Chapter 18
Ergonomic Evaluation of Community Kitchen for Mid-Day Meal Scheme: A Case Study

Pooja Aloorkar, S. M. Qutubuddin, Pooja Rangdal, Saikiran Patil, and Devsudhakar Patil

1 Introduction

Large kitchens are known for a complex work environment, where the workers/cooks are subjected to extreme work environments and a reason of many work-related hazards, injuries and health issues (Kim 2016). Some of the problems related to working in kitchens are musculoskeletal disorders, low back pain and stress (Fazi et al. 2016). Most of the discomfort is due to exposure to harsh heat conditions, exertion of body parts and muscular strain (Shirin Hima Bindu and Reddy 2016). The manual handling of heavy loads, long duration of work in standing postures, pushing, pulling of objects, repetitive movements and awkward postures add up to the discomfort (Rahayu Kamat et al. 2017). It may be due to kitchen workers performing various tasks like cleaning, washing, grinding, cooking, cutting and packaging (Jagannath et al. 2013). In addition to stress, working in a small area, restricted space, time constraints and pressure add up to the discomfort (Rahayu Kamat et al. 2017; Jagannath et al. 2013).

Prolonged working under such extreme conditions may result in chronic injuries to tendons, muscles, ligaments, nerves and blood vessels, which are commonly known as work-related musculoskeletal disorders (WMSDs) (Rahayu Kamat et al. 2017). WMSDs increase the cost of medical services, absenteeism and retraining (Rahayu Kamat et al. 2017). In the food industry, it is important to reduce the risks of musculoskeletal disorders and other associated occupational safety and health concerns, by

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N. K. Rana et al. (eds.), *Technology Enabled Ergonomic Design*, Design Science and Innovation, https://doi.org/10.1007/978-981-16-6982-8_18

proper application of ergonomic principles and interventions. Another factor in the food industry is that they should follow strict health and hygiene standards. Increased automation in the food industry is accompanied by high noise levels, leading to workers suffering from hearing problems (Sujatha et al. 2015).

Ergonomic approaches are significant in optimum designing of work stations for workers to perform tasks efficiently with little fatigue and discomfort (Shikdar and Al-Hadhrami 2012). Therefore, a detailed ergonomic evaluation of such kitchens is significant to identify the deficiencies in the work and working methods for better understanding in order to effect improvements, productivity, health and safety of the workers. The available literature shows numerous studies conducted on the food industry (Kim 2016; Fazi et al. 2016; Sujatha et al. 2015; Kumari and Kaur 2018), commercial kitchens (Shirin Hima Bindu and Reddy 2016; Kumari 2018), catering workers (Jagannath et al. 2013), cafeteria (Rahayu Kamat et al. 2017) and also industrial canteens and hospital kitchens. The ergonomic issues related to these kitchens and a community kitchen preparing food for thousands of children may be similar. Hence the present study is taken in a community kitchen run by a reputed non-government organization serving the society for the last 17 years.

1.1 Objectives

1. To understand the tasks involved in the community kitchens and to identify the level of musculoskeletal discomfort experienced by the workers.
2. To study the awkward postures of the workers and assess the risks involved using assessment tools like RULA and REBA.

2 Methodology

The methodology used for the current study on the mid-day meals kitchen consists of the following steps:

i. Preliminary survey by observations/questionnaire/interview
ii. Visual analogue scale for measuring discomfort level
iii. Postural analysis by Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA)

Prior to conducting the work, the workers were informed about the purpose of the study, the use of measuring instruments, taking videos/photos of the postures and the observation schedule, and the consent of the owners and workers was obtained.

