International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 8 Issue 08 Series. II || Aug 2019 || PP 64-72

Assessing Modular Kitchen through an Ergonomic Lens: A Case Study

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Abstract: *Ergonomic plays a vital role in designing a kitchen area free from fatigue, reduction of unnecessary movement and excessive expenditure of human energy and time. The study analysed the compatibility of kitchen centres with the anthropometric measurements of the homemaker and as to how modifications can be made to make modular kitchen more efficient and comfortable for the homemaker. The criteria chosen for selection was that homemakers should be not working outside the home, living in own house and had no hire help in kitchen. Questionnaire was used to collect anthropometric measurements and kitchen information from the homemaker and the collected data was tabulated and analysed. A posture analysis through REBA technique of the respondent while rolling and roasting chapatti on the platform and kitchen sink while cleaning utensils by observation method was carried out. In- depth analysis of a modular residential kitchen selected and analysed in terms of their ergonomic design along with time and motion study and ergonomically improved kitchen designs were suggested which can directly improve the well-being and efficiency of the homemaker.*
Key words*: Modular Kitchen, Work Centres, Work space Designing, Work Triangle, Ergonomic Parameters*

Date of Submission: 08-08-2019 Date of acceptance: 25-08-2019

I. Introduction

The kitchen is a work room, family room, store room and dining room thus making it a major centre of all activities and heart of any house. The major portion of homemakers total work time four to five hours is spent on cooking and other activities related to feeding the family which is approximately one-fourth of a life span. The work area specially kitchen should be adequately design and properly arranged to reduce the physical, psychological and temporal cost of the homemaker. The planning of the kitchen area need to be considered of prime importance in order to facilitate the caring out the activity and reducing the effect of fatigue and accidents in the kitchen. Every kitchen is unique in itself but, there is a scope for enhancing the work environment of the homemaker by incorporating ergonomic concepts to make kitchen more functional.

Ergonomic kitchen spaces are another great way to save time and energy and efficient ergonomic kitchen requires less stress in looking out for the utensils and ingredients in the kitchen so, the modular kitchen which is a need of an hour should be well planned and comfortable. Modular kitchen is ready made kitchen complete in every detail with cabinets, counter tops, hobs, sink, lighting, electrical appliances like oven, refrigerator, mixer, water purifier etc. it consist of independent units consisting of modules of cabinets made of diversified materials which holds accessories inside, which can facilitate the effective usage of the spaces in kitchen that can be used to construct a complete kitchen. The modular units should be based on human dimensions of homemaker. The main component of ergonomics is incomplete without anthropometry and posture.

Based on ergonomic principles the body measurements and functional reaches along with specification for storage design is essential. Women's vertical reach is of critical significance for the layout of cupboard space and shelves. The problem lays in fixed height countertops and a "one-size-fits-all" approach which is usually seen in modular kitchen now days.

Nickel and Dorsey (1960) have stressed the importance of easy reaches. Posture habits are important factor in designing the kitchen. A well maintained posture enables the body to function most effectively in the activities like bending, reaching, lifting things where both the use of limb is important with least expenditure of energy and maximum amount of strain. (Bullock 1990)

A review of literature on this aspect indicates that Indian architects and product designers rely on conversion of western standards or sometimes based on assumptions or to the average measurements. While working in the kitchen women face numerous problems related to dimensions of the kitchen storage, faulty

design of its kitchen storage furniture and a large walking distance between the centers. The design of the kitchen, storage furniture has direct impact on the strain, time and effort of the home maker. The homemaker spends lot of money in making her kitchen more functional, comfortable and presentable which was earlier a clutter of food supplies and utensils.**T**he present study will try to explore the modular kitchen with all three components from an ergonomic lens and evaluate in terms of compatibility of measurements with design and suggest suitable design solutions which can directly affect the well-being and efficiency of the homemaker.

The present study was undertaken to carry out an in-depth analysis of the selected modular kitchen through an ergonomic lens and suggest suitable design solutions for the same.

