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L Widodo ; I Wayan Sukania; Michael Hendri



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# Ergonomic Risk Analysis of Tofu Cutting Process at Raimin's Small and Medium Enterprise

L Widodo<sup>1,2,a)</sup>, I Wayan Sukania<sup>1,b)</sup>, Michael Hendri<sup>1)</sup>

<sup>1</sup>Industrial Engineering Department, Tarumanagara University, Indonesia

<sup>2</sup>Work System Design and Ergonomic Laboratory, Tarumanagara University, Indonesia

a) Corresponding author: lamtow@ft.untar.ac.id

b) iwayans@ft.untar.ac.id

**Abstract.** The food industry is one of the industries that will continue to exist because it is related to basic human needs. UMKM Raimin is one of the food processing industries, namely tofu production. Currently the tofu production process is carried out manually by relying on the abilities and skills of workers, from the beginning to the end of production. Thus, the most dominant factor affecting work performance is the workers themselves. The aim of this study was to analyze the working conditions from an ergonomic point of view. Initial research using the Nordic Body Map found several complaints on several parts of the worker's body after carrying out activities on the production floor. The highest complaints were on the left shoulder, waist, back, upper and lower arms, lower neck, and left and right wrists. The purpose of this study is to determine the ergonomic risks to the work system and what recommendations are needed for improvement. The analytical tools used are the Nordic Body Map (NBM), Rapid Whole Body Assessment (REBA), Workplace Ergonomic Risk Assessment (WERA) and Heart Rate (HR). The REBA calculation result of the tofu cutting process is 12 (very high risk). The WERA score is 37 (moderate risk). The results of energy calculations based on HR measurements show that the energy required is 6.34 kcal / minute (classified as moderate work). Thus it can be concluded that corrective action needs to be done as soon as possible, so that workers are safer and more comfortable. The end goal is to improve the performance of the tofu production process.

**Keywords:** ergonomic, risk factor, tofu, REBA, WERA, HR

## INTRODUCTION

### Tofu Production Process

In the culinary world, tofu is one of the foods that is familiar to all humans in the world. Apart from its delicious taste, tofu also contains various nutrients that are good for the human body to consume. Another reason why tofu is popular with the community is the way it is made and its raw materials are not too complicated and easy to obtain. Tofu is a food made from coagulated soybean seed presses. Tofu has been known in China since the Han dynasty about 2,200 years ago which was discovered by Liu An. [1] Tofu Raimin SME is a company that is engaged in tofu production. Production is based on the principle of Make to Order production, which means that the number of products produced and the design (tofu dimensions) follows consumer demand. These consumers come from various groups, including the market, distributors, and home consumers.

The main principle of the tofu production process is the coagulation (deposition) of soy milk protein. The materials used were tofu blocks ( $\text{CaSO}_4$ ), acetic acid ( $\text{CH}_3\text{COOH}$ ) and  $\text{MgSO}_4$ . The process of making tofu consists of several stages, namely soaking, milling, cooking, filtering, clumping, molding / hardening and cutting. The milling process is carried out automatically, using a soybean grinding machine. In this process, there were no obstacles that could hinder the production process. Furthermore, the heating process for soybean dough is done manually by workers using a large stove. In this process, there are also no problems with the operators who carry out this heating process. Then, the process of screening soybean starch is carried out manually by the operator using a

filter device, followed by the stirring process of soybean starch, which is also done manually. The next process is the tofu printing process. After going through the above processes, the tofu starch is thick enough and can be cut immediately to the desired size.[2] In the tofu cutting process, the operator gets fatigue in certain body parts because the tofu cutting process is an activity or activity that is carried out repeatedly (repetitive). At Tofu Raimin's SME, there are several production processes that are carried out manually by workers / employees, where in the process or activity the working conditions are less ergonomic. Lack of good work facilities and unnatural work posture are the cause of problems in the worker's body and cause ongoing complaints.

### Unnatural Work Posture

This study was conducted to evaluate the work system from an ergonomic point of view, identify non-ergonomic movements in a work process and conclude what follow-up actions are needed to improve. Activities that are not ergonomically carried out in the observation can be seen in Figure 1 and Figure 2.



