

Work Posture Evaluation of Manual Onion Finishing After Mechanical Peeling in a Food Processing Industry

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ABSTRACT

In industrial food manufacturing, automation is increasingly used to improve processing efficiency. In this study, the onion peeling machine is unable to fully separate the skin from the bulbs, requiring workers to perform manual re-peeling to ensure raw material quality prior to production. This situation creates repetitive hand motion and forward-leaning postures, which may contribute to musculoskeletal strain. Work posture assessment is a crucial aspect of industrial ergonomics to identify the risk of musculoskeletal disorders (MSDs). This study aims to evaluate the work posture of manual onion re-peeling workers using the Rapid Upper Limb Assessment (RULA) and Nordic Body Map (NBM) methods. The study was conducted on a number of respondents using direct observation, photo documentation, and questionnaires. The NBM results showed the most common complaints were in the waist (66%), shoulders, and neck. The average RULA score was 6 indicating a moderate to high risk level requiring immediate corrective action. The results of this study emphasize the importance of ergonomic interventions to reduce the risk of MSDs and support work productivity in the food processing industry.

Keywords: Food Processing Industry, MSDs, Onion Re-Peeling, RULA.

ABSTRAK

Dalam industri manufaktur makanan, otomatisasi semakin banyak digunakan untuk meningkatkan efisiensi pemrosesan. Pada penelitian ini, mesin pengupas bawang tidak dapat memisahkan kulit sepenuhnya dari umbi, sehingga pekerja harus melakukan pengupasan ulang secara manual untuk memastikan kualitas bahan baku sebelum produksi. Situasi ini menciptakan gerakan tangan yang berulang dan postur tubuh condong ke depan, yang dapat berkontribusi pada ketegangan muskuloskeletal. Penilaian postur kerja merupakan aspek penting dari ergonomi industri untuk mengidentifikasi risiko gangguan muskuloskeletal (MSDs). Penelitian ini bertujuan untuk mengevaluasi postur kerja pekerja pengupasan ulang bawang secara manual menggunakan metode Rapid Upper Limb Assessment (RULA) dan Nordic Body Map (NBM). Penelitian dilakukan terhadap sejumlah responden dengan menggunakan observasi langsung, dokumentasi foto, dan kuesioner. Hasil NBM menunjukkan keluhan yang paling umum adalah pada pinggang, bahu, dan leher. Skor RULA menunjukkan tingkat risiko sedang yang memerlukan tindakan korektif segera. Hasil penelitian ini menekankan pentingnya intervensi ergonomis untuk mengurangi risiko MSDs dan mendukung produktivitas kerja di industri pemrosesan makanan.

Kata kunci: Industri Pemrosesan Makanan, MSDs, Pengupasan Ulang Bawang, RULA.



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1. Introduction

Musculoskeletal disorders (MSDs) remain a major occupational health issue across global industries and are strongly associated with repetitive tasks, awkward postures, and long work durations [1]. These disorders affect millions of workers worldwide and impose substantial financial burdens on companies and healthcare systems, prompting the International Labour Organization (ILO) to highlight MSD prevention and ergonomic work environments as key components in achieving Sustainable Development Goals (SDGs) related to labor protection and productivity [2]. Ergonomics plays an essential role in minimizing these risks by optimizing workplace design and improving posture to reduce physical strain [3].

In food-processing operations, onion preparation is a common manual task with a high risk of MSDs due to repetitive hand movements and prolonged static postures [4]. Although mechanical peeling machines are widely used to increase efficiency in industrial environments, their performance can be limited by variations in onion size and skin adhesion. As a result, the machines may not fully remove outer skin layers, requiring workers to perform manual re-peeling and sorting to ensure raw-material quality [5]. This finishing task involves repetitive upper-limb motions, forward-bending trunk posture, and unsupported sitting, potentially increasing musculoskeletal burden on the lower back, neck, and shoulders.

