Ergonomic Intervention Studies and Analysis of Postures in Jawar *Roti* Making units in North Karnataka

Pooja Aloorkar
Student, Department of Industrial & Production Engineering, P.D.A.College of Engineering, Kalaburagi, India
poojaaloorkar01174@gmail.com

Qutubuddin S.M.
Associate Professor, Department of Industrial & Production Engineering, P.D.A.College of Engineering, Kalaburagi, India
syedqutub16@gmail.com

Someshwari Agre, Smita Shabadi and Rudreshwar Hiremath
Students, Department of Industrial & Production Engineering, P.D.A.College of Engineering, Kalaburagi, India
someshwariagare@gmail.com, smitasmita1919@gmail.com, rudreshwarhiremath@gmail.com

Abstract

Ergonomics is the study of the work people do, the environment and the tools they use to perform the work. *Jowar roti* or *Jowar rotti* is a flat and thin bread made from *jowar* (sorghum flour), very common in North Karnataka. The dough is prepared by mixing the hot water with *jowar* flour, and then the roti/rotti is spread on a stone by tapping using the palm. The present work focuses on identification of ergonomic deficiencies in the *Jowar Roti* (Sorghum flat bread) making units and associated problems of musculoskeletal disorders (MSDs), workstation design, postural issues and safety and health issues. *Roti* making is the most laborious and stressful process. Incorrect postures sustained (sitting on floor) for a long period of time while performing *roti* making activities gives rise to musculoskeletal problems. The study consists of selecting 30 workers randomly from 6 different units as working group and 30 women participated in the study as control group. Self reported Body Part Discomfort questionnaire was administered and the hand grip strength was measured before and after work. Rapid Upper Limb Assessment (RULA) was done on selected awkward postures from different activities. RULA results indicated (46.66%) postures in high risk and (33.34%) in medium risk. Statistical tests ANOVA between grip strength of two groups showed significant difference (F value - 94.52683, $p < 0.01$). CATIA V5 software was used for RULA analysis which indicated high risks (scores of 6 or 7). The workstation is redesigned and a standing workstation is modelled in CATIA V5 and RULA analysis for changed workstation indicated low to medium risks (scores of 3 or 4). The findings of the study highlights several environment and safety concerns for which suitable suggestions and recommendations are made to overcome the ergonomic and Occupational Health and Safety issues.

Key Words: *Jowar roti,* Ergonomics, MSDs, RULA, CATIA

Introduction

Ergonomics is defined as the discipline of designing the job to fit the worker, rather than fitting the worker to the job. The physical stress on the workers can be reduced by adapting the job, workstation, equipment and tools which fit the worker, thus eliminating several work related musculoskeletal disorders (MSDs). In the present situation, the significance of ergonomics is focussed on improving productivity, health, safety and comfort issues in micro, small and medium industries. The micro and small scale industries in the informal sector employ a large number of workers for various jobs/tasks. These industries are surrounded by issues like productivity improvement, worker health and safety, and quality of products. Some more issues are workstation design, layout, job structure, poor work environment, and mismatch between job requirements and worker's capabilities. All these issues may lead to worker's health and safety, accidents, development of musculoskeletal disorder and reduces the output. Also these units are characterized by intense labour, irregular work schedule, lack of any safety or welfare benefits and pay system. Therefore it is necessary to mitigate the onset of MSDs and other issues by implementing ergonomic interventions in various work activities.

Jowar roti or *Jowar rotti* is a flat and thin bread made from *jowar* (sorghum flour), very common in North Karnataka and parts of Maharashtra State. The roti making units not only makes *jowar* roti (sorghum), but also makes *chapatti* (wheat bread), *sajji roti* (pearl millet), *dhapati* (made from mixed flour) and *holige* (Indian sweet flat bread with fillings). *Jowar roti* or *jolada rotti*, is a high fiber, gluten free and rich in vitamins, minerals and nutrients. It is oil free and made with only three ingredients flour, water and salt. Jowar cannot be rolled as wheat flour dough; it has to be flattened by rapid patting with both the palms on a stone. The quality of roti depends on the skill of the worker and consistency of dough. To make it the traditional way a lot of skill and experience is needed. With practice one can beat the flour into thin circles of about 20-25 cm. Normally two types of *roti* are made, the usual soft one and the KADAK (hard and crispy). It has a long shelf life of about 3 months and can be eaten over a time.

1.1. *Roti* making units

In the recent years several *roti* making units have mushroomed in North Karnataka due to the demand of the *roti's*. These units are named as *xyz* roti kendra. Majority of the workers are women except a few men needed for distribution and other works. A typical small unit has 10-15 workers on average for making different products, and some units employ even more workers. These units are labour intensive and the output of each unit ranges anything between 2500-5000 *roti's* per day depending on the demand and workers availability. These small scale units cater to the demands of the customer's, hotels, canteens, marriage functions and are also exported to cities and even abroad. *Roti* making is the most laborious and stressful process. Incorrect postures sustained (sitting on floor) for a long period of time while performing *roti* making activities gives rise to musculoskeletal problems. Each worker prepares around 200-250 *roti's* per day.

Thirty workers from six units were randomly selected for the study. The workers are mainly illiterate and work about 7-8 hours per day, sometimes even more during festive and marriage season. The *roti* making process consists of the following steps;
Kneading process (sieving the flour, mixing flour with hot water and kneading dough), Making *roti* (patting with palms on stone), and Baking *roti* (putting roti on pan, applying water with a cloth, turning to bake on other side and removing from pan) Figure 1.