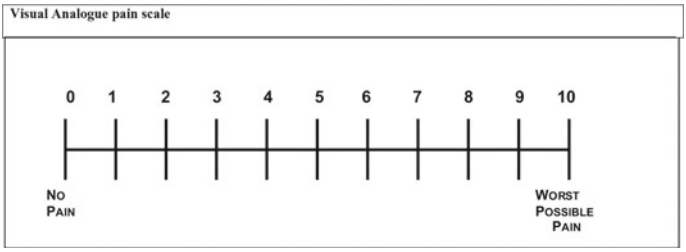


Fig. 1 Visual analogue scale

2.1 Visual Analogue Scale

A visual analogue scale (VAS) is used to determine the overall discomfort/pain level in the workers. A visual analogue scale is a horizontal line, 10 cm in length, with word descriptors at each end. The worker is asked to mark a point on the line as per their feeling of comfort/discomfort. The VAS score is determined by measuring the marked point on the scale from the left end to the point where it is marked. The distance from point zero to the marked point is the result indicators to be processed as a continuous variable (Ghosh 2011).

The advantage of using VAS over other methods is that it gives an overall level of discomfort in the entire body and how the worker feels about the work environment and working methods, rather than giving details of discomfort in each body part separately. For example, the discomfort that a worker feels ranges across a continuum from no pain to extreme pain (Fig. 1).

2.2 Rapid Upper Limb Assessment (RULA)

The tool provides a fast assessment of the posture of the upper limbs, neck and trunk (McAtamney and Corlett 1993). The muscle function and load on the body are also considered in the assessment. The RULA tool generates an action category list with a code that indicates the intervention level necessary to reduce the risk of the worker's discomfort and injury. The tool provides a single score of the entire task which rates the posture, movement and force required. The risk is calculated and gives a score of 1 (low) to 7 (high). The scores are categorized into four action levels that give a recommendation when a risk control action should be initiated (Syed Ali et al. 2018).

2.3 Rapid Entire Body Assessment (REBA)

This method is used for assessing the postures of the entire body. For assessment of postures using REBA the information about the body posture, force, the type of action or movement, repetition, and coupling is collected. The final REBA score generated gives recommendations on the level of risk and required action levels (Hignett and McAtamney 2000). The risk score increases as the postures move away from the neutral position. Various posture combinations are converted into a particular score by using the table which represents the level of musculoskeletal risk. The scores are then grouped into five action levels that indicate the risk levels from no risk to very high risk and the action is taken accordingly.

2.4 Mid-Day Meals Kitchen

The kitchen of the mid-day meal programme of a well-known NGO was selected for the study. The NGO provides nutritious meals to over 15,000 children covering 72 schools in and around Kalaburagi. The meals are prepared in well-equipped kitchens and the food is packed in stainless steel containers for distribution to schools. The food is served by teachers and volunteers to the school children.

The work starts at 4 am in the morning and runs up to 11 am. The unit has five boilers for cooking rice and one for boiling milk, and one boiler for cooking *sambar*. One boiler is kept as a standby in case of any breakdown. Each boiler has a capacity of 75 kg raw rice and the *sambar* boiler has a capacity of 200 kg. The boilers are utilized continuously and the cooking is done in four rounds. In each round, 375 kg of rice is cooked, totalling approximately 14 quintals each day. The *sambar* is cooked in 2 rounds of 200 kg in each round. The cooking time for one round of rice in five boilers is approximately 45–50 min.

The unit works in two schedules. The first schedule starts with boiling milk and preparing breakfast. The food is packed in boxes of different capacities, (100, 50 and 25 students) and at 7 am the breakfast and milk are transported to the schools located around the city and rural areas. Each student is served breakfast and 100 ml of milk. Every day 1200–1400 L of milk and approximately 800 kg of breakfast food is prepared.

Once the breakfast is finished, the workers start the next schedule for cooking lunch. All the utensils and boilers are cleaned and washed prior to the start of the next schedule. The typical menu for lunch is *rice and sambar* for 4 days, *Alu bhath/bisi-bele bhath/Pulav/Pongal* for the remaining two days. On Saturdays the schools run for half-day, so only breakfast is prepared. After preparing the lunch in about four rounds, the food is simultaneously packed in boxes and transported to schools. At around 11 am, all the cooked food is dispatched to the schools. In the evening from 3 to 7 pm, a few workers clean the vegetables and keep ready other materials for the next day's cooking.