Specifications of the Existing Kitchen

- ✓ **Respondent name-** RamilabenPatel
- ✓ **Kitchen area –** 644cm x392cm
- ✓ **Years of working in her modular kitchen-** 3 years (newly made)
- ✓ **Cost –** approximately- 2.5lakhs

Basic information of the Homemaker and her kitchen

The selected respondent is of 45 years, having 3 family members. She resides in tenement in which there is "L" shape kitchen. She is right handed and singly cooks in the kitchen. All the kitchen tasks i.e. pre-preparing, cooking, cleaning, dish washing is done by her only. She has normal eye sight. Orientation of kitchen is southeast.

Anthropometric measurements	
Standing Height	158 cm
Elbow Height	102cm
Maximum Reach • Horizontal • Vertical	 63cm 198cm
Normal Reach • Horizontal • Vertical	 58cm 119cm

Time usually spend in kitchen by Homemaker

The homemaker spent maximum time in modular kitchen in the morning. In morning she spent approximately five hours for work like cleaning the modular kitchen, making breakfast and then lunch preparation. After this work she spends approximately one hour in afternoon for cleaning the utensils, platform etc after lunch. In the evening she spent approximately two hours for the cooking dinner and cleaning the utensils and kitchen.

Satisfaction level of the Homemaker

Kitchen work centers

Homemaker was very satisfied with space in kitchen so that two or more people can stand and work as it is large with three windows. Homemaker was very unsatisfied with the platform width as it is very less, depth of kitchen sink while washing utensils and vegetables as depth is very less, space to open/close refrigerator as it is placed in the corner and placement of electric appliances specially oven, juicer, hand mixer as they are placed in storage. Homemaker was unsatisfied with space near kitchen sink as it is very less, width of kitchen sink as it is small, front barrier of kitchen sink as it is less.

Storage

The homemaker was very unsatisfied with opening base cabinets, drawers, storage space as they are very hard to open/close. The result shows that the homemaker is unsatisfied with storage of her modular kitchen as there is overall less storage space in the modular kitchen.

Surface Height

The homemaker was unsatisfied with platform height, satisfied with working on a cooking stove and very satisfied while taking and putting things in wall cabinets. The result shows that the homemaker is unsatisfied with the surface height of her modular kitchen. As the home maker's height is 158 cm, elbow height is 102 cm and platform height is 86 cm the difference between platform height and elbow height is too much it creates problem for homemaker which will lead to musculoskeletal disorders like back pain, shoulder pain and neck pain in homemaker.

Lighting/ Ventilation

The homemaker was unsatisfied with lighting in her kitchen as there is no extra light above the range and very satisfied with placement of exhaust in her modular kitchen as ventilation is good.

Safety

Homemaker was very unsatisfied with corners in the base cabinet drawers as homemaker has to sit on floor and stretch to reach them, while rolling and roasting chapatti as there is vast difference in elbow height (102) and platform height(86), seeing the food in the utensils kept on the stove because of poor lighting.

Lighting

She find difficulties in cleaning utensils in the sink especially one with intricate designs eg. cut glass. As the light from window reflects in her eyes as glare she felt discomfort and refrains from working in her modular kitchen.

Information about Modular Kitchen

Placement of Electrical Equipment's

Oven is stored in the counter top away from the kitchen but often used. Food processor, sandwich maker and roti maker are stored in base cabinet. Hand mixer, juicer, mixer, toaster, refrigerator are stored in wall cabinets. Mixer, sandwich maker, toaster, roti maker are sometimes used. Hand mixer, food processor, juicer, refrigerator are used often in the kitchen.

