limb Assessment (RULA). The purpose of the Posture Evaluation Index (PEI) is to optimize work posture ergonomically in the work environment so as to produce an index number that represents the level of comfort and health at work. The calculation of the Posture Evaluation Index (PEI) value is carried out using the following formula:

$$PEI = \left(\frac{LBA}{3400}\right) + \left(\frac{OWAS}{4}\right) + \left[\left(\frac{RULA}{7} \times 1{,}42\right)\right]$$

$$= \left(\frac{362}{3400}\right) + \left(\frac{1}{4}\right) + \left[\left(\frac{4{,}6}{7} \times 1{,}42\right)\right]$$

$$= 0{,}10 + 0{,}25 + 0{,}93$$

$$= 1{,}28$$

Conclusion

Ergonomic analysis of Suroboyo Bus passengers using 30 respondents obtained results, namely 12 passengers at low risk of injury and 18 passengers at moderate risk of injury. This study was conducted to determine the ergonomic level of passenger handgrips using the Rapid Upper Limb Assessment (RULA) method. The results of the Rapid Upper Limb Assessment (RULA) obtained scores of 4 and 5. A score of 4 is included in the low risk and may need to be changed. Meanwhile, a score of 5 is included in the moderate risk where further investigation is needed and changes are made as soon as possible. Therefore, the passenger handgrips on the Suroboyo Bus need attention considering the impacts that can be caused by the use of passenger handgrips. The Surabaya City Government can innovate the passenger handgrips or redesign them to reduce injuries to Suroboyo Bus passengers. Furthermore, it can conduct a trial of the results of the new passenger handgrips with the old ones, then compare the level of satisfaction and comfort of Suroboyo Bus passengers.

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