2.5 Preliminary Observations and Study

A preliminary study of the kitchen was carried out through observation, discussion and a simple questionnaire to understand the prevailing problems relating to postures, MSDs, noise, heat and humidity (Table 1). It has been found that the risks of MSDs exist for extreme postures. Almost in all workplaces, the workers adopted awkward postures while doing work. The noise level is reported to be moderate at some places and high in washing and cooking areas. Time pressure is high because the food has to be ready by the allowed time for transporting to the various schools. Illumination levels were also low at some places. Based on the initial observations, the awkward postures were analysed at all workplaces using the assessment tools RULA and REBA.

The workers' demographic data are collected (Table 2). The mean age of male workers is 34.73 (±8.44) and the mean age of female workers is 34.94 (±9.07). The mean height, weight and experience are also noted. The average experience of male workers is 9.42 years (SD 3.91) and the average experience of female workers is 9.12 years with (SD 4.05). The duration of work is 7–9 h depending on the tasks assigned. The minimum age of the workers is 21 and the maximum age is 52 years. Similarly, the minimum experience is 1 year and the maximum experience is 15 years in this unit.

The distribution of work activities among male and female workers and the nature of work is given in Table 3. All male workers perform activities such as food prepara-

Table 1 Worker concern on different ergonomic issues

Occupation	*A	*B	*C	*D	*E	*F	*G
Kitchen workers	Moderate to High	Moderate to High	Moderate *High near cooking area	Moderate	Moderate to High	Moderate	Moderate

* A—musculoskeletal discomfort, * B—awkward postures, * C—Heat, * D—Noise, * E—time pressure, * F—health & Hygiene, * G—any other (dust, vibration, illumination, ventilation)

Table 2 Workers' demographic data

Variables	Male	Female
	Average (SD)	Average (SD)
Age (year)	34.73 (8.44)	34.94 (9.07)
Height (cm)	160.59 (7.42)	155.75 (4.10)
Weight (kg)	60.17 (7.81)	54.21 (5.92)
Experience (year)	9.42 (3.91)	9.12 (4.05)
Duration of work (hour)	7–9	7–9
Working days	6	6

Table 3 Distribution of work activities among kitchen workers

Nature of work	No. of workers (n = 42)	
	Male (n = 22)	Female (n = 20)
Food preparation/cooking	06 (27.27%)	–
Boiler maintenance	02 (9.09%)	–
Distribution/loader	10 (45.45%)	–
Packing food	–	6 (30%)
Cleaning, washing	–	14 (70%)
Office work/procurement	04 (18.18%)	–

tion (27.27%), boiler maintenance (9.09%), distribution/loading (45.45%) and office work (18.18%). The female workers are assigned the task of packing food (30%) and cleaning, washing and preparation (70%).

The food preparation activities include cooking food and all associated activities. As shown in Table 3, the duties are assigned to each employee. But during the course of work, the workers perform many different tasks according to the need of the situation. More number of workers are required in the washing and cleaning section as all the utensils, food boxes and boilers have to be cleaned to maintain the necessary cleanliness and hygiene.

3 Results and Discussion

3.1 Visual Analogue Scale Score

The VAS score gave an overall discomfort level in the entire body of the workers. The responses obtained from the VAS show an overall score of 5.6 with a standard deviation of 0.781. This score indicates a high intensity of discomfort and pain among the kitchen workers. A high VAS score is reported in workers of increasing ages. ANOVA values between VAS score and experience showed $F = 29.327$ and $p < 0.001$. This may be due to the fact that over the years these workers are exposed to high stress and heavy handling jobs.

The activity-wise average VAS score is given in Table 4. The VAS score is compared with the RULA score obtained by assessing awkward postures in each activity. The average RULA score for each activity and the overall RULA score is 6.08 with SD 0.641.

