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

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ABSTRACT
Automation is increasingly applied in food-processing industries to enhance production efficiency. However, in onion-processing operations, peeling machines often fail to completely remove the outer skin, requiring workers to perform manual re-peeling to ensure raw-material quality. This task involves repetitive hand motions and forward-leaning postures, which may contribute to musculoskeletal strain. This study aims to evaluate the work posture of manual onion re-peeling workers using the Nordic Body Map (NBM) and Rapid Upper Limb Assessment (RULA) methods. Four workers participated in the study through direct observation, photo documentation, and questionnaire administration. NBM results indicated that the most frequent complaints occurred in the the shoulders, upper arms, elbows, forearms, wrists, and lower back. The average RULA score of 6 indicates a high-risk posture requiring prompt ergonomic intervention. The strong alignment between NBM and RULA findings reinforces the accuracy of the ergonomic diagnosis. This study highlights the need for ergonomic improvements such as workstation height adjustment, provision of lumbar-supported seating, micro-break scheduling, and simple tool redesign to reduce MSD risks and improve productivity in food-processing operations.
Keywords: Food Processing Industry, MSDs, Onion Re-Peeling, RULA.

ABSTRAK
Otomatisasi semakin banyak diterapkan di industri pengolahan makanan untuk meningkatkan efisiensi produksi. Namun, dalam proses pengolahan bawang, mesin pengupas sering gagal menghilangkan seluruh kulit luar, sehingga pekerja perlu melakukan pengupasan ulang secara manual untuk memastikan kualitas bahan baku. Pekerjaan ini melibatkan gerakan tangan berulang dan postur tubuh condong ke depan, yang dapat menyebabkan ketegangan muskuloskeletal. Penelitian ini bertujuan untuk mengevaluasi postur kerja pekerja pengupasan ulang bawang secara manual menggunakan metode Nordic Body Map (NBM) dan Rapid Upper Limb Assessment (RULA). Sebanyak empat pekerja berpartisipasi dalam penelitian melalui observasi langsung, dokumentasi foto, dan pengisian kuesioner. Hasil NBM menunjukkan bahwa keluhan paling sering terjadi pada bahu, lengan atas, siku, lengan bawah, pergelangan tangan, dan punggung bawah. Rata-rata skor RULA sebesar 6 menunjukkan postur berisiko tinggi yang memerlukan intervensi ergonomi segera. Kesesuaian yang kuat antara temuan NBM dan RULA memperkuat akurasi diagnosis ergonomi. Penelitian ini menekankan perlunya perbaikan ergonomi, seperti penyesuaian tinggi meja kerja, penyediaan kursi dengan sandaran lumbar, penjadwalan istirahat mikro, dan desain ulang alat sederhana untuk mengurangi risiko MSD dan meningkatkan produktivitas di operasi pengolahan makanan.
Kata kunci: Industri Pemrosesan Makanan, MSDs, Pengupasan Ulang Bawang, RULA.

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], [3]. Ergonomics plays an essential role in minimizing these risks by optimizing workplace design and improving posture to reduce physical strain [4], [5].

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. 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. 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, reporting a high prevalence of awkward postures, repetitive hand use, and poor workstation design [6]. However, ergonomic risks arising from post-mechanical manual finishing in industrial snack-processing facilities where machines perform bulk peeling but operators must conduct manual correction due to machine limitations remain underexplored. This gap is significant because hybrid operations combining automation and manual tasks are increasingly common in food manufacturing. Process-engineering studies show that although mechanical peeling improves throughput and product consistency, variability in onion size, shape, and surface conditions frequently requires manual intervention, creating distinct ergonomic hazards that warrant focused [7], [8]. Additionally, current reviews on food-processing technologies emphasize that even advanced robotic or mechanical systems often still rely on human operators for precision finishing or quality correction, underscoring the need to evaluate ergonomic risks in these hybrid environments [9], [10].

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 [11]. The combined approach provides comprehensive insight into ergonomic risks and identifies body regions requiring intervention. 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. The study involved four onion-peeling workers (n = 4) who participated as respondents.

2.1. NBM Method

The Nordic Body Map (NBM) questionnaire was used to identify subjective musculoskeletal discomfort among the respondents. A total of four workers (n = 4) completed the questionnaire by marking body regions where discomfort was felt using a four-point scale: No Pain, Slight Pain, Painful, and Very Painful. The responses were summarized to determine the percentage of complaints for each body segment. The NBM method is widely applied in industrial ergonomics due to its simplicity and effectiveness in detecting early musculoskeletal symptoms [12], [13], [14].

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, considering static loads and movement repetitions [15], [16]. 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.

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. 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.