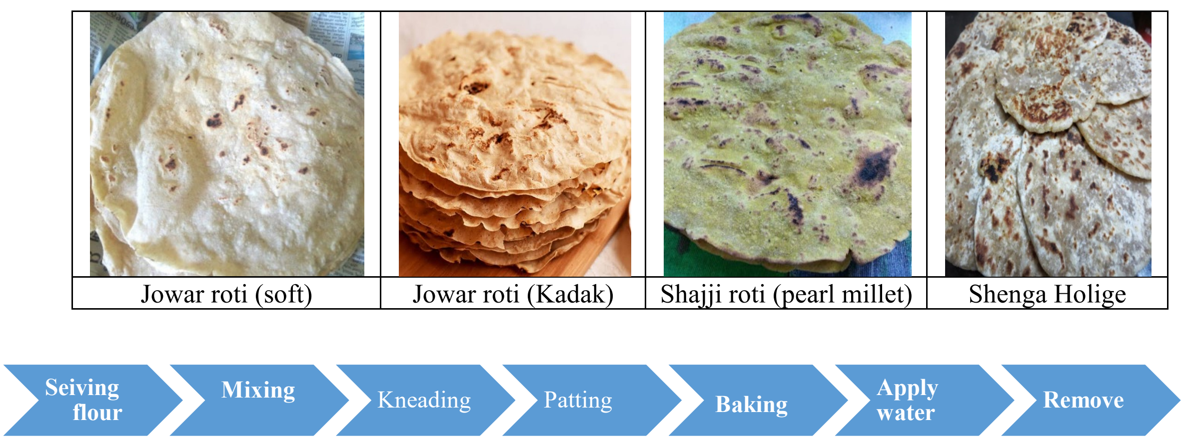


Figure 1. Different types of *Roti's* and *Roti* making process

1.2 Objectives

- To understand the working procedure of workers working in *roti* making & investigate the problems faced by them during work.
- To measure the hand grip strength and its relationship to discomfort.

- To investigate the risk of MSDs by RULA analysis.
- To analyse the present workstation and layout using CATIA software and give recommendations.

2.0 Literature Review

The work in a typical kitchen is difficult from an ergonomics perspective and many ergonomic deficiencies can be found which needs to be addressed. Most of the literature points to various ergonomic deficiencies in the commercial kitchens.
Commercial kitchens are known for difficult work environment where the workers are subjected to extreme work environments and a reason of many work related hazards, injuries and health issues (Pooja et.al. 2020). Most of the discomfort is due to exposure to harsh heat conditions, exertion of body parts and muscular strain, long duration of work in standing postures, pushing, pulling of objects, awkward postures and repetitive movements increase the discomfort (Bindu & Reddy 2016). Prolonged working in small area, restricted space, heat, time constraints and work pressure increase the discomfort of workers and results in injuries to muscles, nerves, tendons and ligaments commonly known as musculoskeletal disorders (Bhatt and Sindhu 2012). Shwetanshu et.al 2018 carried out a study on heat burns injuries in household kitchens due to use of firewood or coal which was unsafe and recommended the use of LPG as a safe and easy means for cooking. Bindu and Reddy (2016) in their study on occupational hazards in commercial kitchens reported prevalence of work related health issues and unsafe work conditions. Beheshti et.al (2018) carried out a study on prevalence of MSD in kitchen workers using RULA technique. Mrunalini & Deepika (2013) conducted a study on Grip Strength of Students and its relation to body postures. Ali et.al. (2018) in their study on MSD of workers in food production using RULA analysis and found a majority of postures have high risk.
Many more research is available on kitchen workers, restaurant workers, community workers and canteen workers etc. but very few literatures is available on *roti* making units. Hence the present study is taken up as a project work on *roti* making units.

3.0 Methods

The cross-sectional study was conducted on workers in *roti* making units. The participants with at least one year work experience were selected. The participants were informed about the purpose of study before taking part. The methodology adapted for study and data collection was; demographic questionnaire, body part discomfort questionnaire, calculation of body mass index, measurement of hand grip and pinch force, Rapid Upper Limb Assessment (RULA), Measurement of Anthropometric data, Using CATIA software for RULA analysis and modelling, and Design of a workstation in CATIA.

3.1 Data Collection Tools

The data were collected using the following tools:
Demographic questionnaire: The questionnaire had questions about age, height, weight, experience, working hours per day.
Body Part discomfort questionnaire: The body part questionnaire was used to record the MSD symptoms in different body parts of the study population. Similar questionnaire was used by (Pooja et.al. 2021) in a study on community kitchen workers. Sahu et.al. (2013) used the body part discomfort questionnaire for Evaluation of the musculoskeletal problems related to Occupational health of sweet makers of West Bengal.
Body Mass Index: Body Mass Index was calculated to determine the obesity levels among the working group. Body mass index (BMI) is a good indicator of an individual's body fitness and gives an impression about the risk of developing MSDs (Mukherjee et.al 2020)
Measurement of Hand Grip and Pinch Force: Hand Grip Strength and Pinch force were measure Baseline dynamometers. Hand grip strength is generally recommended as a measure for determining musculoskeletal function. It gives a measure of isometric strength and overall muscular strength of the upper limb (Mukherjee et.al 2020, Mrunalini & Deepika 2015)
Rapid Upper Limb Assessment (RULA) technique: RULA is one of the most popular and simple technique to evaluate working posture of workers to analyze the incorrect working postures leading to MSDs. RULA analyzes postures related to upper part of body, i.e.neck, upper limbs, shoulder and trunk. The examiner rates the static posture of worker or a picture, based on upper body joint angles. The joint angle is associated with a score in RULA scoring sheet according to a predefined range of angles. From these joint scores, a final grand score is obtained and recommendations made. (Manzoor et.al. 2019, Beheshti et.al.2018, Sahu et.al. 2013)