Previous studies on onion-processing ergonomics have predominantly examined fully manual peeling in small-scale or home-industry settings [6], emphasizing the high prevalence of awkward posture, repetitive hand use, and low workstation ergonomics [7] [8]. However, ergonomic risks in post-mechanical manual finishing processes within industrial snack-processing facilities remain insufficiently explored, particularly where automation is used but manual correction remains necessary due to machine limitations [9]. This gap is critical because such hybrid operations are increasingly common in food manufacturing environments where consistency and product quality are prioritized.

Therefore, this study investigates musculoskeletal symptoms and work-posture risks among onion workers engaged in manual re-peeling after mechanical peeling in an industrial food-processing facility. By integrating the Nordic Body Map (NBM) questionnaire and Rapid Upper Limb Assessment (RULA) method, this research combines subjective discomfort reporting with objective posture evaluation [1]. The combined approach provides comprehensive insight into ergonomic risks and identifies body regions requiring intervention [10], [11]. The novelty of this study lies in evaluating manual finishing activities in a semi-automated industrial context, providing evidence-based recommendations for improving ergonomics in similar hybrid processing systems.

2. Method

The research followed three stages: (1) preliminary observation and task documentation, (2) administration of NBM questionnaires to assess worker discomfort, and (3) RULA analysis of upper-limb posture supported by photographic documentation.

2.1. NBM Method

The NBM is used to identify subjective worker complaints. Respondents are asked to fill out a body map by marking the body parts experiencing pain. The data is then summarized to calculate the percentage of complaints in each body segment. Several studies have shown the NBM to be effective for rapid surveys in the context of industrial ergonomics [12].

2.2. RULA Method

RULA is used to assess ergonomic risks in the upper body. Assessment is conducted through direct observation and photo/video documentation. The RULA score is calculated based on the position of the arms, wrists, neck, and back, taking into account static loads and movement repetitions [13]. The proven reliability of RULA in the last decade demonstrates its effectiveness not only in identifying MSD risk factors but also in guiding ergonomic improvements that help reduce those risks in practice [14].

The author began this research by conducting observations in one of the food and beverage companies regarding the conditions in the field. Next, the author conducted interviews with workers and recorded worker activities in the form of photos. Next, filling out a questionnaire was asked to the onion peeling workers as respondents, and measurements were taken of the angle of the body's work posture of the workers (employees). The data analysis method used in this study is the RULA method, namely a method to determine the level of MSD complaints in workers and to measure whether the work being done is ergonomically safe and recommendations for improvements to the work system if the score is relatively high.

Work posture assessment is carried out using the RULA method because this method is used to assess the posture, style, and movement of a work activity related to the use of the upper limbs. This method was developed to investigate the risk of abnormalities that workers may experience while carrying out upper limb work activities [15]. The RULA worksheet was used as a reference to evaluate upper-limb posture and determine the level of ergonomic risk, as shown in Figure 1. And the classification of ergonomic risk levels based on the RULA total score is presented in Table 1.

ERGONOMICS **RULA Employee Assessment Worksheet** Task Name: _____ Date: _____

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:

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

Step 2: Locate Lower Arm Position:

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:

Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:

Step 4a: Adjust...
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A.

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held >10 minutes): +0
If action repeated occurs 4X per minute: +1

Step 7: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in Table C.

Table A: Scores

Upper Arm	Lower Arm	Wrist Score			
		1	2	3	4
1	1	1	2	2	3
1	2	2	2	2	3
1	3	2	3	3	4
1	4	2	3	3	4
2	1	3	3	3	4
2	2	3	4	4	5
2	3	3	4	4	5
2	4	3	4	4	5
3	1	4	4	4	5
3	2	4	4	4	5
3	3	4	4	4	5
3	4	4	4	4	5
4	1	5	5	5	6
4	2	5	5	5	6
4	3	5	5	5	6
4	4	5	5	5	6
5	1	6	6	6	7
5	2	6	6	6	7
5	3	6	6	6	7
5	4	6	6	6	7
6	1	7	7	7	8
6	2	7	7	7	8
6	3	7	7	7	8
6	4	7	7	7	8

Table B: Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

Table B: Neck, Trunk, Leg Score

Neck	Trunk Posture Score					
	1	2	3	4	5	6
1	1	2	3	4	5	6
2	2	3	4	5	6	7
3	3	4	5	6	7	8
4	4	5	6	7	8	9
5	5	6	7	8	9	10
6	6	7	8	9	10	11

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B.

