Ergo-physiological Work Station Reduces Cardiovascular Load and Visual Complaints of Carved Artists

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Abstract. The problem felt by carving artists after doing full day activities is the increase in cardiovascular load and decreased ability to see objects. Physical signs that are felt by artists carving are increased heart rate and dizzy eyes or run away. One of the causes of an increase in cardiovascular load is a work station that is less ergonomic and a work environment that is not in accordance with the physiological needs of workers. Subjects carry out activities for 8 hours, starting at 8:00 a.m. up to 5:00 p.m., with a 1 hour break. Data is observed in conditions before and after the ergo-physiological rules are implemented. Measurements were made 4 times, namely at the initial and final conditions of the treatment without treatment and the initial and final conditions with treatment. Problem solving will be focused on the appropriate human aspect and utilization of technology, so that it will get the ECSHEP work process (effective, convenient, safe, healthy, efficient and productive) technical easy to work, economical, ergonomic, energy saving, environmentally friendly and in accordance with the trend of the era. The method of this research is experimental with the same subject design. Ten samples of responders who perform activities on conditions before and after treatment. Was examined data on environmental conditions were analyzed by the Mann-Whitney test. Data on cardiovascular load were tested with two pair sample t-tests, while visual data complaints were tested with Wilcoxon signed rank test at a significance level of 5%. The results showed that ergo-physiological implementation, in the form of giving work tables and chairs and improving environmental conditions can reduce cardiovascular load and improve the sharp vision of carved artists. The direct impact that can be felt by artisans is increased productivity and maintained product quality.

1. Introduction
The civilization of a nation is often identified through artistic activities. The greatness of a civilization is determined by the high and low value of works of art that can be produced by artists in its era. One proof of the Indonesian nation's civilization that was admired by the world was the Borobudur Temple. The heritage temple of the Archipelago Buddhists located in Magelang, Central Java, is almost entirely enhanced by the scratches of the carving artists.

Carving artists or often called carvers have a characteristic in their activities, namely sitting on the floor with their legs folded, so that the knee touches the chest. When doing activities, workers often complain because they feel a rapid heartbeat with the ability to see objects rather less [1]. An increase in heart rate is actually a normal symptom that is also felt by actors in other fields of activity. When you first exercise, for example volleyball or soccer, players will feel a slight increase in heart rate, but slowly in line with the amount and duration and weight of the exercise performed, the increase in heart rate will
decrease and be more stable [2]. Suitability between tools and humans who operate the tool greatly affects the high and low heart rate. A good tool has the characteristics that the user will feel comfortable during the service life and the product produced has adequate quality. Good tools and supported with good environmental conditions or ergo-physiology will produce good productivity and precision products. Reference [3] states that ergo-physiological work stations have special characteristics, namely work stations that are ergonomically supported by working environment conditions that are in accordance with the physiological needs of the people who work at the work station.

In the realm of carving, the use of anthropometric work tools and the comfort aspects of the work environment greatly affect the high and low heart rate. The better the suitability between the size of the body and the tools used, the lower the adverse effects due to the cardiovascular overload felt by workers [4]. Reference [5] determines the classification of physical workload based on a comparison between the increase in work pulse and maximum pulse due to cardiovascular burden. The cardiovascular load formula (cardiovascular load =% CVL) is the working pulse minus the resting pulse divided by the maximum pulse minus the resting pulse multiplied by one hundred percent. The maximum pulse rate varies for each person depending on the physical condition and age of each person. The formula for maximum pulse (DNM) is 208 - 0.7 x age [6] [7].

Based on the results of the calculation of % CVL, it is then used to classify ongoing working conditions, namely:

| No. | %CVL     | Description                  |
|-----|----------|------------------------------|
| 1   | CVL ≤ 30%| No fatigue occurs            |
| 2   | 30% < CVL≤ 60% | Required repairs               |
| 3   | 60% < CVL≤ 80% | Work in a short time          |
| 4   | 80% < CVL≤ 100% | Immediate action is required |
| 5   | CVL > 100% | Not allowed to move          |