**FIGURE 1.** The Process of Removing Tofu From Mold



**FIGURE 2.** The Process of Tofu Cutting

After observing this work system, it can be seen that workers carry out the process of removing tofu from the mold box (before the cutting process) in an ergonomic position, as well as during the tofu cutting process. Posture, such as bending, squatting, repetition of movements, etc. are factors that cause complaints to the parts of the skeletal muscles that a person feels, ranging from very mild complaints to very painful (Musculoskeletal Disorders). This paper discusses the condition of the work system along with ergonomic analysis, which will then become the basis for system improvement.

### Ergonomic and Work Sytem

Ergonomics is a systematic branch of science that utilizes information about the nature, abilities and limitations of humans to design a work system so that people can live and work in that system properly, achieving the desired goals through that work effectively, safely and comfortably[3][4], [5].

## Nordic Body Map (NBM)

The Nordic Body Map questionnaire is a questionnaire used to find symptoms and complaints of musculoskeletal disorders in workers. Filling the Nordic Body Map questionnaire aims to find out complaints about the body parts of workers who feel pain before and after doing work at the work station and are divided into 27 body parts. Nordic Body Map is a development of the Nordic Musculoskeletal Questionnaire (NMQ) which is a questionnaire used to find symptoms and complaints of musculoskeletal disorder in workers [6],[7],[8].

## Rapid Entire Body Assessment (REBA) and Workplace Ergonomic Risk Assessment (WERA)

Rapid Entire Body Assessment (REBA) is a method developed in the field of ergonomics that can be used to quickly assess an operator's work position or posture of the neck, back, arms, wrists and feet. REBA can be used for whole body assessment as an evaluation of musculoskeletal load on posture, repetition and force [9][10][10]. Workplace Ergonomic Risk Assessment (WERA), which is a survey tool developed for rapid screening of tasks to describe physical risk factors associated with Work-related Musculoskeletal Disorder (WMSDs). The WERA assessment consists of six physical risk factors including posture, repetition, strength, vibration, contact stress, and duration of work and involves five major body parts, namely the shoulders, wrists, back, neck, and feet [11][12], [13]. Worksheet of REBA and WERA can be seen in Figure 3 and Figure 4.

**REBA Employee Assessment Worksheet**

Based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, Mullaney, Applied Ergonomics 31 (2000) 201-205

### A. Neck, Trunk and Leg Analysis

**Step 1: Locate Neck Position**

Step 1a: Adjust...  
If neck is twisted: +1  
If neck is side bending: +1

**Step 2: Locate Trunk Position**

Step 2a: Adjust...  
If trunk is twisted: +1  
If trunk is side bending: +2

**Step 3: Legs**

Step 3a: Adjust...  
If leg is twisted: +1  
If leg is side bending: +2

**Step 4: Look-up Posture Score in Table A**

Using values from steps 1-3 above, locate score in Table A.

**Step 5: Add Force/Load Score**

If load < 11 lbs: +0  
If load 11 to 22 lbs: +1  
If load > 22 lbs: +2  
Adjust: If shock or rapid build up of force: add +1

**Step 6: Score A, Find Row in Table C**

Add values from steps 4 & 5 to obtain Score A.  
Find Row in Table C.

**Scoring:**

- 1 = negligible risk
- 2 or 3 = low risk, change may be needed
- 4 to 7 = medium risk, further investigation, change soon
- 8 to 10 = high risk, investigate and implement change
- 11+ = very high risk, implement change

### B. Arm and Wrist Analysis

**Step 7: Locate Upper Arm Position:**

Step 7a: Adjust...  
If shoulder is twisted: +1  
If upper arm is abducted: +1  
If arm is supported or person is leaning: -1

**Step 8: Locate Lower Arm Position:**

Step 8a: Adjust...  
If wrist is bent from midline or twisted: Add +1

**Step 9: Locate Wrist Position:**

Step 9a: Adjust...  
If wrist is bent from midline or twisted: Add +1

**Step 10: Look-up Posture Score in Table B**

Using values from steps 7-9 above, locate score in Table B.

**Step 11: Add Coupling Score**

Well fitting Handle and mid range power grip: good: +0  
Acceptable but not ideal hand hold or coupling acceptable with another body part: fair: +1  
Hand hold not acceptable but possible: poor: +2  
No handles, awkward, unsafe with any body part: Unacceptable: +3

**Step 12: Score B, Find Column in Table C**

Add values from steps 10 & 11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.