Anthropometric data: For designing the workstation for *roti* makers, it was necessary to collect information on anthropometric dimensions of the subjects. Some of the dimensions measured were Sitting Height, Squatting Height, Hip Breadth, Arm reach, Stature, Elbow height, Palm length, palm breadth etc. were measured. Measurements were made using Baseline anthropometry callipers and Holtain anthropometer. (Qutubuddin et.al.2012)
Computer-Aided Three-dimensional Interactive Application (CATIA): To design the existing work station for RULA analysis, CATIA software was used. Human manikin is built in the software based on anthropometry measurements and risks involved in postures are obtained by RULA analysis (Manzoor et.al.2019, Varsha et.al.2018, Kumari 2013)
Design of a improved workstation: The recommended workstation is again designed in CATIA software and RULA analysis is carried out. The final scores of RULA analysis on both the existing workstation and recommended workstation are compared to highlight the decrease in postural risks. (Ali et.al 2018, Manzoor et.al.2019, Varsha et.al.2018, Kumari 2013)

4.0 Results and Discussion

4.1 Demographic Characteristics

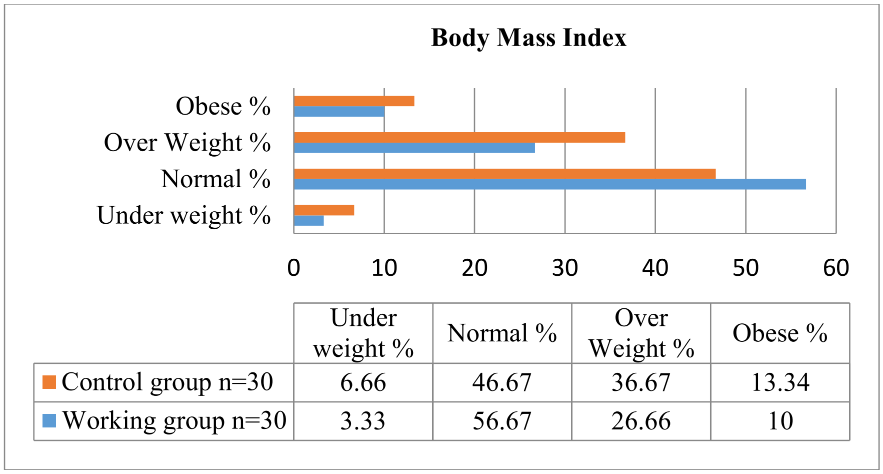
Table 1. Demographic Characteristics of Control Group and Working Group

Parameter	Control Group	Working Group
Age (yr)	32.27 ± 10.28	36.8 ± 7.07
Height (cm)	153.93 ± 4.26	153.00 ± 3.95
Weight (kg)	55.70 ± 8.25	55.10 ± 4.91
BMI (kg/m^2)	24.24 ± 3.16	23.39 ± 3.47
Experience (yr)	-	8.90 ± 4.30
Grip Strength (kg)	17.56 ± 2.83	17.20 ± 1.88
Working hours	1-2	7-9

In the present study, the sample consisted of all female workers, both in working group (mean age 36.8 ± 7.07 year) and control group (mean age 32.27 ± 10.28). Control group women are housewives and they also are familiar with *roti* making process and spend about 1-2 hours daily in *roti* making activities. The mean height and weight of both the groups is highlighted in Table 1. The Body Mass Index was calculated for control group (mean BMI 24.24 ± 3.16 kg/m^2) and working group (mean BMI 23.39 ± 3.47 kg/m^2). The average experience of working group is 8.90 ± 4.30 year. The working hours per day and the hand grip strength of both the groups is given in Table 1.

4.2 Body Mass Index (BMI)

Body mass index (BMI) is a good indicator of an individual's body fitness and gives an impression about the risk of developing MSDs. Several studies are reported in literature ((Mukherjee et.al 2020, Pooja et.al.2021). From Figure 2, it is observed that in the control group, 46.67% women have normal BMI and 36.67% women are overweight. The obesity percentage in control group is 13.34%. Similarly in the working group the working women with normal BMI are 56.67% and 26.66% workers are overweight. In working group the obesity is only 10%. The working women are subjected to physical stress and works in awkward postures for 6-8 hours a day. Hence the percentage of women having overweight or obesity is less than the control group women. Even though the BMI levels are near normal for a majority of women (56.67%) in working group, still the reported discomfort/pain in body parts is higher than the control group. This may be due to the working conditions, workstation design and unnatural postures adapted for long hours.



	Under weight %	Normal %	Over Weight %	Obese %
Control group n=30	6.66	46.67	36.67	13.34
Working group n=30	3.33	56.67	26.66	10