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held >10 minutes): +0
If action repeated occurs 4X per minute: +1

Step 14: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in Table C.

Table C: Scoring (final score from Table C)

Neck, Trunk, Leg Score	1	2	3	4	5	6	7	8	9	10	11
1	1	2	3	4	5	6	7	8	9	10	11
2	2	3	4	5	6	7	8	9	10	11	12
3	3	4	5	6	7	8	9	10	11	12	13
4	4	5	6	7	8	9	10	11	12	13	14
5	5	6	7	8	9	10	11	12	13	14	15
6	6	7	8	9	10	11	12	13	14	15	16
7	7	8	9	10	11	12	13	14	15	16	17
8	8	9	10	11	12	13	14	15	16	17	18
9	9	10	11	12	13	14	15	16	17	18	19
10	10	11	12	13	14	15	16	17	18	19	20
11	11	12	13	14	15	16	17	18	19	20	21
12	12	13	14	15	16	17	18	19	20	21	22
13	13	14	15	16	17	18	19	20	21	22	23
14	14	15	16	17	18	19	20	21	22	23	24
15	15	16	17	18	19	20	21	22	23	24	25
16	16	17	18	19	20	21	22	23	24	25	26
17	17	18	19	20	21	22	23	24	25	26	27
18	18	19	20	21	22	23	24	25	26	27	28
19	19	20	21	22	23	24	25	26	27	28	29
20	20	21	22	23	24	25	26	27	28	29	30

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

Figure 1. RULA Worksheet [4]

Table 1. Classification of Risk Levels Based on Individual Total Scores [4]

Likert Scale	Total Individual Score	Risk level	Corrective action
1	28-49	Low	No corrective action is required yet
2	50-70	Currently	Action may be needed at a later date
3	71-90	Tall	Immediate action is required
4	92-122	Very high	Comprehensive action is needed as soon as possible

3. Result and Discussion

3.1. Nordic Body Map (NBM)

The initial NBM assessment conducted through direct observation and worker self-reports indicated early patterns of musculoskeletal discomfort, reflecting the areas most frequently affected during onion-peeling activities. As initial results from direct field observation and NBM responses, the data indicate dominant complaints in the waist (66%), right/left shoulder (60%), and neck (45%), with additional discomfort in the arms (30%) and wrists (26%), as shown in Table 2.

Table 2. NBM Questionnaire Recapitulation

Parts of body	Percentage of Respondents
Neck	45
Right/left shoulder	60
Waist	66
Arm	30
Wrist	26

Based on the initial NBM assessment gathered through direct observation and worker questionnaires, the highest complaint was found in the waist area (66%), indicating this region as the most affected during peeling activities. The highest percentage of scores in the no pain category with a value of 100% was in the left ankle and right leg, 83%. While the percentage on the Likert scale was somewhat painful at 50% in the left hand, right hand, left thigh, right thigh, left knee, right knee, left calf, right calf, left foot and right foot. The highest percentage on the Likert scale of pain was in the upper neck, left shoulder, right shoulder, left elbow, right elbow, left forearm, right forearm, left wrist and right wrist with a percentage of 75%. Furthermore, on the percentage on the Likert scale of Very Pain, the highest percentage was 75% in the left upper arm and waist.

From the complaints felt by workers, it can result in a decrease in worker productivity. The percentage of complaints felt by workers will increase if the worker does it continuously and for a long period of time. The working position illustrated in Figure 2 visually confirms the NBM results, particularly the lumbar flexion and repetitive upper-limb activity associated with increased musculoskeletal strain.



Figure 2. Working Position Illustration

According to NBM data, the lumbar region shows the highest level of complaints, followed by the shoulders and neck. These conditions indicate tension caused by hunched sitting and repetitive shoulder movements when peeling food.