Components of kitchen

The walls of the kitchen are of light cream colour with oil base emulsion paint having medium texture finish. The ceiling is of white colour distemper having rough texture and medium finish. Floor is of very light grey colorkota stone having smooth and glossy finish. The work surface is white color medium shade marble having smooth and glossy finish. The storage cabinets, doors and windows are of medium brown colour wood laminated material having medium texture and medium quality of finish. The refrigerator is of dark red colour with smooth and glossyfinish. The floor, work surface, refrigerator were clean while walls, ceiling, doors, windows and storage cabinets were found to be moderately clean.

Domestic Services

In the existing modular kitchen municipality water source is available in modular kitchen. She has only drinking water facility in her kitchen. Water storage is both underground and over head tank. Gas pipe line is provided in the kitchen. The covered garbage bin is placed below the sink. Garbage is collected by municipality pickup.

Measurements of Kitchen:

Kitchen area	**Dimensions(cm)**	**Standard Dimensions**	**Remarks**
Platform height	86	85-90 cm	Not Suitable
Platform width	63	60-65 cm	Suitable
Toe height	10	10 cm	Suitable
Toe depth	5	3-4 cm	Suitable
Sink length (only bowl)	47	73-75 cm (including drain board)	Not suitable
Sink barrier	3	2-3 cm	Suitable
Sink depth	18	35-40 cm	Not suitable
Tap height (from sink to spout)	22	15-20 cm	Suitable
Number of drawers	16		
Number of pullouts	0		
Corner cabinets	1		
Water purifier tap height from the platform	74	20-25 cm	Not suitable
Refrigerator placement	Near cooking range	Usually at the end of the work area	Not suitable
Work triangle measurement • Range to sink • Sink to refrigerator • Refrigerator to range Total work triangle	 278 479 217 **974**	 121-182 121-213 121-274	Not suitable
Number of windows	3	--	--
Lights located in the Kitchen	2	Maximum -3 Minimum – 1	Not suitable
Ventilation	Chimney		
Readings of Environmental Meter (Average) **Lighting (Natural) (LUX)**			
Morning	516	500-800	

Afternoon	522	600-700	Slightly less
Evening	414	400-500	
Air velocity (RH)	55.9	50-70	Suitable
Noise Level (db)			
Before work	34.43	70	Highly not suitable
During work	58.7	60	
After work	39.4	80	

Problem faced by homemaker while using modular kitchen

When the respondent was inquired regarding the problems faced by her while working in her modular kitchen, the main problems highlighted were insufficient lighting at various work centers, insufficient platform width, less depth of the existing sink while cleaning the utensils in sink, improper placement of dining table, large work triangle because of lot of walking between the centers. She cannot keep her eyes fully open while working at sink center due to large amount of light coming from the window as glare.

Existing layout

1. Floorplan
2. Range/ refrigerator area
3. Sink area

In-depth analysis of the Existing Kitchen

Since, the questionnaire revealed that homemaker was quite unsatisfied with the modular kitchen in spite of large space and newly made. So the researcher decided to do a in-depth design analysis of this existing modular kitchen through various techniques.

✓ **Time motion study**

The time- motion analysis revealed that some storage arrangements need to be done according to storage principles so the homemaker can save their time and energy in doing the task.

✓ **Compatibility of the homemaker with kitchen dimensions and Posture adopted by her**

The platform height of the kitchen was not found suitable as per the homemakers height. The platform height is 86cm and the homemakers elbow height is 102 cm. As a result the homemaker has to bend while doing the task (Washing utensils) which leads to MSD (Musculoskeletal disorders). The researcher suggested 93cm as platform height due to which posture is automatically improved. The improved posture of the worker leads to less strain on neck and shoulder.

✓ **Work triangle**

The work triangle of the modular kitchen is very large because of the placement of the refrigerator at the extreme end of the platform. The gap between platform and refrigerator is 40cm and homemaker also faced the problem while opening/ closing refrigerator because of dining table. The work triangle gets interrupted due to the dining table. The researcher suggested the placement of refrigerator towards the other side of the platform. The ideal work triangle should be between 500-700cm. The work triangle should never cut or any furniture shouldn't be within the work triangle. The existing work triangle is 974 cm. In the suggested plan the work triangle has reduced to921cm.