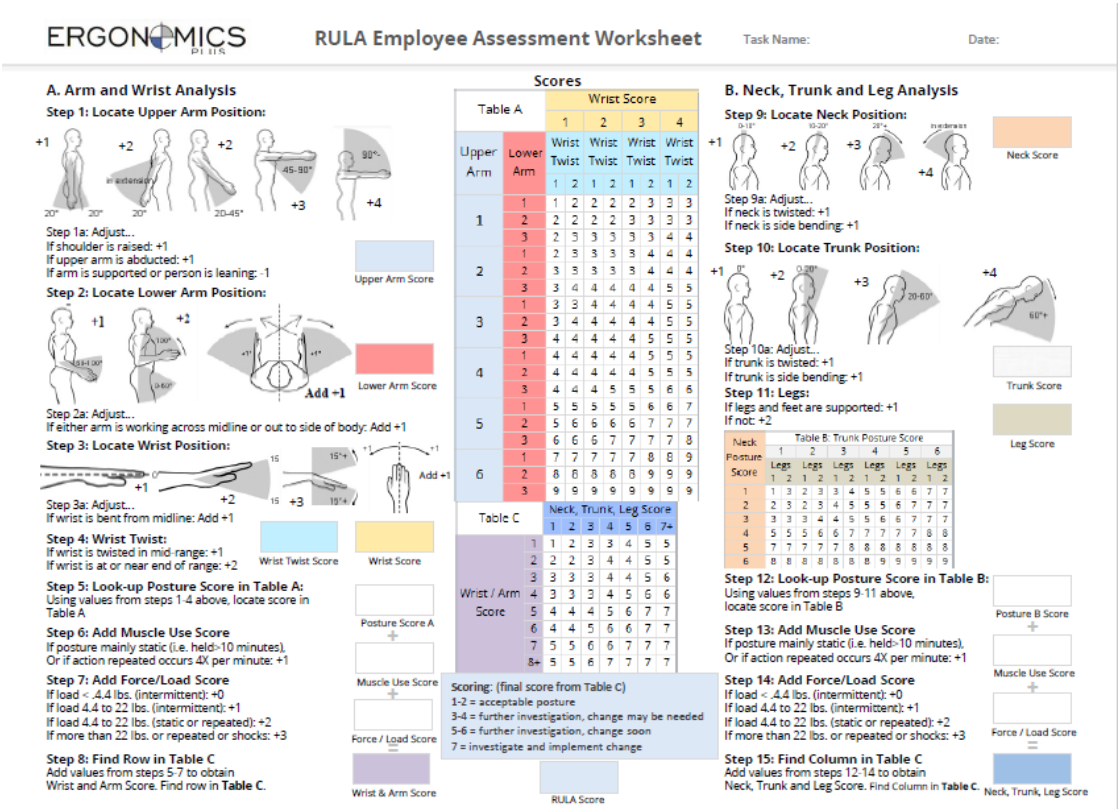

Figure 1. RULA Worksheet [17]

Table 1. Rula Score Classification Table [17]

RULA Score	Risk Level	Action Required
1–2	Low Risk	Acceptable posture. No action needed.
3–4	Medium Risk	Further investigation is needed.
5–6	High Risk	Investigation and changes should be implemented soon.
7	Very High Risk	Immediate investigation and corrective action required.

3. Result and Discussion

3.1. Nordic Body Map (NBM)

The observation of onion-peeling activities revealed considerable physical demands, particularly due to static postures and repetitive upper-limb movements performed throughout the task. These conditions were reflected in the musculoskeletal discomfort reported by workers through the Nordic Body Map (NBM) questionnaire, where several body regions showed noticeably higher levels of complaints. The distribution of these discomforts provides an initial indication of which body parts are subjected to the greatest strain and highlights potential ergonomic risks present in the workstation. To provide a clearer overview of the discomfort patterns experienced by workers, a summary table is presented below, outlining the affected body regions and the corresponding percentage of respondents reporting complaints.