3.2. RULA data processing

The data used in this study were obtained through direct observation of workers during actual work activities, representing an existing assessment of their current posture conditions. Based on the observations, the workers' body postures were determined while peeling onions. The arm and wrist posture angles were identified and scored based on RULA criteria, as shown in Figure 3.



Figure 3. RULA measurement position A; (a) upper arm; (b) lower arm; (c) wrist.

Neck, trunk, and leg postures were assessed using RULA scoring guidelines, as illustrated in Figure 4.



Figure 4. RULA measurement position B; (a) neck, (b) trunk and leg.

The posture scoring results obtained from the RULA assessment are presented in Table 3, showing the contribution of upper-arm, lower-arm, wrist, neck, trunk, and leg postures to the final risk score.

Table 3. RULA Result Scores

A	Score	B	Score
Upper arm	+3	Neck	+3
Lower arm	+1	Trunk	+3
Wrist	+3	Leg	+1
Wrist twist	+2	Posture B	+4
Posture A	+4	Muscle use	+1
Muscle use	+1	Force/load	+0
Force/load	+0	Neck, trunk, leg	+5
Wrist & arm	+5	RULA score	+6

Posture measurements showed an average RULA score of 6 with a range of 4–7. This posture is classified as moderate to high risk, indicating the need for workstation design improvements [9]. The results showed a good agreement between subjective complaints (NBM) and objective measurements (RULA). Body parts with high RULA scores corresponded to areas of high complaints on the NBM. This finding is in line with which statement that the integration of both methods improves the accuracy of field ergonomic diagnosis [19].

This study showed significant static and repetitive loads on food peelers, which is consistent with preliminary research using NBM. The main complaints were in the waist and shoulders, indicating an unergonomic workstation design. These findings are consistent with previous research in the food and manufacturing sectors [20] [21]. The risk of MSDs impacts productivity and occupational health costs. Ergonomic improvements focus not only on worker well-being but also on company operational efficiency. Simple interventions such as adjusting desk height, providing ergonomic chairs, and job rotation can reduce ergonomic risks.

The integration of RULA and NBM results is in line with similar studies in the manufacturing industry, which emphasize the importance of combining subjective and objective methods. Studies in Thailand and Bangladesh have shown the effectiveness of simple ergonomic interventions in reducing MSD complaints in workers.

These findings confirm that prolonged static sitting posture and repetitive upper-limb movement were the dominant ergonomic risk factors. The alignment between NBM and RULA results reinforces the reliability of the combined diagnostic approach. For SMEs, ergonomic interventions such as optimizing table height (± 5 –10 cm adjustment), adding lumbar support, and applying short scheduled breaks every 60–90 minutes can significantly reduce musculoskeletal complaints without high investment.

4. Conclusion

This study evaluated the work posture of onion peelers using the NBM and RULA methods to identify musculoskeletal risk factors in small-scale food-processing activities. The results showed that the highest discomfort was reported in the lumbar region, shoulders, and neck, which aligns with the observed forward-bending sitting posture and repetitive upper-limb movements. The average RULA score of 6 indicates a moderate to high ergonomic risk, requiring prompt intervention to prevent musculoskeletal disorders.

The integration of subjective (NBM) and objective (RULA) assessments proved effective in validating risk areas and providing a comprehensive understanding of physical strain in manual peeling tasks. These findings highlight the importance of ergonomic improvements in small food-processing environments, particularly those involving repetitive hand-intensive tasks and unsupported sitting postures. Improving workstation height, providing back support, scheduling micro-breaks, and promoting proper body posture are essential low-cost interventions that can be applied in SMEs to reduce musculoskeletal strain and enhance productivity.

This study is limited by its small sample size and single-site observation, which may restrict generalizability. Future research should include larger samples across multiple food-processing sites and evaluate the effectiveness of ergonomic modifications through post-intervention measurements, complemented by biomechanical or wearable-sensor-based assessment tools.

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