Figure 2. Body Mass Index of Working group and Control Group

4.3 Body Part Discomfort Questionnaire

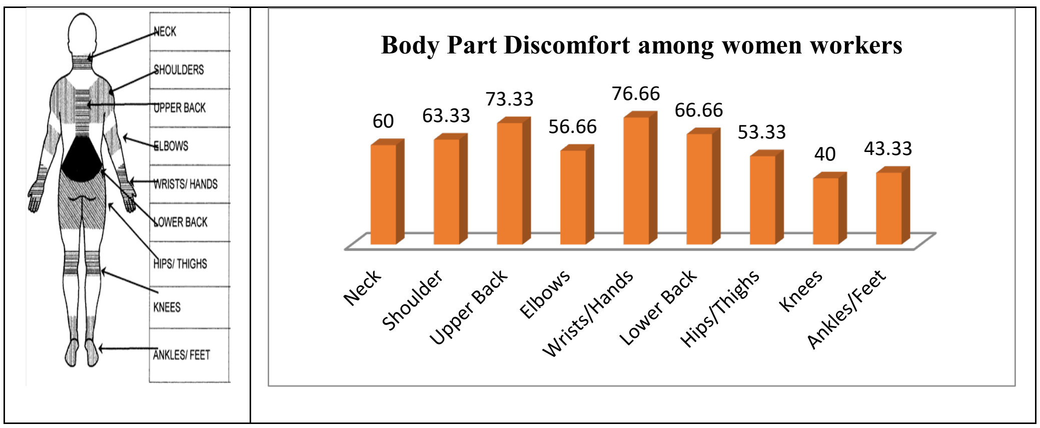


Figure 3. Musculoskeletal disorder symptoms reported in different body segments as reported by working group

As seen from responses for the Body Part Discomfort Questionnaire in Figure 3, the working women reported a maximum pain in wrists/hands (76%) and upper back (73%). Major contributor of the pain is the awkward posture of women sitting on the floor and the use of both the hands, wrists and palms while patting the *roti's.* Pain in shoulder is reported to be (63%), lower back (66%), neck (60%) and Elbows (56%). Continuously working in the awkward postures like bending, twisting, stretching and working with pain and discomfort may lead to development of musculoskeletal disorders. To reduce the risk factors and prevalence of MSDs, ergonomic interventions are necessary, such as redesign of workstation. In the literature similar results of discomfort are reported in (Manzoor et.al.2019, Shakya et.al.2018, Roopa 2014)

4.4 Measurement of Hand Grip Strength and Pinch Force

Hand grip strength (HGS) and pinch strength are widely considered as an objective index of functionality of upper extremity (Mrunallini & Deepika 2015). Hand function is most vital in various daily activities involving upper limb such as holding objects, carry out domestic work etc. The HGS is widely accepted as an indicaor of muscular strength and functionality. In the present study, HGS and pinch strength measure was to evaluate the fitness among the working women. The Baseline hand‑grip dynamometer and pinch strength dynamometer was used to measure the grip strength of the hands os working group before starting the work of roti making and aftwer working for 6 hours. The grip strength of control group was also measured.

Each subject holds the dynamometer in the hand to be tested, with the elbow by the side of the body and the arm at right angles. When ready, the participant squeezes the dynamometer with maximum isometric effort and the readings are noted. The results of measurements of HGS and pinch strength are given in Table 2.

Table 2. Grip Strength measurements and hand dimensions

Parameter	Working Group		Control Group
	Before work	After work	
Grip Strength *Roti* making (kg)	17.20 ± 1.88	14.95 ± 2.44	17.56 ± 2.83
Pinch Strength (kg)	5.95 ± 1.01	5.27 ± 1.14	6.78 ± 1.29
Hand Length (cm)	17.93 ± 0.61		18.07 ± 0.29
Hand Breadth (cm)	8.24 ± 0.68		8.31 ± 0.59

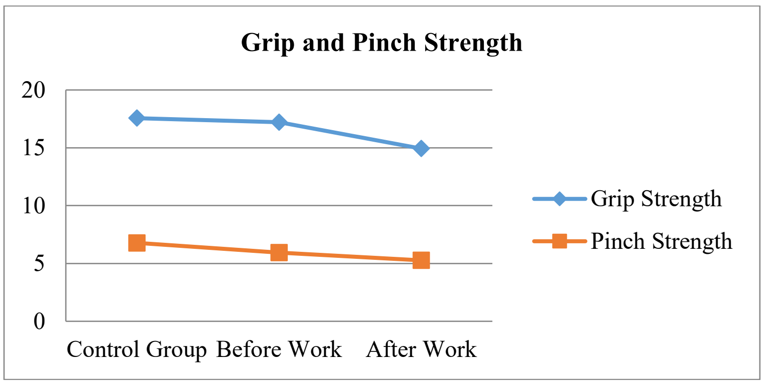


Figure 4. Comparison of Grip and Pinch Strength between groups

Table 3. ANOVA results for Grip strength between working group before and after work.

Source	SS	*df*	*MS*	*F* value
Between Groups	86.9288	1	86.9288	*F*=94.52683
Within Groups	507.1626	58	8.7442	
Error	26.669	29	0.9196	
The *F*-ratio is 94.52683. The *p*-value is < .00001. The result is significant at *p* < 0.01				

Statistically significant results were observed when comparisons were made using ANOVA, between the working group before work and after work. The F-ratio being 94.52683 and *p-value* < 0.00001. The result is significant at p<0.01 (Table 3).

4.5 Anthropometric data

As the work involves the use of hands and palms for patting the roti's, the hand anthropometry dimensions were measured. The hand anthropometry like hand span and breadth is significant dimension to determine the completion time of a roti, as the area covered during patting is related to hand dimensions. For designing the workstation for *roti* makers, it was necessary to collect information on anthropometric dimensions of the subjects. Some of the dimensions measured were Sitting Height, Squatting Height, Hip Breadth, Arm reach, Stature, Elbow height, Palm length, palm breadth etc. were measured. Measurements were made using Baseline anthropometry calipers and Holtain anthropometer. Figure 5 shows the hand dimensions like hand length, hand breadth and hand span were measured. As the work of *roti* making involves the use of hands and palms, the measurement is significant. The dimensions of hand are also a significant contributor to grip strength (Mrunalini & Deepika 2015).