The amount of cardiovascular load is determined by the pulse of work, age, resting pulse and maximum pulse. The size of the resting pulse has the greatest role in determining the% CVL value. Based on [8], for art artists who have a resting pulse rate of 98 and 19 years with a working pulse of 123 beats/minute will have %CVL of 25.85%, which means a very safe condition. The safe value does not apply to someone who has a resting pulse of 92 beats/minute or below. Safe values also do not apply to someone over 38 years old even though they have a resting pulse of 98 beats/minute. The% CVL value is also not safe for those who have a working pulse above 123 beats/minute. These values will move progressively according to changes in age, work pulse, resting pulse and data only represent the results of the measurement only. The results of measuring cardiovascular load together with cardiovascular strains are very adequate to predict the level of health and fitness of workers. Furthermore the ratio of changes in heart rate between work heart rate and resting heart rate called cardiovascular strains (cardiovascular strain = CVS) is formulated as follows. CVS = 100 times the work heart rate minus resting heart rate divided by resting heart rate [9]. Based on the percentage value, CVS values can be classified as follows:

| No. | %CVS     | Description                          |
|-----|----------|--------------------------------------|
| 1   | CVS : 0% - 50% | Acceptable/no need for action        |
| 2   | CVS : 51% - 80% | Moderate/needed action in a few months |
| 3   | CVS : 81% - 120% | Height/action is needed in a few weeks |
| 4   | CVS : 121% - 150% | Very high/action is needed in a few days |
| 5   | CVS : 151% - 180% | Unable to accelerate, immediate action is required |

The size of the cardiovascular strain also needs attention because it is related to the work of the heart [10]. For everyday craftsmen who have a resting pulse rate of 67 beats/minute and after activity have a working pulse rate of 134 beats/minute, based on the calculation of the cardiovascular strain value of
100%, which means that the person has a high CVS value and must be careful heart, work station repairs are needed in a few weeks.

In line with cardiovascular load and cardiovascular strains, visual complaints are also the effects of afflictions that occur due to poor work stations [11]. References [12] and [13] state that, visual complaints are closely related to visual acuity. Light reflected into the eye from objects around it is the basis for a person's ability to see. The sharpness of vision depends on the amount of light received by the eye. Perception of the color of objects depends a lot on the wavelength of light reflected into the eye. The mixture of wavelengths reflected by an object will affect the perception of the color.

In art activities, carving artists often experience visual complaints caused by fatigue and pain due to unnatural work positions as a result of less anthropometric work stations. Some are needed at rest to reduce visual complaints that occur. Similar events actually we often feel after a long time in front of a computer or cellphone.

2. Methodology
The research was carried out in several carving artist workshops, with the same design as the subject involving 10 carving artists who volunteered to sit as people trying to research. Interventions are given to subjects in period 2, in the form of ergo-physiological work stations, namely the presence of comfort from the subject when they are and using a work station. Ergo-physiological intervention is also in the form of regulation of environmental conditions consisting of wind speed, noise, humidity, dry temperature, wet temperature and light intersection. The Japanese olympus FE-15 digital camera for documentation, table of psychometrics to determine relative humidity by% unit, stop watch - British-made diamond brand with seconds units, used for recording the time of the pulse, as well as the working time of the subject, sound level meter, lux meter, black globe thermometer, sling thermometer, anemometer, super Japanese anthropometer tool made in Japan with 0.1 cm accuracy, which is used to measure the anthropometry of the subject.

Measurements were made 2 times, namely before the intervention was done (P1) and after the intervention was done (P2). Data analysis begins with a descriptive analysis and normality test of data with shapiroWilk. Normal distributed data were analyzed using t-paired test and data that were not normally distributed using the Wilcoxon test. Officers are involved in observing are ergonomics (masters or ergonomics doctors) and doctors who master palpation techniques (holding and counting pulse on the wrist).