Table 2. Recapitulation of Nordic Body Map (NBM) Responses

Body Region	Score Pattern	NP (%)	SP (%)	P (%)	VP (%)	Remarks
Upper Neck	1, 3, 3, 3	25	0	75	0	High discomfort
Shoulder (Left)	4, 3, 3, 3	0	0	75	25	Very high risk
Shoulder (Right)	4, 3, 3, 3	0	0	75	25	Very high risk
Upper Arm (Left)	4, 1, 4, 4	25	0	0	75	Dominant VP
Upper Arm (Right)	3, 3, 4, 4	0	0	50	50	Severe discomfort
Elbow (Left)	3, 3, 3, 3	0	0	100	0	Consistent pain
Elbow (Right)	3, 3, 3, 3	0	0	100	0	Consistent pain
Forearm (Left)	3, 3, 3, 3	0	0	100	0	Consistent pain
Forearm (Right)	3, 3, 3, 3	0	0	100	0	Consistent pain
Wrist (Left)	3, 4, 3, 3	0	0	75	25	High repetitive load
Wrist (Right)	3, 4, 3, 3	0	0	75	25	High repetitive load
Hand (Left)	3, 3, 2, 2	0	50	50	0	Moderate risk
Hand (Right)	3, 3, 2, 2	0	50	50	0	Moderate risk
Upper Back	3, 1, 3, 3	25	0	75	0	Postural load
Middle Back	3, 3, 3, 3	0	0	100	0	Static bending
**Lower Back / Waist	3, 4, 4, 4	0	0	25	75	Most severe pain
Hip / Buttock	3, 3, 3, 1	25	0	75	0	Sitting pressure
Thigh (Left)	2, 1, 2, 2	25	75	0	0	Minor discomfort
Thigh (Right)	2, 1, 2, 2	25	75	0	0	Minor discomfort
Knee (Left)	2, 1, 2, 2	25	75	0	0	Repetitive sitting
Knee (Right)	2, 1, 2, 2	25	75	0	0	Repetitive sitting
Calf (Left)	2, 1, 2, 2	25	75	0	0	Mild discomfort
Calf (Right)	2, 1, 2, 2	25	75	0	0	Mild discomfort
Ankle (Left)	1, 1, 1, 1	100	0	0	0	No discomfort
Ankle (Right)	1, 1, 1, 1	100	0	0	0	No discomfort
Foot (Left)	2, 1, 2, 2	25	75	0	0	Low risk
Foot (Right)	2, 1, 2, 2	25	75	0	0	Low risk

Scale:
1 = No Pain (NP), 2 = Slight Pain (SP), 3 = Painful (P), 4 = Very Painful (VP)
n = 4 workers

The results in Table 2 show that several upper-body regions experienced high levels of discomfort, particularly the shoulders, upper arms, elbows, forearms, wrists, and lower back, which were dominated by Painful (P) and Very Painful (VP) responses. Consistent pain was reported in both elbows and forearms, while the lower back showed the highest proportion of Very Painful (VP) ratings. In contrast, the lower limbs; including the thighs, knees, calves, ankles, and feet; generally displayed lower discomfort, with most responses falling within the No Pain (NP) or Slight Pain (SP) categories. These patterns reflect differing physical demands across body regions during the onion-peeling activity. To further illustrate the physical conditions that may contribute to the discomfort patterns identified in Table 2, Figure 2 presents an overview of the workers' typical working posture during the manual onion re-peeling task. This illustration provides a visual context of the body positions maintained during the activity, helping to clarify how certain postures may relate to the specific complaint areas reported by the workers.

Figure 2. Woking Position Illustration

As shown in Figure 2, the workers perform the peeling task in a seated position with a forward-leaning trunk and continuous upper-limb activity. The posture often requires the shoulders to remain slightly elevated and the arms to be positioned in front of the body for extended periods. In addition, the repetitive wrist and hand motions involved in handling and peeling the onions contribute to localized strain in the upper limbs. The illustration also indicates limited back support and minimal variation in working posture, which may lead to increased discomfort in the lower back and hip areas over time. These visual observations help explain the distribution of musculoskeletal complaints reported by workers in the NBM results.

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	+2
Lower arm	+2	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 resulted in an average RULA score of 6, which falls within the high-risk category, indicating that investigation and corrective actions are required soon. The objective posture scores obtained through RULA correspond closely with the subjective discomfort patterns identified through the NBM questionnaire. Regions such as the shoulders, upper arms, wrists, and lower back reported by workers as painful or very painful are the same areas that received elevated posture scores. This convergence between subjective and objective findings strengthens the validity of the ergonomic diagnosis in this study. This finding is in line with which statement that the integration of both methods improves the accuracy of field ergonomic diagnosis [11].

The results further indicate that food-peeling workers are exposed to notable static and repetitive loads. Continuous forward trunk inclination limited back support, and repetitive upper-limb motions (particularly gripping and twisting) contribute substantially to musculoskeletal strain. These findings align with previous studies on manual food-processing tasks, which commonly identify high complaint rates in the shoulder and lower-back regions during prolonged repetitive activities [18], [19]. The presence of repeated musculoskeletal symptoms not only affects worker well-being but also carries potential implications for productivity, absenteeism, and economic costs at both organizational and health-system levels [20], [21]. Consequently, ergonomic improvements that target both worker well-being and operational efficiency, such as workstation height adjustment, provision of ergonomic seating, job rotation, micro-breaks, and simple tool redesign; are supported by systematic reviews and guidance as effective measures to reduce ergonomic risk.

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 shoulders, upper arms, elbows, forearms, wrists, and lower back, 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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