Hand length	Hand breadth	Hand Span

Figure 5. Anthropometry measurements of hand

4.6 Rapid Upper Limb Assessment (RULA)

RULA-Rapid Upper Limb Assessment (Manzoor et.al.2019, Ali et.al.2018) is a survey method developed for ergonomic risk assessments of upper limbs, where musculoskeletal disorders are prevailing. It is a simple pen and paper tool to assess postural loads on the upper limbs of body. It also assesses posture, movement and force associated with tasks. RULA uses a coding system to generate an action list indicating the level of risks and ergonomic intervention required. Table 4 shows the RULA assessment results of working group.

Table 4. Evaluation of overall MSD risk by RULA (n=30)

RULA Score	MSDs Risk Level	Worker Posture (%)
1-2	Negligible	-
3-4	Lower risk	6 (20)
5-6	Medium eisk	10 (33.34)
7	High risk	14 (46.66)
Average (SD)		5.70 (1.46)

The working group postures were captured using a camera. Postures of work such as kneading, mixing, patting *roti's*, applying water and baking were analysed using the RULA assessment tool. The average value of RULA score is 5.70 (SD 1.46). About 46.66% were categorized as high risk requiring immediate change and 33.34% postures were analysed as having medium risk. Only 20% of the total postures had low risk. As the work of *roti* making involves awkward postures with high risk, ergonomic intervention are necessary. Similar results were obtained by Manzoor et.al. 2019 in stone polishing industries and Ali et.al.2018 in food production activity.

A comparative analysis of RULA scores of different activities like mixing, kneading, patting, apply water, turn and remove among different groups are shown in Figure 6. The maximum average score of 6.8 for apply water activity in the working group. The upper arm is stretched far away from body and abducted. The lowest score of RULA for working group is 5, for the mixing of flour activity. For the control group, the maximum RULA score obtained if for patting *roti* activity and removing *roti* from the pan. The control group women work in the comfort of their homes and work for just 1-2 hours a day. Ergonomic intervention is necessary to improve the postures and reduce the risk of MSDs. Hence a new design of workstation is recommended and is modelled in CATIA software.

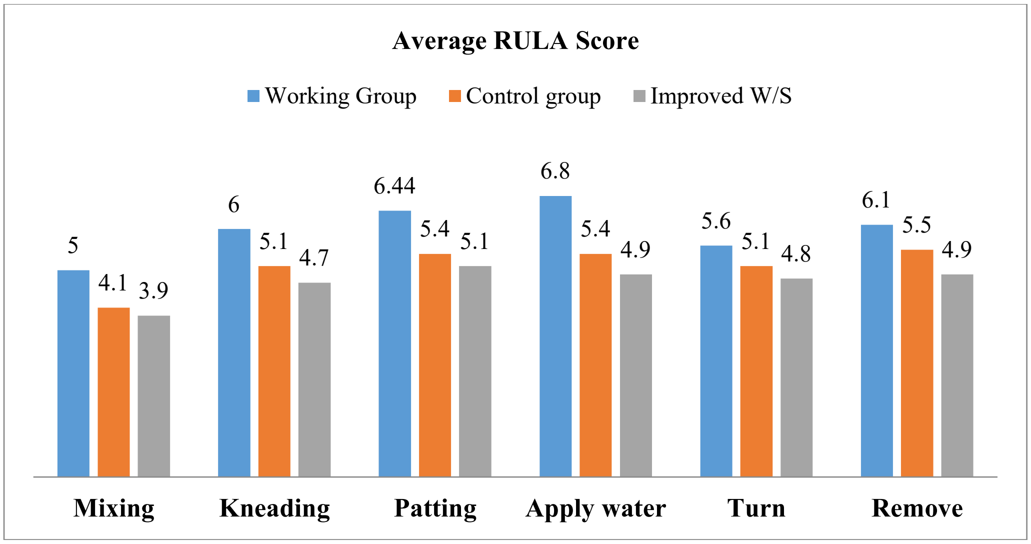


Figure 6. Comparison of average RULA scores for different activities among groups

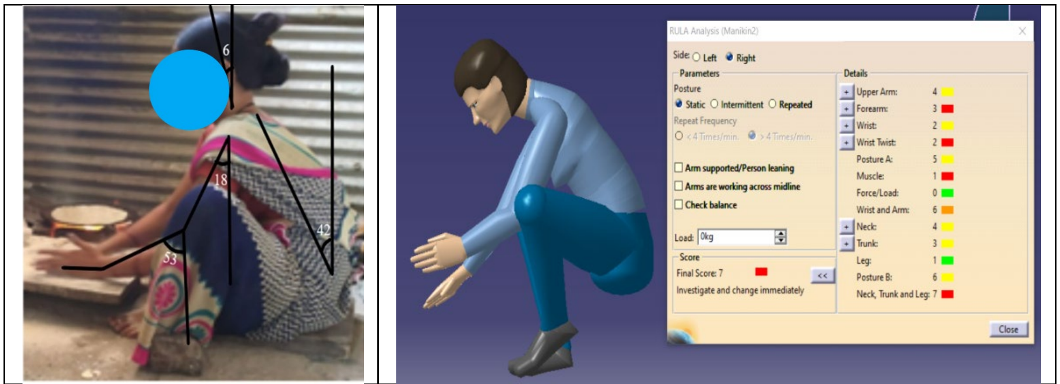
Table 5. ANOVA results for mean RULA scores of Working group, Control group and Recommended Workstation for working group.