**Step 13: Activity Score**

- +1 1 or more body parts are held for longer than 1 minute (static)
- +1 Repeated small range actions (more than 4x per minute)
- +1 Actions causes rapid large range changes in postures or unstable base

**Table A: Neck**

|       | 1 | 2 | 3 |
|-------|---|---|---|
| Neck  | 1 | 2 | 3 |
| Trunk | 1 | 2 | 3 |
| Legs  | 1 | 2 | 3 |

**Table B: Lower Arm**

|           | 1 | 2 |
|-----------|---|---|
| Wrist     | 1 | 2 |
| Upper Arm | 1 | 2 |
| Lower Arm | 1 | 2 |

**Table C: Final REBA Score**

| Score A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------|---|---|---|---|---|---|---|---|---|----|----|----|
| Score B | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score C | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score D | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score E | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score F | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score G | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score H | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score I | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score J | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score K | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score L | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score M | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score O | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score P | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score Q | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score R | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score S | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score T | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score U | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score V | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score W | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score X | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score Y | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Score Z | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

**Final REBA Score**

Task name: \_\_\_\_\_ Reviewer: \_\_\_\_\_ Date: \_\_\_\_\_

This tool is provided without warranty. The author has provided this tool as a simple means for applying the concepts provided in REBA.

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r.burke@ergonomics.com (816) 444-1667

FIGURE 3. REBA Worksheet

**WORKPLACE ERGONOMIC RISK ASSESSMENT (WERA)**

| PHYSICAL RISK FACTOR |                | RISK LEVEL                      |                                    |                             | SCORING SYSTEM                                                                                                                                                                                                                                                                                                                                       |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
|----------------------|----------------|---------------------------------|------------------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--|--|--|--|------------|-----|-----|------|--|-----|---|---|---|--|-----|---|---|---|--|------|---|---|---|--|
|                      |                | LOW                             | MEDIUM                             | HIGH                        |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| 1. Shoulder          | 1a. Posture    |                                 |                                    |                             | <table border="1"> <tr><td colspan="5">1a. POSTURE</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table> | 1a. POSTURE |  |  |  |  | Risk Level | LOW | MED | HIGH |  | LOW | 2 | 3 | 4 |  | MED | 3 | 4 | 5 |  | HIGH | 4 | 5 | 6 |  |
|                      | 1a. POSTURE    |                                 |                                    |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| Risk Level           | LOW            | MED                             | HIGH                               |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| LOW                  | 2              | 3                               | 4                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| MED                  | 3              | 4                               | 5                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| HIGH                 | 4              | 5                               | 6                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
|                      | 1b. Repetition | Light movement with more pauses | Moderate movement with some pauses | Heavy movement with no rest | Score 1 <input type="text"/>                                                                                                                                                                                                                                                                                                                         |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| 2. Wrist             | 2a. Posture    |                                 |                                    |                             | <table border="1"> <tr><td colspan="5">2a. POSTURE</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table> | 2a. POSTURE |  |  |  |  | Risk Level | LOW | MED | HIGH |  | LOW | 2 | 3 | 4 |  | MED | 3 | 4 | 5 |  | HIGH | 4 | 5 | 6 |  |
|                      | 2a. POSTURE    |                                 |                                    |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| Risk Level           | LOW            | MED                             | HIGH                               |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| LOW                  | 2              | 3                               | 4                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| MED                  | 3              | 4                               | 5                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| HIGH                 | 4              | 5                               | 6                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
