Himachal Journal of Agricultural Research Vol. 32(1) : 121-125, 2006

Ergonomically designed kitchen counters and work analysis

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Abstract

It was aimed to design a comfortable kitchen by assessing the existing work centres with prevalent set standards and to evolve the kitchen counter heights on the basis of anthropometric data and ergonomic cost of kitchen activities at three main work counters i.e. preparation, cooking and sink. The study was conducted in Palampur town of District Kangra with a total sample of 100 women respondents and households for survey and thirty respondents for experimental analysis. The results highlighted that there were significant differences in the dimensions (height, width and depth) of existing kitchens under survey vis-a-vis the set standards commonly used for all three main work centres. Anthropometric measurements were used as a reference data to evolve suitable kitchen counter heights. Four commonly performed kitchen activities viz. chopping, kneading dough, cooking and dish washing were selected for ergonomic evaluation on the basis of heart rate values, energy expenditure and perceived exertion by the respondents. Three different heights in which one was based on comfortable height evolved of entire sample and others were below or above the same. The analysis showed that 96cm for cooking; 84cm for chopping and 79cm for kneading dough and dishwashing were most suitable kitchen counter heights with least ergonomic cost of work of the sampled respondents.

Key Words : Ergonomics, Work Load, Set Standards, Kitchen Counters, Work Analysis.

Introduction

Any type of job including household work, the work, worker and work place interface play an important role in achieving the maximum output with minimum input along with ensured safety and satisfaction of the worker. Studies indicate that Indian women put a high degree of physical effort in the kitchen which snatches away 70 percent of her working hours and approximately 3000 kilocalories of energy (Bhattacharya, 1996). Comfortable design of kitchen in the home is important in order to reduce ergonomic cost of work and fatigue to minimum, maintenance of good posture and enhanced productivity. Activities performed in the right posture put less strain on muscles and body ligaments and reduces the work cost leading to worker's efficiency and productivity (Oberoi *et al.* 1987). Properly planned and convenient work counters can play a key role in reducing physiological cost of work to a considerable extent. Hence, the present study has been planned with following specific **objectives**: -

- Assessment of existing kitchen work centres on the basis of set standards.
- Estimation of ergonomic cost of selected kitchen activities on the basis of evolved / convenient heights of work centres.

Methodology

2.1 Sampling and Research Design

The study was conducted in Palampur town and surrounding areas in district Kangra. Descriptive type of survey design along with an experimental plan was considered appropriate to achieve the objectives of the present study. A multistage random sampling technique was adopted to select wards, localities and ultimate 100 women respondents for survey and 30 physically fit volunteers from the main sample for experimental plan. The data were collected on well-structured pre- tested interview schedule through personal interview method. Experiment was set up at Residence Laboratory, Department of Family Resource Management, College of Home Science, CSKHPKV, Palampur.

2.2 Variables

The dependent variable was dimensions of work counters while independent variables in the study included personal and family attributes and

anthropometric measurements of the respondents.

2.3 Anthropometric Measurements

The following anthropometric measurements were studied as a reference data in planning and recommending work counter heights i.e. height, weight, elbow height, functional reach, maximum arm reach and total span. Various tools such as measuring tape, weighing machine, polar heart rate monitor, etc. were used to gather data.

2.4 Experimental Plan

Four commonly performed kitchen activities viz. chopping, kneading dough, cooking and dish washing were selected for ergonomic evaluation on three different heights in which one was based on comfortable height evolved of entire sample and others were below and above the same.

2.5 Standardizations

The standardized procedure was followed for each activity with required materials and specified time. Adjustable wooden counters were used to determine the three different heights of work counters.

2.6 Ergonomic cost evaluation of Kitchen work

The ergonomic evaluation was done on the basis of heart rate values and energy expenditure was also calculated by applying formulae given by Verghese (1995):

$$0.058 \times \text{Heart Rate (b.min}^{-1}) - 8.72$$

Further classification of physiological workload was done as per rating scale of perceived exertion given by Borg (1982).

2.7 Analysis

The data were analyzed by applying descriptive statistics (frequencies, percentages, average and standard deviation) and relational statistics such as Student's 't' – test and correlation.