✓ **Lighting**

There is no lighting source on sink area and range area. The researcher suggests lighting on both sides of chimney and also above the sink area.

✓ **Detailing of various centers**

1. **Sink Centre:** The height of the sink is too low compared to the elbow height of the homemaker. Due to which the sink becomes too deep for homemaker and while cleaning utensils the homemaker has to bend to reach the utensils kept in sink. There is no light source above the sink due to which homemaker find difficulties in cleaning utensils at evening and night.
2. **Range Centre:** The height of the platform is too low compared to the elbow height of the homemaker. Due to which the range centre is too deep during cutting, chopping, kneading and rolling/roasting of chappati. The homemaker has to bend while working on the platform. There is no light source above the platform due to which homemaker finds difficulties in cooking during evening and night hours.
3. **Refrigerator Centre:** Dining table is kept very near to refrigerator. Due to which homemaker find difficulties in opening/ closing or putting in/ taking out things from the refrigerator.

Time- Motion Analysis

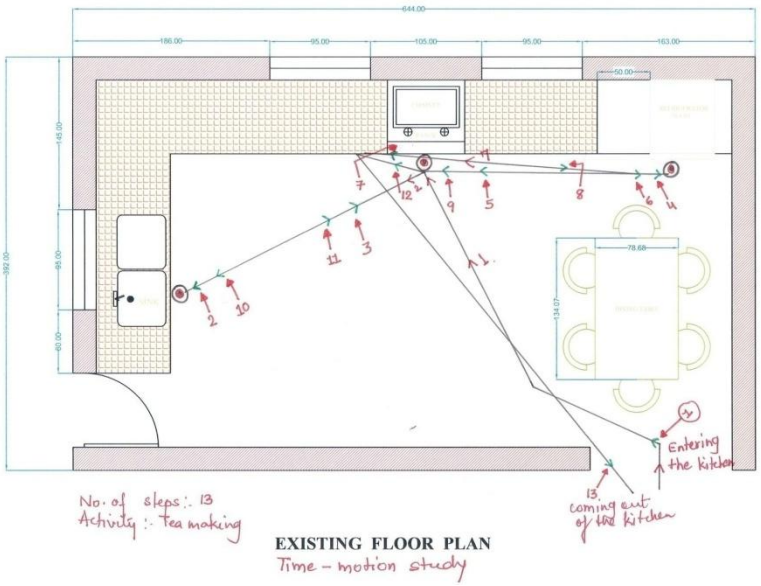
Motion and time study can reduce and control costs, improve working conditions and environment, and motivate people. However, the most important things istolearn how to train homemakers in these skills and techniques so they can become motion and time conscious.

Tools/ Equipment's used- Pedometer, Camera

Method of time – motion analysis:

Homemaker had very large modular kitchen hence distance between work centers was also large. We suggested "tea preparation process" for time motion study. Videography was done for the whole process. Homemaker's movements from one work centre to another work centre while tea preparation was recorded. Each step between the work centers was studied; the extra steps which could be eliminated during the process were pointed out. Simple changes were suggested in her present modular kitchen so that homemaker's time and energy can be saved and she feels less fatigue.

Observation sheet :



Tea preparation activity steps

Used morning tea utensil already present on the range.

Step-1- Enter and move towards range, took lighter from drawer below range and start the stove.

Step-2- Range to water source to get water.

Step-3- Water source to range and put water in utensils (in standing position took out sugar and tea leaves from drawer below the range and put them in utensil)

Step- 4- Range to refrigerator to get Ginger.

Step- 5- Refrigerator to range to crush ginger in bowl and put it in utensil.

Step- 6- Range to refrigerator to get milk and put it on platform.

Step- 7- Refrigerator to side cabinet of range to get cup and saucer and tea masala from nearby drawer and put milk in utensil.

Step-8- Range to refrigerator to put milk back.