3. Result and Discuss
3.1. Characteristics of Subjects
Characteristics of subjects including age, weight, height, work experience, resting pulse and body mass index (BMI) are presented in Table 3.

| No. | Description             | Average | Standard of Deviation | Range  |
|-----|-------------------------|---------|-----------------------|--------|
| 1   | Age (year)              | 37.72   | 4.72                  | 30 – 51|
| 2   | Weight (kg)             | 60.56   | 6.22                  | 49 – 71|
| 3   | Height (cm)             | 167.61  | 4.12                  | 150 – 171|
| 4   | Work experience (year)  | 11.31   | 4.91                  | 10 – 20|
| 5   | Resting pulse Period 1  | 84.31   | 3.92                  | 77.33 – 90.67|
Most of the subjects of research are educated at Senior high school level (50%), while those with elementary and college education are 30% and 20% respectively. Subjects totaling 10 people are all male and are employees at UD. Jatayu, CV. Rinna and UD. Agus. The life span of the subject is 30 s.d. 51 years, average 37.72 ± 4.72 years. Subject weight ranges from 49 s.d. 71 kg with mean of 60.56 ± 6.22 kg. The subject's height is in the range of 150 s.d. 171 cm with mean of 167.61 ± 4.12 cm. The work experience of the subject ranged from 10 s.d. 20 years with an average of 11.31 ± 4.91 years. Work experience related to the ability of adaptation and freshness level of craftsmen.

The resting pulse can also show the degree of physical fitness of a person, the lower the resting pulse of a person the better the physical fitness. In this study the subjects' pulse rate ranged from 77.33 s.d. 90.67 beats per minute (bpm) with an average of 84.31 ± 2.92 bpm before the ergonomic implementation (study period I) and between 69.33 s.d. 85.33 bpm with a mean of 78.02 ± 4.53 bpm after the implementation of ergonomics (research period II). The resting pulse in period I and period II is still in the range of 69.33 bpm s.d. 90.67 bpm, which shows the physical condition of the subject in good health, because the workload is very light to light category.

Prior to the conduct of the study all the population received medical examinations from the Doctors. Out of 45 people, 10 of them were selected. From the results of the examination which includes blood pressure measurement, sugar levels in time and pulse have obtained health status of the sample, which is healthy.

### 3.2. Environment Conditions

The characteristics of the ergo-physiological work station are anthropometric work stations that are supported by comfortable environmental conditions, in accordance with the physiological needs of workers. In this study uncomfortable environmental conditions are made comfortable, on the contrary those that are already classified as comfortable are maintained. The tools used to create comfortable environmental conditions include: the intensity of light that has not been well improved by adding a set of 4-level parallel fluorescent lights with the equivalent of 40 watts. Dry temperature and wet temperatures that have not yet entered the comfortable temperature category are improved by increasing the wind speed using an exhaust fan, while the noise status that has been well maintained. Furthermore, environmental conditions that have met the ergo-physiological classification are maintained during period 1 and period 2.

The results of the normality test for environmental conditions, both for the working environment condition during period I and period II, show that normal data distribution is light intensity, while drying temperature data, wet temperature, humidity, ball temperature, wind speed, noise and WBGT index not normally distributed. If one of the data is not normal then the test using non-parametric test equipment. Thus the data were tested by Mann-Whitney test.

Environmental conditions consisting of dry temperature, wet temperature, relative humidity, wind speed, light intensity, ball temperature and noise also greatly affect the subject condition. The data of light intensity, wind speed and noise are measured at five points and at different times. The result of data analysis shows that environmental condition seen from dry temperature, wet temperature, ball temperature, relative humidity, wind speed, light intensity and noise period I and in period II is no difference. It is said that because all values \( p > 0.05 \) or it can be said that : (a) the average of dry temperature in the study period I is not significantly different with the average of dry temperature at the time of observation period II; (b) the average of wet temperature at observation period I was not

|   | Resting pulse Period II (bpm) | 78.02 | 4.53 | 69.33 – 85.33 |
|---|-------------------------------|-------|------|---------------|
|   | Body mass index (BMI) (kg/m²)  | 21.67 | 3.37 | 18.34 – 24.89 |

Description : bpm = beats per minute.
significantly different with mean wet temperature of period II; (c) the average of sphere temperature at observation period I was not significantly different with mean of ball temperature of period II; (d) the relative humidity average at observation period I was not significantly different with the mean of relative humidity during observation period II; (e) the average of wind velocity in observation of period I is not significantly different with mean of wind velocity of period II, and (f) average of noise, WBGT and light intensity at observation period I is not significantly different with mean of noise, WBGT and light intensity of period II.