|                      | 2b. Repetition | 0-10 times per minute           | 11-20 times per minute             | Over 20 times per minute    | Score 2 <input type="text"/>                                                                                                                                                                                                                                                                                                                         |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| 3. Back              | 3a. Posture    |                                 |                                    |                             | <table border="1"> <tr><td colspan="5">3a. POSTURE</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table> | 3a. POSTURE |  |  |  |  | Risk Level | LOW | MED | HIGH |  | LOW | 2 | 3 | 4 |  | MED | 3 | 4 | 5 |  | HIGH | 4 | 5 | 6 |  |
|                      | 3a. POSTURE    |                                 |                                    |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| Risk Level           | LOW            | MED                             | HIGH                               |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| LOW                  | 2              | 3                               | 4                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| MED                  | 3              | 4                               | 5                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| HIGH                 | 4              | 5                               | 6                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
|                      | 3b. Repetition | 0-3 times per minute            | 4-8 times per minute               | 9-12 times per minute       | Score 3 <input type="text"/>                                                                                                                                                                                                                                                                                                                         |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| 4. Neck              | 4a. Posture    |                                 |                                    |                             | <table border="1"> <tr><td colspan="5">4a. POSTURE</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table> | 4a. POSTURE |  |  |  |  | Risk Level | LOW | MED | HIGH |  | LOW | 2 | 3 | 4 |  | MED | 3 | 4 | 5 |  | HIGH | 4 | 5 | 6 |  |
|                      | 4a. POSTURE    |                                 |                                    |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| Risk Level           | LOW            | MED                             | HIGH                               |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| LOW                  | 2              | 3                               | 4                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| MED                  | 3              | 4                               | 5                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| HIGH                 | 4              | 5                               | 6                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
|                      | 4b. Repetition | Light movement with more pauses | Moderate movement with some pauses | Heavy movement with no rest | Score 4 <input type="text"/>                                                                                                                                                                                                                                                                                                                         |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| 5. Leg               | 5a. Posture    |                                 |                                    |                             | <table border="1"> <tr><td colspan="5">5a. POSTURE</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table> | 5a. POSTURE |  |  |  |  | Risk Level | LOW | MED | HIGH |  | LOW | 2 | 3 | 4 |  | MED | 3 | 4 | 5 |  | HIGH | 4 | 5 | 6 |  |
|                      | 5a. POSTURE    |                                 |                                    |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| Risk Level           | LOW            | MED                             | HIGH                               |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| LOW                  | 2              | 3                               | 4                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| MED                  | 3              | 4                               | 5                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
| HIGH                 | 4              | 5                               | 6                                  |                             |                                                                                                                                                                                                                                                                                                                                                      |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |
|                      |                |                                 |                                    |                             | Score 5 <input type="text"/>                                                                                                                                                                                                                                                                                                                         |             |  |  |  |  |            |     |     |      |  |     |   |   |   |  |     |   |   |   |  |      |   |   |   |  |