Source	SS	*df*	*MS*	*F* value
Between Groups	5.1208	2	2.5604	*F*=9.07665
Within Groups	4.2313	15	0..2821	
Total	9.3522	17		
The *F*-ratio is 9.07665. The *p*-value is .002611. The result is significant at *p* < 0.01				

Statistically significant results were observed for RULA scores, when comparisons were made using ANOVA, between the working group before work and after work and control group. The F-ratio being 9.07665 and p-*value* < 0.002611. The result is significant at p<0.01 (Table 5).

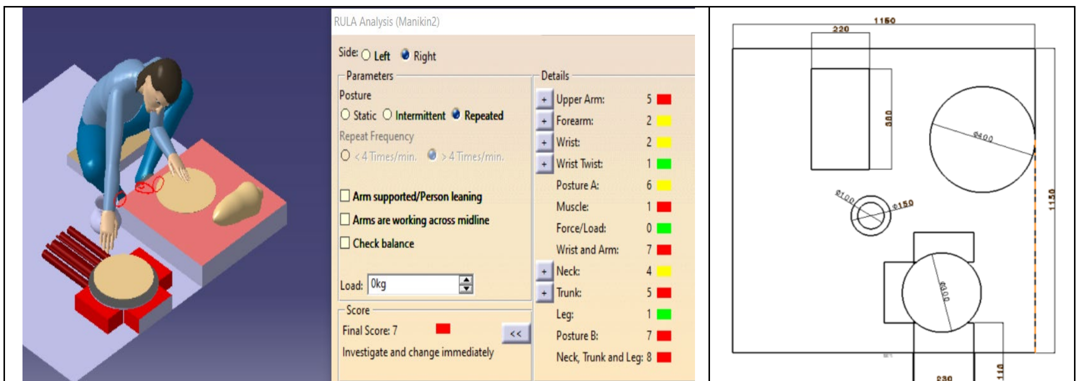
4.7 Computer-Aided Three-dimensional Interactive Application (CATIA)

In the present work RULA analysis of some postures covering different activities is done using CATIA software. The actual photos of postures are taken and converted into a 3-D model in CATIA. Anthropometry dimensions are considered for building a real like human manikin in sitting or standing postures (Manzoor et.al. 2019). In CATIA the virtual environment and workstation details are developed. The anthropometric dimensions selected for building human manikin were 50th percentile of Indian population data. Digital Human Modeling in CATIA integrates dynamic simulation and ergonomics assessments, thus enabling the designer to visualize the workplace and improve in digital/virtual environment. Figure 7 (a) shows the actual working posture of patting *roti* by a worker. The posture is marked with body angles deviating from the neutral axis and measured using a goniometer. From the RULA assessment sheet, the scoring for different body parts is done. The same posture is built and simulated in CATIA software 7(b), and the RULA analysis done in CATIA. The posture gives a RULA score of '7' indicating high risk and needs to be corrected immediately, as also given by the manual assessment using RULA scoring sheet.
In Figure 8 (a), the complete workstation along with the human manikin is simulated for 'applying water activity' and RULA analysis carried out. The RULA score is '7' indicating high risk and requires immediate attention. The complete drawing of layout is shown in 8 (b).



a **b**

Figure 7.Actual working posture (a) patting *roti,* (b) CATIA model and RULA score sheet

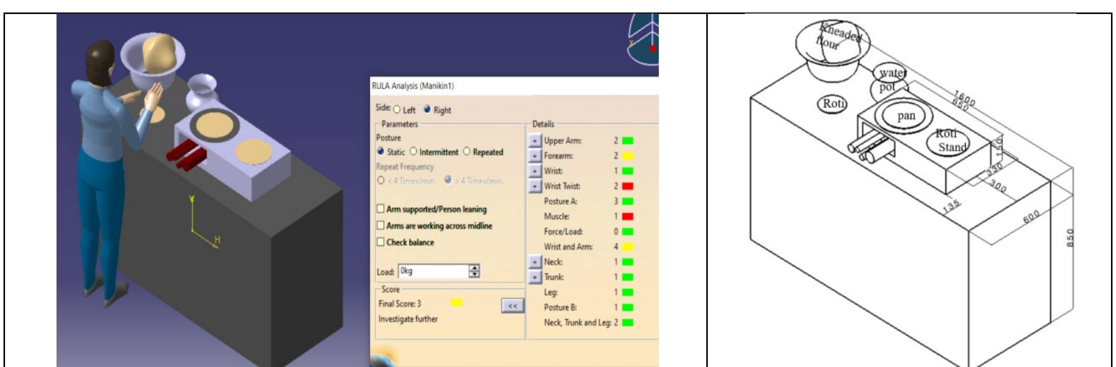


a b

Figure 8. (a) Actual working posture and layout shown in CATIA with RULA analysis (b) Layout

4.8 Recommended Design of Workstation

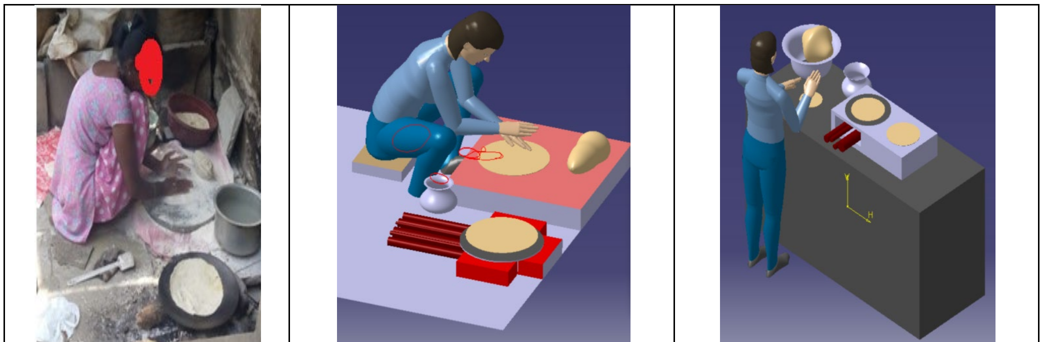
As seen from the results of observation, it is clearly shown that the workers mostly work in extreme awkward postures continuously sitting on the floor. The awkward postures of the back, elbow, wrists and elbows are near extreme range of motion, leading to development of MSDs.