To know the suitability between the tools used by artisans done anthropometry measurement. The size obtained should be in accordance with the size of the body and comfortable to use by crafters. Anthropometric data is very important for the designers of the tool to get the most appropriate size. The more samples involved the better, even in developed countries already available anthropometry data that represent the population of the country. Data obtained by: (1) all subjects measured; (2) anthropometric data of all subjects is taken average and its standard intersection (3) the average value of the subject then searched the percentile value with SPSS. From anthropometry data then desk and chair work in design. The height of the table uses a high reference point 95th elbow, so the table height is determined 71.7 cm. Table length uses a 95th percentile shoulder width of 95, which is 49 cm, so the length of the table is made 100 cm. Table width is determined using 95th percentile hand coverage range, so it is made 69 cm.

3.3. Cardiovascular Load and Strain Cardiovascular
The effect of carving activities on cardiovascular load was measured in period I and period II. Measurements are made by calculating the maximum workload from the sample.

| No. | Description          | Value | Df | Value |
|-----|----------------------|-------|----|-------|
| 1   | %CVL before activity | 0.723 | 10 | 0.073 |
| 2   | %CVL before activity | 0.945 | 10 | 0.265 |
| 3   | %CVL after activity  | 0.843 | 10 | 0.783 |
| 4   | %CVL after activity  | 0.78  | 10 | 0.564 |
| 5   | CVS before activity  | 0.890 | 10 | 0.765 |
| 6   | CVS before activity  | 0.976 | 10 | 0.171 |
| 7   | CVS after activity   | 0.897 | 10 | 0.072 |
| 8   | CVS after activity   | 0.784 | 10 | 0.672 |

From the table it can be seen that the Z values of cardiovascular load and cardiovascular strains in period I and II, both cardiovascular load before activity and after activity have a value of p> 0.05, so it can be said that the eight data are normally distributed. Because data is normally distributed, different mean tests use the t-paired test. Test results in Table 5.

| No. | Variable          | Period I average | Period II average | Value t  | Value p |
|-----|-------------------|------------------|-------------------|----------|---------|
| 1   | %CVL before activity | 07.11            | 07.22             | 1.857    | 0.076   |
| 2   | %CVL after activity | 47.43            | 14.92             | 1.672    | 0.0001  |
| 3   | CVS before activity | 12.24            | 12.03             | 1.982    | 0.164   |
| 4   | CVS after activity  | 95.24            | 27.92             | 1.278    | 0.0001  |

The average% of %CVL in period I was 07.11 ± 06.21% and the mean of% CVL rest breaks in period II was 07.22 ± 03.19% with a value of t = 1.857. The difference in% of resting CVL in period I was not significantly different from% CVL resting in period II because the value of p> 0.05.

To determine the cardiovascular load (% CVL) it is necessary to calculate the age, duration of work and maximum workload of the sample. From Table 5.5 it can be seen the range of% of period I CVL
after the activity shows the subject's cardiovascular burden in an area that is detrimental to health because it must be lowered. The range of CVL in the second period is also not all in the safe area because there is still CVL close to the safe threshold, even though on average it is good, which is below 30%.

Cardiovascular strain in period 1, which is 95% is also in a fairly high area, needed repairs to the work station as soon as possible, at least in a few weeks. The safe limit for cardiovascular strains is 50%. After the subject was given treatment, among others, given the ergonomic work station and the room conditions arranged according to physiological needs, the cardiovascular load value dropped dramatically in period 2, ie from 47.43% in period 1 to 14.92% in period 2. With a t value = 1.672 and the value of p = 0.0001, or decreases by 68.54%. Cardiovascular strain also changes to good in period 2. Initially 95.24% in period 1 changes to 27.92% in period 2, or decreases by 70.68%, with a value of t = 1.278 and a value of p = 0.0001. This shows that CVL after activity was significantly different (p <0.05) between period I and period II, with a confidence level of 95%.