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| PHYSICAL RISK FACTOR                    |                                             | RISK LEVEL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                          |      | SCORING SYSTEM                                                                                                                                                                                                                                                                                                                                             |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
|-----------------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--|--|--|------------|-------------|--------|----------|------|-------|--------------------|--------------------------|-----|-------|-------------------------------------------------------|--------------------------|------|-------|------------------------------------------|--------------------------|------|---|---|---|--|
|                                         |                                             | LOW                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | MEDIUM                   | HIGH |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| 6. Forceful                             | Lifting the load                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      | <table border="1"> <tr><td colspan="5">6. FORCEFUL</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table>       | 6. FORCEFUL       |  |  |  |            | Risk Level  | LOW    | MED      | HIGH |       | LOW                | 2                        | 3   | 4     |                                                       | MED                      | 3    | 4     | 5                                        |                          | HIGH | 4 | 5 | 6 |  |
|                                         | 6. FORCEFUL                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| Risk Level                              | LOW                                         | MED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | HIGH                     |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| LOW                                     | 2                                           | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| MED                                     | 3                                           | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 5                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| HIGH                                    | 4                                           | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 6                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
|                                         |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      | Score 6 <input type="text"/>                                                                                                                                                                                                                                                                                                                               |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| 7. Vibration                            | Using of vibration tool                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      | <table border="1"> <tr><td colspan="5">7. VIBRATION</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table>      | 7. VIBRATION      |  |  |  |            | Risk Level  | LOW    | MED      | HIGH |       | LOW                | 2                        | 3   | 4     |                                                       | MED                      | 3    | 4     | 5                                        |                          | HIGH | 4 | 5 | 6 |  |
|                                         | 7. VIBRATION                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| Risk Level                              | LOW                                         | MED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | HIGH                     |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| LOW                                     | 2                                           | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| MED                                     | 3                                           | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 5                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| HIGH                                    | 4                                           | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 6                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
|                                         |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      | Score 7 <input type="text"/>                                                                                                                                                                                                                                                                                                                               |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| 8. Contact stress                       | Using of tool handle Or wearing hand gloves |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      | <table border="1"> <tr><td colspan="5">8. CONTACT STRESS</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table> | 8. CONTACT STRESS |  |  |  |            | Risk Level  | LOW    | MED      | HIGH |       | LOW                | 2                        | 3   | 4     |                                                       | MED                      | 3    | 4     | 5                                        |                          | HIGH | 4 | 5 | 6 |  |
|                                         | 8. CONTACT STRESS                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| Risk Level                              | LOW                                         | MED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | HIGH                     |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| LOW                                     | 2                                           | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| MED                                     | 3                                           | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 5                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| HIGH                                    | 4                                           | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 6                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
|                                         |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      | Score 8 <input type="text"/>                                                                                                                                                                                                                                                                                                                               |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| 9. Task duration                        | Task-hr/day                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      | <table border="1"> <tr><td colspan="5">9. TASK DURATION</td></tr> <tr><td>Risk Level</td><td>LOW</td><td>MED</td><td colspan="2">HIGH</td></tr> <tr><td>LOW</td><td>2</td><td>3</td><td colspan="2">4</td></tr> <tr><td>MED</td><td>3</td><td>4</td><td colspan="2">5</td></tr> <tr><td>HIGH</td><td>4</td><td>5</td><td colspan="2">6</td></tr> </table>  | 9. TASK DURATION  |  |  |  |            | Risk Level  | LOW    | MED      | HIGH |       | LOW                | 2                        | 3   | 4     |                                                       | MED                      | 3    | 4     | 5                                        |                          | HIGH | 4 | 5 | 6 |  |
|                                         | 9. TASK DURATION                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| Risk Level                              | LOW                                         | MED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | HIGH                     |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| LOW                                     | 2                                           | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| MED                                     | 3                                           | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 5                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| HIGH                                    | 4                                           | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 6                        |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
|                                         |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      | Score 9 <input type="text"/>                                                                                                                                                                                                                                                                                                                               |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| <b>FINAL SCORE</b> <input type="text"/> |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| Job/Task : _____                        |                                             | <table border="1"> <tr><th colspan="4">Action Level</th></tr> <tr><th>Risk Level</th><th>Final Score</th><th>Action</th><th>Tick (v)</th></tr> <tr><td>LOW</td><td>10-27</td><td>Task is acceptable</td><td><input type="checkbox"/></td></tr> <tr><td>MED</td><td>28-44</td><td>Task is need to further investigate &amp; required change</td><td><input type="checkbox"/></td></tr> <tr><td>HIGH</td><td>45-54</td><td>Task is not accepted, immediately change</td><td><input type="checkbox"/></td></tr> </table> |                          |      |                                                                                                                                                                                                                                                                                                                                                            | Action Level      |  |  |  | Risk Level | Final Score | Action | Tick (v) | LOW  | 10-27 | Task is acceptable | <input type="checkbox"/> | MED | 28-44 | Task is need to further investigate & required change | <input type="checkbox"/> | HIGH | 45-54 | Task is not accepted, immediately change | <input type="checkbox"/> |      |   |   |   |  |
| Action Level                            |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| Risk Level                              | Final Score                                 | Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Tick (v)                 |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| LOW                                     | 10-27                                       | Task is acceptable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <input type="checkbox"/> |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| MED                                     | 28-44                                       | Task is need to further investigate & required change                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <input type="checkbox"/> |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| HIGH                                    | 45-54                                       | Task is not accepted, immediately change                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <input type="checkbox"/> |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| Date : _____                            |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |
| Observer : _____                        |                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                          |      |                                                                                                                                                                                                                                                                                                                                                            |                   |  |  |  |            |             |        |          |      |       |                    |                          |     |       |                                                       |                          |      |       |                                          |                          |      |   |   |   |  |