Step -9- Refrigerator to range and put tea masala in utensil.

Step-10- Range to sink to put water glass above the sink window.

Step-11- Sink to range for boiling tea and tasting the tea.

Step- 12- Range to side space near range for straining tea in cup.

Step-13- Range to outside of the kitchen for serving tea.

Steps that can be eliminated

Step- 4- Range to refrigerator to get Ginger.

Step- 6- Range to refrigerator to get milk and put it on platform.
Step -9- Refrigerator to range and put tea masala in utensil.

- ✓ **Total footsteps –**84
- ✓ **One footstep-** 26cm
- ✓ **Total time taken –** 3.51Minutes
- ✓ **Name of the activity –** tea making
- ✓ **Walking distance during activity –**21m

Posture analysis of major activities carried out in existing modular kitchen:

Sitting and standing with proper postural alignment will allow one to work more efficiently with less fatigue and strain on your body's ligaments and **muscles**. Being aware of good posture is the first step to breaking old poor postural habits and reducing stress and strain on spine.

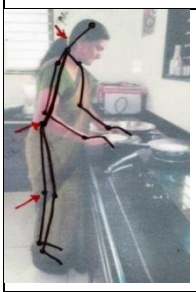
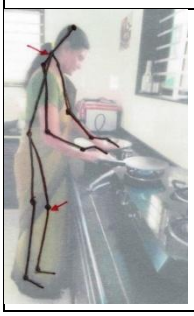
Method of posture analysis through REBA (Rapid Entire Body Assessment)

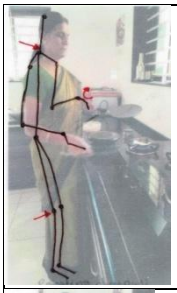
The REBA worksheet is divided into two body segment sections on the labeled A and B. section A (left side) covers the neck, trunk and leg. Section B (right side) covers the arm and wrist. This segmenting of the worksheet ensures that any awkward or constrained postures of the neck, trunk or legs which might influence the postures of the arms and wrist are included in the assessment. First score group A (trunk, neck and legs) postures, than score group B (upper arms, lower arms and wrists) posture for left and right. For each region, there is a posture scoring scale and additional adjustments which need to be considered and accounted for in the score. Fill table A, B and C in order. REBA score is obtained from table C.

Activities of posture analysis

Rolling roasting chappati: Roti making is a daily work for every housewife. Homemaker makes roti usually thrice in a whole day. Each time she takes 10 to 15 minutes to make roti. As a whole 45 minutes homemaker takes same position for rolling and roasting chappati. The homemaker may suffer from musculoskeletal disorders like pain in neck, trunk, hand, shoulder, back and leg if she continues with the same posture.

Rubbing /Washing utensils: Rubbing and washing utensils is a daily work for every housewife. Homemaker rubs and washes utensils three times in a day. Each time it takes 10 to 15 minutes to rub and wash utensils. As a whole 45 minutes homemaker takes same position for rubbing and washing utensils. The homemaker may suffer from musculoskeletal disorders like pain in neck, trunk, hand, shoulder, back and leg if she continues with the same posture.