ANOVA test results show f-ratio value is 5.65773. The p-value is 0.034852. The result is significant at $p < 0.05$. The average visual analogue scale score for various activities obtained from the responses of the workers performing different activities and the average scores of RULA assessment is shown. Maximum discomfort is reported by the workers in the cooking area according to RULA analysis with a discomfort score of 7, followed by workers doing stirring and cooking sambar (score

Table 4 Activity-wise VAS and RULA scores

Task/Activities	Average VAS score	Average RULA score
Cut vegetables	5.7	5.4
Washing	5.2	6.1
Cooking rice	6.7	7
Stirring food	6.3	6.8
Moving food to packing	4.5	5.9
Packing food	4.9	5.3
Washing containers	5.9	6.1

6.8). This is due to the fact that the workers have to perform the activities working above the shoulders and continuously standing. Another issue is the heat from the kitchen as the workers are very close without any protection from heat stress. The VAS discomfort score also indicated cooking activity as the most difficult (average score 6.7) task followed by stirring the food (average score 6.3), as the workers continuously stand near the boiler.

3.2 Postural Analysis

About 32 workers' postures were selected for RULA and REBA analysis. The results of RULA (Table 5) indicate that 37.5% of the postures fall under the high-risk category and are subject to immediate change. As many as 28.15% of postures fall in the medium-risk category requiring further investigation and change soon. The low-risk category is shown to be in 25% of postures, while 9.37 postures require no change and are acceptable. The results of RULA are in line with some of the earlier reported by Fazi et al. (2016); Rahayu Kamat et al. 2017; Syed Ali et al. 2018).

The results of REBA analysis highlight 21.87% of postures in the very high-risk category and 31.25% postures in the high-risk category. Here the risks are due to working in extreme conditions in awkward postures. The workers at the boilers

Table 5 RULA action levels and percentage of workers in each category

RULA	1–2	3–4	5–6	7
Level of risk	Negligible	Low	Medium	High
Required action	Not required	Change may be needed	Investigate change soon	Change immediately
No. of workers	3	8	9	12
% of workers	9.37	25.00	28.15	37.50

Table 6 REBA action levels and percentage of workers in each category

REBA	1	2–3	4–7	8–10	11 +
Level of Risk	Negligible	Low	Medium	High	Very High
Required Action	No action required	Change may be needed	Investigate change soon	Investigate and change	Change immediately
No of workers	0	5	8	10	7
% of workers	0	15.62	25.00	31.25	21.87

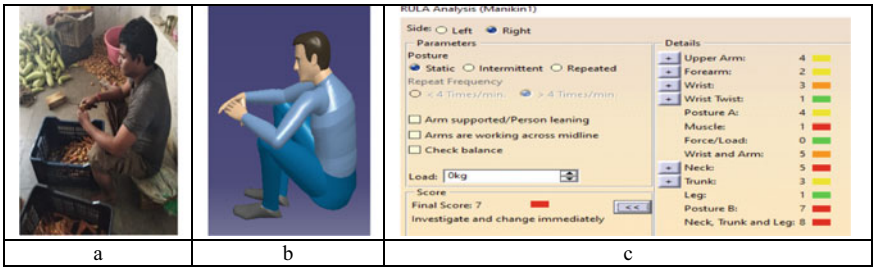
for loading and unloading, the cleaning and some packing workers reported high REBA scores. To reduce the risks and prevalence of discomfort, these postures should be attended first and changed immediately. Postures in the medium and low risks category are 25% and 15.62%, respectively. Earlier REBA assessment studies done on workers by Rahayu Kamat et al. (2017); Syed Ali et al. (2018) indicated similar results. Similar results are reported by Jagadish et al. (2018) in a study on small-scale industries (Table 6).