a b

Figure 9. (a) Recommended design of Workstation for *Roti* Making Process and RULA analysis in CATIA, (b) layout of workstation

Moreover, the repetitive activities in awkward postures also contribute to stress on joints and muscles leading to fatigue (Faridah et.al 2020, Ali et. al. 2018). To reduce the risks of MSDs and discomfort, a new work station is simulated and modelled in CATIA. Based on the anthropometry dimensions for 50th percentile, the new design is made. The height of the platform is taken as 85 cm (Varsha et.al.2018, Qutubuddin et.al.2012, Manzoor et.al.2019). Figure 9 (a) shows the recommended workstation designed using Digital Human Modeling in CATIA, and 9(b) shows the drawings and specifications. To an extent the awkward postures are reduced, which in turn reduces the risk of MSDs. RULA analysis of redesigned workstation for activities such as kneading, patting, and baking *roti's* indicated a maximum score of '4' suggesting medium risk. Figure 10 shows the actual posture of pating roti, CATIA model of existing workstation and recommended workstation modelled in CATIA.



(a) Actual work station	(b) CATIA model of workstation	(c) Recommended work station

Figure 10. Actual workstation (a), CATIA model of actual workstation (b)
and Recommended workstation Designed in CATIA (c)

5.0 Conclusion

The *roti* making units are a source of employment to a large number of women, therefore it becomes necessary to provide a safe work environment and ergonomically designed work place. The study was carried out at selected few roti making units. The workers reported through self administered body part discomfort questionnaire. The maximum pain was experienced in hands/wrists (76%) and upper back (73%), due to continuous repetitive work and awkward postures.

Body mass index (BMI) was calculated for working group and control group. In the working group, due to repetitive work a majority of women (56%) have normal BMI and only 10% workers were obese. The hand grip strength was measured for the working group before and after work. The grip strength reduced considerably due to repetitive work of hands and wrists. Statistical analysis by ANOVA between working and control groups indicated F-ratio being 94.52683 and *p-value* < 0.00001, significant at $p<0.01$. RULA analysis of working postures of working group showed about 46% of postures fall in high risk category, signalling immediate change in postures. The actual postures were built in CATIA software and RULA analysis was done. The results were similar to manual RULA analysis. The work station was redesigned in CATIA to suggest improvements. The new station was simulated and RULA analysis was done. The maximum RULA score obtained was '4', indicating medium risk. Statistical analysis ANOVA was done on RULA scores across different groups. The results are significant at $p<0.01$ and F-ratio=9.07665. Overall the ergonomic intervention study in roti making units points to various ergonomic deficiencies, poor layout, work environment and work practices.

Recommendations

- Job rotation to remove the risks of fatigue
- Job design to incorporate good ergonomic practices and provide relief from repetitive motions, awkward postures etc.
- Provide possible safety solutions wherever possible, near the stoves/fire wood, spacing between work stations, safety against burns etc.
- Basic first aid should be available always.
- Work stations designed ergonomically to accommodate variability in workers, based on anthropometric data. (5th to 95th percentile)

- Good ventilation, lighting and thermal comfort.
- Encourage the use of personnel protective equipments.
- Preferably fire wood to be replaced by gas stoves.

Roti making units represent a labour intensive industry. The women face many problems due to awkward postures, poor infrastructure and working conditions. Still local women prefer working due to economic conditions. Usually, the pains and discomfort is ignored due to fear of being jobless. The women workers lack awareness and education, and sometimes indifferent attitude of employers adds up to their woes. It is suggested to carry further research in biomechanical analysis of forces on wrists and hands, ergonomic assessment of work environment and physical workload of women.

References

Pooja Aloorkar, Qutubuddin S.M, Pooja Rangdal, Saikiran Patil, Devsudhakar Patil- Ergonomic Evaluation Of Community Kitchen For Midday Meal Scheme-A Case Study, *Proceedings of International Conference on Humanizing Work and Work Environment (HWWE2020)*, 2020

E. Shirin Hima Bindu, Mahalaxmi V Reddy – Occupational Hazards among Cooks in Commercial Kitchens, *International Journal of Science and Research*, Vol.5(6) June (2016)

Hema Bhatt and M. Sidhu – An Epidemiological Study to Assess Fatigue Patterns at Kitchen Workstation. *J Hum Ecol, 39(1): 19-25 (2012)*

Jaita Mandal – A Review on Mechanical & Physical Hazards at Domestic Kitchen. *International Journal of Safety and Health* vol.2 (1), (2012).

A Murunalini, J Deepika – Grip Strength among College Youth and its Relation to Body Postures, *International Journal of Science and Research.* Vol. 4(3) March (2015),

Kumari A – An Ergonomic Approach for Modifying the Workstation Design of Food Processing Enterprises. *Journal of Ergonomics* Vol. 8 (2018).