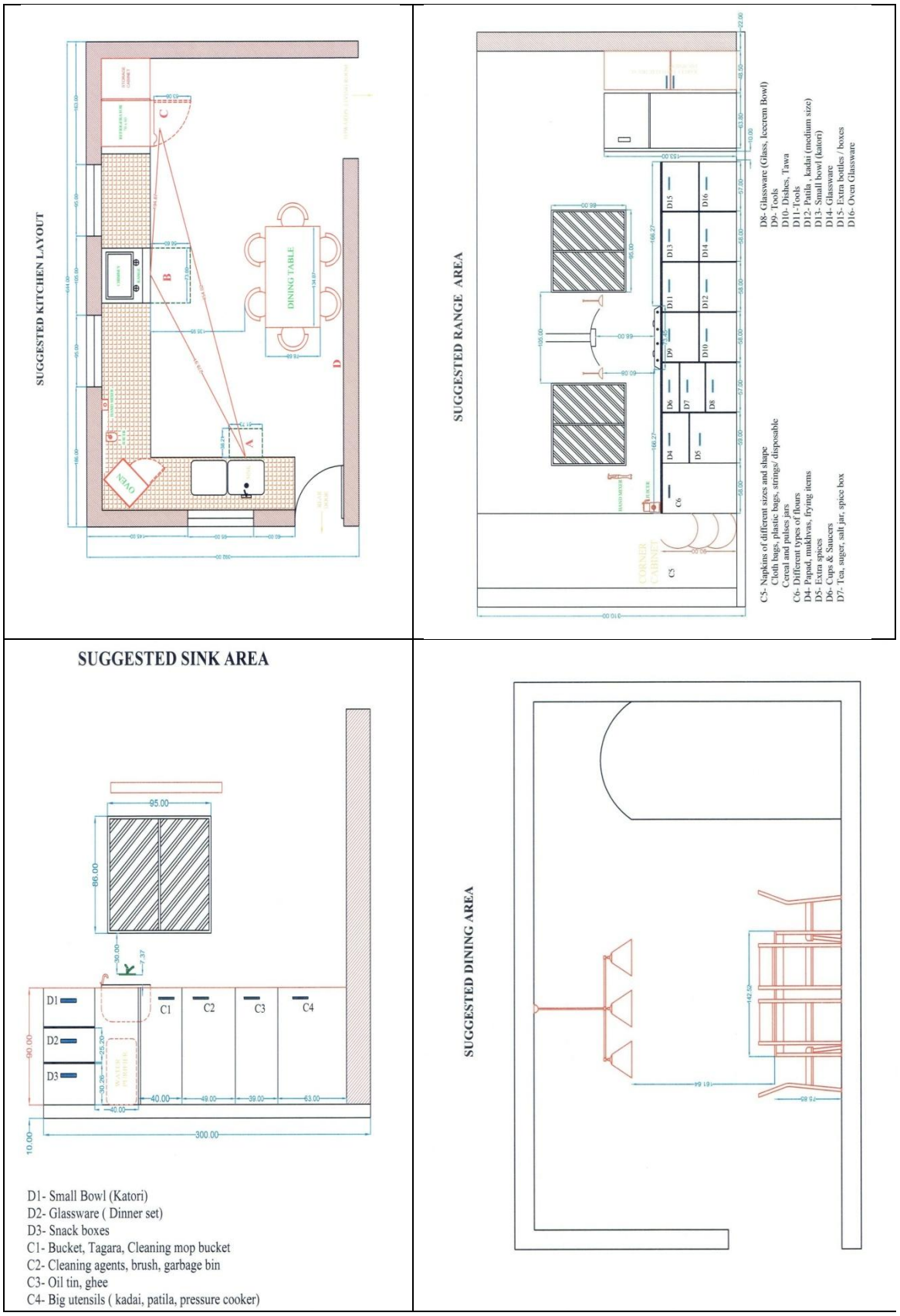
Rolling/ roasting Chappati	**Posture**	**REBAScore**	**Risk Level**	**Action Category**
	Neck bent forward, Both arms below shoulder level stretched forward	**9**	**High**	Investigate Implement change
	Neck and back bent forward, Both arms below shoulder stretched forward	**7**	**Medium risk**	Further investigation change soon

	Both arms below shoulder stretched forward, one arm twistedback	**7**	**Medium risk**	Further investigation change soon
	Neck bent forward, both arms below shoulder stretched forward	**7**	**Medium risk**	Further investigation change soon

Rubbing Utensils				
	Neck bent forward, back bent forward, both arms below shoulders one hand stretched forward and another hand twisted backward	**11**	**Very high**	Implement immediate change.