Results and Discussion

Evaluation of ktchen work centres on the basis of set standards

Kitchen work counters need to be planned carefully to increase efficiency and safe health to the users. The existing kitchen work counters have been evaluated on the basis of recommended standards most prevalent in use. The components of work centres are evaluated in its dimensions of height, width and depth, which play a key role in increasing work efficiency and reducing fatigue to a minimum.

3.1 Cooking centre

3.1.1 Existing Dimensions and Set Standards

The cooking centre is designed for all kinds of cooking and serving food. The results showed that average height (79.06cm) and depth (55.89 cm) of the existing cooking centre was less than the set standards i.e. 85cm and 60.96cm respectively while average width (131.00 cm) was more than the set standards (91.44cm). The significant difference was found in the average and set standards in height (t-value=16.1636*); depth (t-value=9.5956*) and width (t-value =29.4744*) of cooking centres between existing and recommended set standards (Table 1). According to Bredger (1995) stooped working postures (in which the trunk is inclined forward) result from working surfaces, which are too low, or from the need to reach over obstacles.

3.1.2 Evolved Standards and Ergonomic Cost of Work

Anthropometric measurements of all subjects were recorded which were used as reference data in recommending heights of kitchen centres i.e. preparation (84cm), cooking (96cm) and dishwashing (79cm) cm respectively. The percentile values for standing height were found to be 147.72, 154.5, 161.65 cm at 5th, 50th and 95th percentile. Elbow height of the subject at 5th, 50th, and 95th percentile were observed as 92.45, 98 and 104 cm respectively.

3.1.3 Ergonomic cost of work

Ergonomic cost of work was determined in terms of cardiovascular stress of increased / decreased heart rate of the sample in performing selected kitchen activities i.e. chopping, kneading, cooking and dishwashing in three work counters of different heights in preparation, cooking and sink centres.

The activity of cooking vegetables/meals was carried out at three heights viz. 96, 101 and 109 cm. The average heart rate at rest was found to lie between 86-88 b.min^{-1}. The working heart rate values were minimum (97.39 b.min^{-1}) at 96cm height of working counter which was most suitable than all other suggested counter heights (Table 2).

Table 1. t- test showing significant difference in the existing dimensions and set standards of work centres of the kitchen

S.No.	Variables	Observed Mean (cm)	Set Standard (cm)	Mean Difference	t-value
1.	Cooking Centre	79.06	96.00	-16.94 (0.3671)	29.7829*
	Height	79.06	85.00	-5.94 (0.3671)	16.1636*
	Width	131.00	91.44	39.56 (1.3423)	29.4744*
	Depth	55.89	60.96	-5.07 (0.5274)	9.5956*
2.	Preparation Centre	79.06	84.00	-4.94 (0.3671)	12.9495*
	Height	79.06	85.00	-5.94 (0.3671)	16.1636*
	Width	113.96	76.20	37.76 (1.2563)	30.0609*
	Depth	55.89	60.96	-5.07 (0.5274)	9.5956*
3.	Sink Centre	79.06	79.00	0.06 (0.3671)	0.8877
	Height	79.06	80.00	-0.94 (0.3671)	2.5444*
	Width	58.97	45.72	13.25 (1.3114)	10.1101*
	Depth	27.03	25.40	1.63 (0.6228)	2.6263*

* Significant at 5 % level of probability; two tailed test ; df = 99
Figures in parentheses indicate standard error

Table 2.Ergonomic cost of kitchen work in terms of heart rate, energy expenditure and perceived exertion

S. No.	Activities	Heart Rate (beats/min.)		% Change	Energy Expenditure (kj/min)		% Change	Perceived Exertion				
		Rest	Working		Rest	Working		VD 1	D 2	MD 3	FE 4	VE 5
1.	Chopping Vegetable											
	79cm	86.86	95.84	10.34	5.09	6.52	28.05	-	-	-	26	4
	84cm	85.73	94.10	9.76	4.91	6.24	27.07	-	-	-	10	20
	88cm	87.22	98.63	13.08	5.15	6.96	35.23	-	1	15	14	-
2.	Cooking Vegetable											
	96cm	86.08	97.39	13.14	4.97	6.77	36.22	-	-	-	19	11
	101cm	87.31	99.08	13.48	5.16	7.03	36.25	-	1	16	9	4
	109cm	87.57	101.95	16.42	5.20	7.49	43.92	1	18	11	-	-
3.	Kneading Dough											
	79cm	87.42	103.57	18.47	5.18	7.75	49.57	-	-	-	19	11
	84cm	88.05	106.02	20.40	5.28	8.14	54.11	-	1	16	9	4
	88cm	88.59	110.51	24.74	5.37	8.85	64.94	1	18	11	-	-
4.	Dish Washing											
	79cm	87.55	105.42	20.41	5.39	8.04	49.14	1	11	15	3	-
	84cm	88.75	108.06	21.75	5.20	8.46	62.69	14	13	3	-	-