Based on WERA: An observational tool develop to investigate the physical risk factor associated with WMSDs, Mohd Norulzaki Abdul Rahman, Mohd Rizki Abdul Razak and Jafri Mohd Rahani, Journal of Human Ergology, 2011, 40(2), 10-16

FIGURE 4. WERA Worksheet

## Heart Rate Analysis

Heart rate measurement before and after work with a Heart Rate Monitor (HRM) can be used to measure the level of energy consumption. The amount of energy expended for a job can be measured by calculating heart rate and demographic factors and by using regression it can be seen the relationship between heart rate, body weight, height and age with energy [14][15][16], [17].

## METHODS

Research at Tofu MSMEs begins with conducting a preliminary study in the form of interviews, direct observation, and providing a nordic body map (NBM) questionnaire to workers. This research was carried out directly in the field. Along with this activity, a literature study was carried out. From the results of the initial field study, the problems, objectives and limitations of the research were formulated. The data on NBM complaints that have been collected are then further evaluated using the REBA, WERA, and HRM methods. The aim is to find out which jobs have the highest risk of physical complaints, the level of energy consumption of workers. From the calculation of several ergonomic tools it can be concluded what actions are needed to improve working conditions.

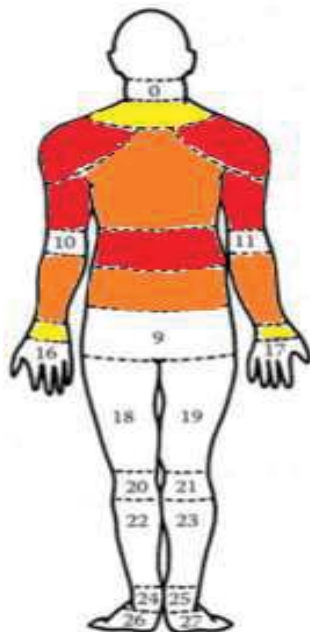
## RESULT AND DISCUSSION

At Tahu Raimin's UMKM, there are 3 workers who work in the tofu cutting division with a working time of 11 hours / day. After conducting interviews and distributing the Nordic Body Map to workers, results were obtained as in Table 1 and Figure 5.

**TABLE 1.** Data of Tofu Cutting Operator

| Operator | Gender | Age<br>(years) | Height<br>(cm) | Weight<br>(kg) | Work Experience<br>(years) |
|----------|--------|----------------|----------------|----------------|----------------------------|
| 1        | Male   | 31             | 162            | 55             | 4                          |
| 2        | Male   | 30             | 159            | 61             | 3                          |
| 3        | Male   | 25             | 165            | 60             | 1                          |

The results of the collection and processing of the Nordic Body Map questionnaire data can be seen that there are physical complaints experienced by workers in several parts of the body when doing their work. The analysis was conducted based on the complaints felt by workers with sick (S) and very sick (VS) levels. The body parts experiencing physical complaints can be seen in Figure 5.



Where:

Red Color: Very sick (VS)

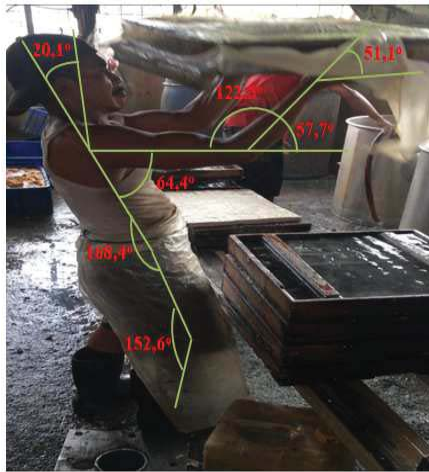
Orange Color: Pain (S)

Yellow Color: Somewhat Sick (SS)

The highest complaints are on the *left shoulder, waist, back, upper and lower arms, lower neck, and left and right wrists.*

**FIGURE 5.** Physical Complaints to Workers

After analyzing the physical complaints felt by workers using the Nordic Body Map questionnaire, the next step is to carry out a Rapid Entire Body Assessment to find out the REBA score. Documentation of the results of observations of each work position that has been given angles to facilitate the calculation of the REBA score can be seen in Figure 6 and Figure 7.



**FIGURE 6.** Process of removing tofu from mold.



**FIGURE 7.** Process of tofu cutting

The next stage is to conduct a Workplace Ergonomic Risk Assessment (WERA) assessment. The following are the results of calculating the REBA and WERA scores which can be seen in Table 2.