Suitable Design Solutions after Ergonomic Assessment

SNo	Suggestions	Reason
1	**Sink area**	
	✓ Lighting on the top of the sink area.	No natural light in evening
	✓ Decrease depth of the sink	Homemaker is tall that's why she had to bend more while carrying out the activities**.**
	✓ Water purifier placed under the sink (UTS) area and the tap of water purifier placed on corner of the sink rim.	Water purifier placed too high on the wall
2	**Range/ Refrigerator area**	
	✓ Lighting on both the sides of the chimney above the storage.	No natural light in evening and chimney has no light.
	✓ Hand mixer fixed on the wall, beside the wall cabinet	It was placed away from the kitchen towards stairs.
	✓ Oven placed at the corner of the kitchen platform	It was placed away from the kitchen towards stairs.
	✓ Juicer placed near the oven on the platform.	It was placed away from the kitchen towards stairs
	✓ Rollers in corner cabinet below the corner of the platform.	She had to bend much to get things kept in corner shelf.
	✓ Refrigerator moved towards the platform and suggested crockery equipment cupboard between refrigerator and wall.	To reduce distance between work centres and to keep rarely used electrical equipment's in cupboard which is placed away from the kitchen.
3	**Dining area**	
	✓ The dining table has been moved on "D" wall and hanging light suggested directly above the dining table.	It hindered while opening the refrigerator. Moreover it cuts the work triangle of the kitchen.


SUGGESTED KITCHEN LAYOUT
DINING TABLE
OVEN
SUGGESTED RANGE AREA
D8- Glassware (Glass, Icecrem Bowl)
D9- Tools
D10- Dishes, Tawa
D11-Tools
D12- Patila , kadai (medium size)
D13- Small bowl (katori)
D14- Glassware
D15- Extra bottles / boxes
D16- Oven Glassware
C5- Napkins of different sizes and shape
Cloth bags, plastic bags, strings/ disposable
Cereal and pulses jars
C6- Different types of flours
D4- Papad, makhvas, frying items
D5- Extra spices
D6- Cups & Saucers
D7- Tea, suger, salt jar, spice box
SUGGESTED SINK AREA
SUGGESTED DINING AREA
D1- Small Bowl (Katori)
D2- Glassware (Dinner set)
D3- Snack boxes
C1- Bucket, Tagara, Cleaning mop bucket
C2- Cleaning agents, brush, garbage bin
C3- Oil tin, ghee
C4- Big utensils (kadai, patila, pressure cooker)

Acknowledgement

We are very thankful to GUJCOST (Gujarat Council on Science and Technology) for giving out the financial support and SICART for physical facilities for carrying out this research work. I express my deep obligations to my respondent who co-operated with me by sparing her precious time for this work.

References

[1]. Patel. S. and Patel. U. (2017) "Extent of problems faced by the homemakers regarding existing modern kitchens" International Journal Of Applied Home Science, vol:4 (7 & 8), July and Aug 2017. ISSN : 2394-1413, Pp :562-567
[2]. Savant. D. and Rodge. J. (2015) ' Assessment of postural deviation of selected women while mopping floor in squatting and standing posture.' Asian Journal of Home Science Vol 10 issue 2 December, Pp 360-363
[3]. Rodge. J. and Saranbekar. H. (2014) 'Ergonomic evaluation of kitchen sink.' Asian Journal of Home Science Vol 9, issue 1 June, Pp219-222.
[4]. N.Gupta, (2016) "Designing Modular Kitchen: A Practical Manual for Home Science", Guru Publishing House, Gujarat, ISBN-978-93-81471-61-6
[5]. P. R. Boyce, (2008) Human Factor in Lighting, Third Edition, Tylor andFrancies group, London, New York, Pp: 28 to33
[6]. Sumangala. P. P. (1995) Thesis on "Development of standards based on anthropometric measurements and their implications in the designing of kitchen and storage" referred Shodhgangahttps://shodhganga.inflibnet.ac.in/

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