Faridah Hanim Ismail, Suriati Osman, Faradewi Bee A. Rahman – Ergonomics Kitchen: A Better Place to Work. *International Journal of Academic Research in Business and Social Sciences Vol*. (11), Nov (2020)

Lakshmi Karthik, Roopa Rao – Ergonomic assessment of musculoskeletal discomfort among chefs in commercial kitchens, *International Journal For Innovative Research In Multidisciplinary Field ISSN.* Vol 6(5), May (2020).

Beheshti MH, Tajpuor A, Jari A, Samadi S, Borhani Jebeli M, Rahmanzadeh H – Evaluation of Ergonomic Risk Factors for Musculoskeletal Disorders among Kitchen Workers. *Archives of Occupational Health,* Vol (2), April (2018).

Shakya N, Shrestha S – Prevalence of work related musculoskeletal disorders among canteen staff of Kathmandu University , *Journal of Kathmandu Medical College*, Vol. (7), Oct (2018).

M. Suhas, P. Prajapathi, D.A. Jolhe**,** R.R. Lakhe – A Study of Indian kitchen from Ergonomic Consideration**,** *Industrial Engineering Journal,* Vol. (12) , Feb(2019).

Roopa Rao – Prevalence of Musculoskeletal Discomfort among Women working in Khakhra Making Units, *Online International Interdisciplinary Research Journal,* Vol (4), Jan – Feb (2014).

Subhashis Sahu, Subhabrata Moitra and Santi Gopal Maity – Evaluation of the musculoskeletal problems related to Occupational health of sweet makers of West Bengal**,** *US National Library of Medicine enlisted journal,* Vol. 6(2), (2013).

S. A. Syed Ali, S. R. Kamat and S. B. Mohamed – Analysis Awkward Posture at Food Production Activity Using Rula Assessment, Journal *of Fundamental and Applied Sciences ISSN,* Vol, (10) Jan (2018).

Varsha Karandikar, Shriram Sane, Shraddha Chinchkar and Anand Joshi – Ergonomic Workstation Design and Methods Improvement in a Food Processing Industry , International Journal of Advance Industrial Engineering E-ISSN, Vol. (4)1, March (2016).

U.V. Kiran, Nalini, and Anjali Mathur – Ergonomics Analysis of Roti Making *International journal of Family and Home Science* Vol. 7(1), Jan-June (2011).

Mukherjee P, Roy AS, Bandyopadhyay A, Gangopadhyay S. A detailed study on morphological profile, hand grip strength, flexibility, and working postures in housemaids of Kolkata. BLDE Univ J Health Sci 5:200-8. 2020.

Qutubuddin S.M., Hebbal S.S., Kumar A.C.S.- Significance Of Anthropometric Data for the Manufacturing Organizations, *International J. of Engg. Research & Indu. Appls. (IJERIA). 5 (1), 111-126*, 2012.

M.Manzoor Hussain, Qutubuddin S M, Katuru Phani Raja Kumar, Ch Kesava Reddy- Digital Human Modeling in Ergonomic Risk Assessment of Working Postures using RULA, *Proceedings of the International Conference on Industrial Engineering and Operations Management Bangkok, Thailand, March 5-7, 2019*

M. Manzoor Hussain, Katuru Phani Raja Kumar, Qutubuddin S.M., Hebbal S.S.- Occupational Health and Safety Issues among Workers in Stone Industries in North Karnataka, *Proceedings of the International Conference on Industrial Engineering and Operations Management Bangkok, Thailand, March 5-7, 2019*

Bibliographies

			
Pooja Aloorkar	**Someshwari Agre**	**Smita Shabadi**	**Rudreshwar Hiremath**

Pooja Aloorkar, Someshwari Agre, Smita Shabadi and Rudreshwar Hiremath are students in Industrial & Production Engineering Department, P.D.A.College of Engineering, Kalaburagi. Apart from academics they are a part of the research group in Human Factors and Ergonomics Laboratory. They are also actively involved in organizing various events and local industrial visits under IEOM student chapter, and have competed in Best Student Chapter competition at 11th Annual IEOM International Conference at Singapore. 7-11 March 2021. Pooja Aloorkar has presented a paper at 18th International Conference on Humanizing Work and Work Environment (HWWE2020) 10th -12th Dec 2020. She has also presented a paper in First Central American and Caribbean International Conference on Industrial Engineering and Operations Management, Port-au-Prince, Haiti, June 15-16, 2021.

Dr.Qutubuddin S.M. presently working as Associate Professor, Industrial and Production Engineering Department, P.D.A.College of Engineering, Kalaburagi. He has more than 29 years experience in teaching and research and has published more than 35 papers in International and National journals and Conferences. Under his supervision 01 research scholar has completed PhD and 02 are undergoing. His research interest include Human Factors and Ergonomics, Occupational Health and Safety; Production/Operations Management. He has introduced the course Human Factors and Ergonomics in the curriculum in under graduate engineering and has developed laboratories such as Industrial Engineering Laboratory, Human Factors & Ergonomics Laboratory and Quality Control Laboratory. He was actively involved in getting NBA accreditation for the department. He is a life member of ISTE, IIPE, IAENG and IEOM Society USA. He has started a student chapter of Industrial Engineering and Operations Management Society (IEOM) Michigan, USA in the institute. The chapter was awarded the best student chapter in the year 2019 at IEOM International conference in Bangkok, and in 2020 at IEOM International conference held at DUBAI. He is serving regularly in various capacities as a Reviewer, Track Chair, Session Chair and Technical Committee member in IEOM International conferences since 2015. Under his guidance UG students have participated and presented papers in International Conferences in India and abroad.