3.4. Visual Complaints

By observing several major indicators that show the level of visual complaints, such as headaches, objects that appear double, tired eyes, watery eyes, dry eyes, sore eyes, blurred vision and the occurrence of reading errors the results of calculations as presented in Table 5.3 below are obtained. The results of testing the normality of data for speed, accuracy and constancy can be seen in Table 6.

| No. | Description                                      | Value | Df  | Value p |
|-----|--------------------------------------------------|-------|-----|---------|
| 1   | Headache Period I                                | 0.546 | 10  | 0.055   |
| 2   | Headache Period II                               | 0.427 | 10  | 0.113   |
| 3   | Objects seen double in Period I                  | 0.678 | 10  | 0.679   |
| 4   | Objects seen double in Period II                 | 0.257 | 10  | 0.527   |
| 5   | Tired ayes in Period I                           | 0.674 | 10  | 0.553   |
| 6   | Tired ayes in Period II                          | 0.489 | 10  | 0.511   |
| 7   | Watery eyes Period I                             | 0.345 | 10  | 0.235   |
| 8   | Watery eyes Period II                            | 0.982 | 10  | 0.872   |
| 9   | Dry eyes Period I                                | 0.763 | 10  | 0.283   |
| 10  | Dry eyes Period II                               | 0.387 | 10  | 0.834   |
| 11  | Sore eyes Period I                               | 0.893 | 10  | 0.065   |
| 12  | Sore eyes Period II                              | 0.346 | 10  | 0.981   |
| 13  | Blurred view period I                            | 0.654 | 10  | 0.921   |
| 14  | Blurred view period II                           | 0.234 | 10  | 0.782   |
| 15  | Reading error period I                           | 0.873 | 10  | 0.923   |
| 16  | Reading error period I                           | 0.256 | 10  | 0.567   |

It can be seen that the Z value of headache indicators in period I is 0.546 with a value of p = 0.055, as well as in period II is 0.427 with a value of p = 0.113. It turns out that the value of p> 0.05, so it can be concluded that both data are normally distributed. The Z value of objects seen double, both in period I and period II are also normally distributed, as well as data on tired eyes, watery eyes, dry eyes, sore eyes, blurred vision and reading error parameters.

Since data is normally distributed, different mean testing uses t-paired. The results of different mean testing using t-paired can be seen in Table 7.

| No. | Variable                | Period I average | Period II average | Value t  | Value p |
|-----|-------------------------|------------------|------------------|----------|---------|
| 1   | Headache                | 108.81           | 101.19           | -0.218   | 0.0001  |
| 2   | Objects seen double     | 78.05            | 75.71            | -0.3145  | 0.0001  |
Subjects whose visual complaints were observed in the first period, where subjects had not been treated (using ergonomic work stations) had a visual complaint load score of 644.46 and experienced improvement in period 2 to 595.41.

Indicators of visual complaints, namely headaches improved by 7% in period 2, which was an average of 108.81 in period 1 to 101.19 in period 2. Data on visual complaints of double-visible objects also improved, from a score of 78.05 in period 1 to be 75.71, or decrease by 2.99%, with a value of t = -0.3145. Data on visual complaints of eye fatigue, runny eyes, dry eyes and sore eyes also experienced considerable improvement. Improvement of the condition after being given treatment is also seen in the visual complaints data blurred vision. Initially the score was at 92.32, declining quite large to 75.55, or improving by 18.17%. The same thing also happened in visual complaints data read errors. In period 1 the score is at 98.54 and changes to 90.04 in period 2, or there is a decrease of 8.63%, with a value of t = -0.231. All the data above has a value of p <0.05, so that it can be said that the improvement of visual complaints from period 1 to period 2 is significantly different. The results of data analysis showed that the indicators of visual complaints were seen from headaches, objects seen as double, tired eyes, watery eyes, dry eyes, sore eyes, blurred vision and period I and period II reading errors were significantly different.

4. Conclusions
Based on the previous discussion can be concluded some of the essence of research to answer the existing problems, as follows. By utilizing appropriate technology, namely ergonomic work stations and regulated work environments according to physiological needs, it was found that cardiovascular load values dropped dramatically in period 2, from 47.43% in period 1 to 14.92% in period 2. With t values = 1.672 and the value of p = 0.0001, or decreases by 68.54%. Cardiovascular strain also changes to good in period 2. Initially 95.24% in period 1 changes to 27.92% in period 2, or decreases by 70.68%, with a value of t = 1.278 and a value of p = 0.0001. This shows that CVL and cardiovascular strains after activity differed significantly (p <0.05) between period I and period II.

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