3.3 Work Environment

Another significant contributor to ergonomic assessment is the work environment. Different environment parameters were measured in the kitchen by appropriate measuring instruments. Five readings were taken at different points in the kitchen. The noise measured (LUTRON SL-4023SD) exceeded more than the allowable limit of exposure (90 dB) at two places near the boilers and the washing and packing section. Illumination levels were also measured (LUTRON lux meter model LX-1102 SD). Overall the illumination was low (110–213 lx) at many places. The recommended value of illumination for kitchens is about 300–500 lx (Kumari and Kaur 2018). The temperature and humidity were measured (HTC HD-304 Temperature meter). As Kalaburagi has day temperatures varying from about 26 to 44° during the year, the measured values (28.7 °C–34.4 °C) were during the month of October–November.

3.4 Workstation Redesign

To illustrate the nature of ergonomic interventions that can improve worker performance and reduce the risk of musculoskeletal disorders, the activity of cutting vegetables is selected. Around 3–4 workers are involved in cutting and preparing vegetables for use in cooking. The existing workplace is just squatting on the floor to perform

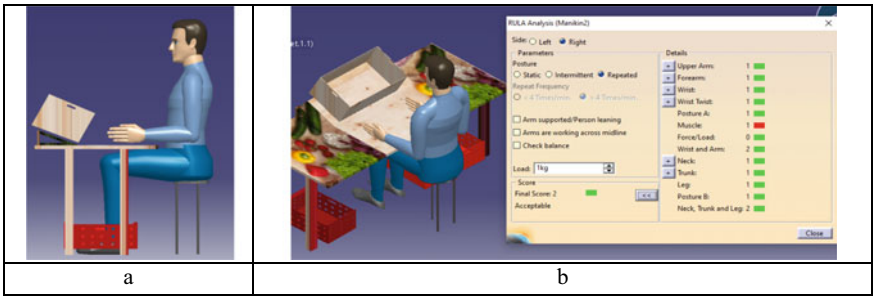


a b c

Fig. 2 Existing workplace and posture (**a**), CATIA model (**b**) and RULA analysis score (**c**) for vegetable cutting activity

the task. The workers adapt several awkward postures during the work according to their comfort. The average VAS score for this activity was 5.7 and the average RULA score was 5.4. One of the worst postures was captured through the photograph (Fig. 2a) and was modeled in CATIA software (Fig. 2b). The same posture was analysed using the RULA assessment tool option in CATIA, which indicated a high risk with a score of 7 (Fig. 2c).

The existing workstation was redesigned by providing a comfortable sitting posture to the workers. The worktable layout is arranged according to the principles of motion economy. The worker is provided with a low back support adjustable chair so that he can work in a comfortable posture. Anthropometry measurements and design of workstation principles (Shikdar and Al-Hadhrami 2012; Kumari 2018; Qutubuddin et al. 2012) were followed. The new workstation design and the human manikin posture were analysed using the RULA tool. The final score of the RULA assessment was 2, indicating a low risk. Due to the changed posture of the worker, the risks of musculoskeletal disorders are minimized and worker comfort and safety increased (Fig. 3).



a b

Fig. 3 Redesign workstation for vegetable cutting (**a**) and RULA analysis score (**b**)

4 Conclusion

The present study is mainly focused on the ergonomic evaluation of the kitchen for mid-day meal scheme. The study is a part of planned series in the field of the food production industry, and highlights the prevalence of MSDs and ergonomic issues. The overall result of VAS indicated a discomfort score of 5.6. The results of RULA analysis showed 37.50% of workers are at high risk and need immediate attention to change working postures. Similar results were obtained from REBA analysis indicating 31.25% postures in high risk and 21.87% in very high risk. It can be concluded that fatigue, discomfort, and prevalence of MSDs are influenced by postures and work activities. Workers report heavy lifting of loads intermittently.

Overall the study finds certain ergonomic deficiencies, layout problems, lack of personnel protective equipment (PPEs) and work station design as reasons for high risks in postures and discomfort. It is suggested to use height adjustable hydraulic operated pallet trucks for movement of food grains from stores and also cooked food from the boiler to packing areas. It becomes more significant to reduce the risks by having proper postural modifications, workstation design, training, reducing the loaded weights and rest breaks.

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