**TABLE 2.** Calculation results of REBA and WERA

| No. | Activity                            | REBA score | Risk Level            | WERA Score | Risk Level         |
|-----|-------------------------------------|------------|-----------------------|------------|--------------------|
| 1   | Process of removing tofu from mold. | 12         | <i>Very High Risk</i> | 36         | <i>Medium Risk</i> |
| 2   | Process of tofu cutting             | 11         | <i>Very High Risk</i> | 37         | <i>Medium Risk</i> |

Measurement of physical workload is done by measuring heart rate using a Heart Rate Monitor (HRM), namely the Garmin Forerunner 735XT. This tool is programmed automatically so that it is able to record the worker's heart rate to determine the workload level of the workload experienced by the worker. Measurements are taken when doing the tofu cutting process. The mean heart rate during work was 119. The level of energy consumption of workers in the tofu cutting process with the formula: [18]

$$\begin{aligned}
 VO_2 &= 0.019HR - 0.024h + 0.016w + 0.045a + 1.15 \\
 &= 0.019(116) - 0.024(162) + 0.016(55) + 0.045(31) + 1.15 \\
 &= 2.033 - 4.008 + 1.04 + 1.17 + 1.15 \\
 &= 1.268 \text{ litre/min}
 \end{aligned}$$

Expenditor energy can be calculated with the equation: 1 liter  $O_2$  = 5 kcal, so that the level of energy consumption of workers in the tofu cutting process is (1.268 litres  $O_2$  x 5 kcal) = 6.34 kcal /min and is categorized as medium work (5.0 - 7, 5 kcal / min). A graph of the heart rate measurement results during the tofu cutting activity can be seen in Figure 8.

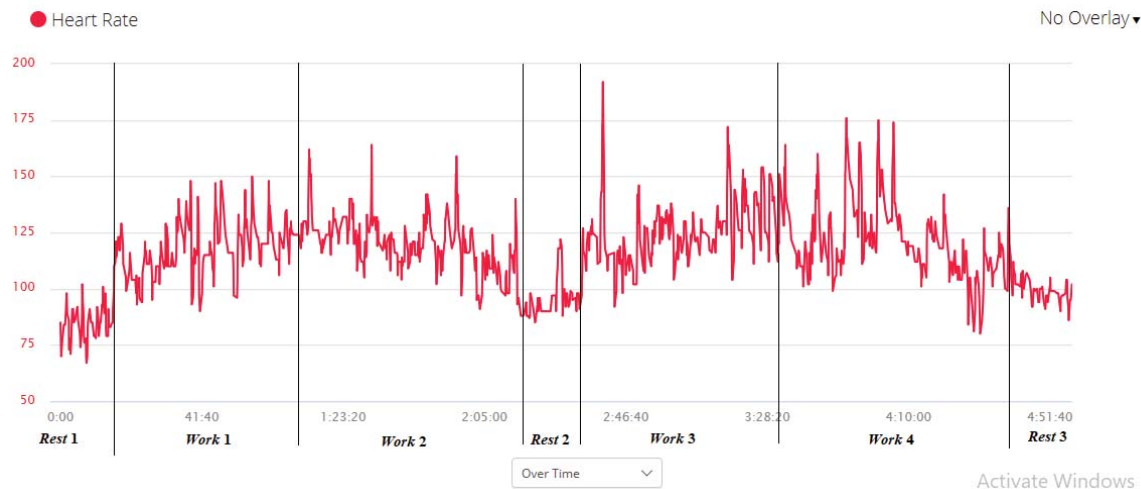


FIGURE 8. Heart Rate during tofu cutting process

## CONCLUSION

Based on the results of the Nordic Body Map questionnaire, there were 12 physical complaints experienced by workers during the tofu cutting process. Then by assessing body posture using the REBA method, the process of removing tofu from mold and tofu cutting were categorized as very high risk (scores: 11 and 12). According to the WERA analysis, this work was categorized as medium (score: 36 and 37), while from measuring heart rate using a Garmin Forerunner 735XT watch, the work was categorized as medium work (6.34 kcal / min). From these results, it can be concluded that work in the tofu cutting division (removing tofu from mold and tofu cutting) is less ergonomic and requires corrective intervention. As a note of limitation, in this study there were only 3 workers studied, because that is the maximum number of existing workers. Suggestions for further research, the object can be expanded to similar industries on a larger scale.

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