VD- Very Difficult, D-Difficult, MD- Moderately Difficult, FE- Fairly Easy, VE- Very Easy
Borg's Rating Scale (1982)

Similarly energy expenditure and perceived exertion on Borg's scale during working at 96cm was minimum (6.77 kj/min.) than other counter heights. Energy expenditure was derived parameter of heart rate, which was measured in kj/min. by applying formulae: Energy Expenditure = 0.159 x HR ($b.min.^{-1}$) - 8.72.

Borg's rating scale (1982) was used to determine the perceived exertion of individual correlated with physiological responses like energy expenditure and heart rate, which is largely used for determining occupational workload. Thus, it can be concluded that 96cm was most convenient heights for cooking meals.

3.2 Preparation counter

3.2.1 Existing Dimensions and Set Standards

It is the place where pre-cooking activities are performed. The results showed that average height (79.06cm) and depth (55.89cm) of preparation centre were less than set standard i.e. 85cm and 60.96cm respectively while average width (113.96cm) was greater than set standards i.e. 76.20 cm. The dimensions of height and depth of preparation centres were same as that of cooking centre as it was an extension of the same counter. The significant differences were found in average and set standards in height (t value = 16.1636*); depth (t value =9.5956*); width (t value =30.0609*) of preparation counters.

3.2.2 Ergonomic cost of work at preparation counter

Preparation activities of chopping vegetables and kneading dough were carried out for assessment of ergonomic cost at three different heights of the preparation counter i.e. 79cm, 84cm and 88cm. The working heart rate was minimum (94.10 bpm) at 84 cm for chopping vegetable and (103.57 bpm) at 79cm for kneading dough. Similar trend was followed for energy expenditure (6.77 kj/min) at 79cm for kneading dough and for chopping vegetables it was found to be 6.52 kj/min. However, activity of kneading dough was perceived to be tiresome than chopping vegetables at Borg's rating scale. Thus, it can be concluded that for chopping vegetables the convenient height was 84 cm, whereas, for kneading dough it was 79 cm (Table 2).

3.3 Sink centre

3.3.1 Existing dimensions and set standards

This is a multi purpose centre and serves for washing fruits, vegetables and utensils. It also provides water for mixing, cooking and drinking. Therefore, dimensions of the sink viz. height, width and depth are of considerable importance for maintaining proper posture and safe health of the user. The average height (79.06cm) was almost same as that of set standards (80cm). Average width (58.97cm) and depth (27.03cm) was greater than set standards i.e. 45.72 cm and 25.40 cm respectively. The significant difference was found in average and set standards in height (t value =2.5444*); depth (t value =2.6263*) and width (t value =10.1101*) of sink centres (Table 1).

3.3.2 Evolved sink standards and cost of work of dishwashing

The activity of dishwashing was carried out at two different heights viz. 79 and 84cm. The heart rate at rest was found to lie between 87-89 bpm. The working heart rate was minimum (105.42 bpm) at 79 cm with least energy expenditure (8.04 kj/min.) as compared to working at counter height of 84 cm (8.46 kj/min). Thus it can be concluded that human energy expenditure during dishwashing was minimum at 79 cm.

Conclusion

- The average existing height and depth of the kitchen work counters were significantly less than set standards. However, width of work centres was significantly more than set standard.
- The average existing height of preparation and cooking centres was found to be significantly less than the standards evolved through laboratory experiments while it was not significant for sink centers.
- Ergonomic cost of work was found to be minimum during chopping at 84 cm (preparation counter); cooking at 96 cm (cooking counter); kneading dough and dishwashing at 79 cm (sink centre).

Acknowledgement

The authors wish to acknowledge the financial support given by the Indian Council of Agricultural Research for taking up the research, which was monitored by Dr. (Mrs.) Tej Verma, ADG (Home Science). ICAR, New Delhi.

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