PRINT: ISSN 0973-7189 ONLINE: ISSN 2456-6780
Stud Home Com Sci, 5(2): 73-77 (2011)
DOI: 10.31901/24566780.2011/05.02.01

Assessment of Physiological Stress Parameters of Female Workers Engaged in Selected Cooking Activities

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KEYWORDS Cooking Activities. Ergonomics. Grip Strength. Physiological Parameters. Pinch Strength

ABSTRACT The present study was undertaken to assess the different physiological stress parameters of female workers engaged in selected cooking activities in-terms of ergonomic standards. Study was conducted in Ludhiana city on purposively selected sixteen respondents having similar physical and physiological parameters and were performing kitchen activities in routine. For experiment, the most commonly performed five activities were selected. Results revealed that energy expenditure ranged from 7.0 to10 kJ\min, TCCW was between 200.81 to 364.30 beats, PCW was 12.82 to 26.26 $bmin^{-1}$; maximum for grating activity and minimum for rolling of chapattis. The percent increase in heart rate was also found maximum for grating, that is, 38.56 per cent and minimum for rolling chapattis, that is,16.20 per cent. Reduction in grip and pinch strength of right hand was found more as compared to the left hand. The percent deviation in thoracic and in lumbar region was maximum during kneading and minimum during rolling.

INTRODUCTION

Ergonomics contributes to the designing and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities as well as limitations of the workers. To obtain maximum efficiency in work with least cost to the body energy, there should be an ideal relationship between work, worker and work place (Steidl and Bratton 1968). The homemaker is the predominant figure in the home and household work is an indispensible part of the homemaker. She requires a lot of energy and time to complete work inside and outside the home with satisfaction and desired standards. Researchers have proved that any work station design or work environment that helps to perform the work with minimum energy and put minimum stress on cardio vascular system and muscular system is the best design of work (Varghese et al. 1995). So the kitchen workstation should be adequately designed and properly arranged in order to reduce the physical, physiological and temporal costs of the homemaker. If the body fails to maintain the equilibrium while doing work, it adds to the human energy cost and physiological dynamics such as energy expansion, physiological cost of work, muscular effort etc. Therefore, a need was felt to assess the different physiological stress parameters of the homemakers engaged in selected cooking activities.

METHODOLOGY

Selection of Respondents: Study was conducted in Ludhiana city on purposively selected sixteen respondents having similar physical and physiological parameters. Selected homemakers had mean age 33.7 years, mean height 156.87 cms, mean weight 61.42 kg and mean heart rate 74.7 $bmin^{-1}$.

Standardization of Activities: Based on a baseline survey conducted prior to the experiment, five activities in which the respondents faced maximum problems, were selected. These were cutting, kneading dough, rolling *chapattis*, grating and dish washing. Each of the activity was performed for fifteen minutes. For cutting and grating activities carrots were taken . Kneading was done of wheat flour weighing 500 grams. For dish washing, medium sized utensils including skillet, *patila*, full plates, bowls, glasses, serving bowls, different types of spoons etc. of stainless steel were used.

Collection of Data: A specially structured check performa was used to record personal data and readings during the experiment. Prior appointments were fixed with the selected subjects. As per the convenience of the subjects, visits were made and experiments were carried out. Readings were taken while the subjects performed the intended tasks. Subjects were encouraged to work in a natural way and not to be influenced by the interviewer's presence.

Before the start of each activity subjects were rested for 15 minutes. At this point of resting position their heart rate, grip strength, pinch strength and normal spine position were taken. Subjects were explained to perform each activity for 15 minutes using their daily used equipment and tools. Heart rate was noted during work at the interval of 5 minutes each. Later these readings were averaged to get mean values. Posture adopted during activity was also taken with flexi curve and drawn on the chart paper. Immediately after the termination of each activity the subject was made to sit in relaxed position and recovery heart rate was recorded for 5 minutes at the interval of 1 minutes each (or till the value touched the resting value) with the help of heart rate monitor. Reading of grip strength and pinch strength were also recorded. Rest period of 30 minutes duration was given every time before the start of the next activity.

Assessment of Physiological Parameters: Based on the heart rate readings the following parameters were calculated.

1. Average heart rate during rest, work and recovery period.
2. The energy expenditure per minute was estimated from heart rate using the following formula and the classification of work load was done as per Varghese et al. (1994).

Energy Expenditure (kJ/min) = 0.159 x Average Heart rate ($bmin^{-1}$) – 8.72

3. The Total Cardiac Cost of Work (TCCW) was also estimated for the whole day based on the cardiac cost of work and cardiac cost of recovery.

Cardiac Cost of Work (CCW) = Increased Average heart rate x Duration of work

Increased Average heart rate during work= Average working heart rate – Average heart rate during rest

Cardiac Cost of Recovery (CCR) = Increased average heart rate during recovery x Duration

Increased average heart rate during recovery= Average recovery heart rate – Average resting heart rate.

Statistical Analysis of Experimental Data: Simple averages, percentages, standard deviation and paired 't' test was used to find out significance of differences between existing and improved working conditions.

RESULTS AND DISCUSSION

Cardiovascular Responses During the Selected Activities

It is evident from the data presented in Table 1 that while performing different activities in the kitchen average heart rate was found to be maximum during grating of carrots (106 $bmin^{-1}$) and minimum during rolling of *chapattis* (91$bmin^{-1}$). Increase over base in average heart rate was also found to be maximum for grating (29.5 $bmin^{-1}$) and minimum for rolling of *chapattis* (13.1b min^{-1}). The calculated percent increase of heart beat was 38.56 $bmin^{-1}$ for grating carrots, 34.74 $bmin^{-1}$ for kneading dough, 30.57 $bmin^{-1}$ for cutting carrots, 21.29 $bmin^{-1}$ for dish washing and only 16.2 $bmin^{-1}$ for rolling of *chapatti*. So it can be concluded that among the selected kitchen activities maximum force was exerted for grating followed by kneading dough. The least force was required for rolling chapattis.

The paired 't' test results were found to be highly significant at 1% level of significance indicating that there is significant difference in the average heart rate at rest and during activity.

Energy Expenditure, Total Cardiac Cost of Work (TCCW) and Physiological Cost of Work (PCW) of Different Activities

It can be observed from Table 2 that amongst the selected activities the mean values for energy expenditure, total cardiac cost of work

Table 1: Increase in cardiovascular responses of the selected respondents while performing the different activities

Activity	*At rest ($bmin^{-1}$)*	*During activity ($bmin^{-1}$)*	*Increase over base*	*Percentage increase*	*'t' value*
Cutting	76.20± 0.84	99.5±2.75	23.3	30.57± 3.7	47.65*
Grating	76.50± 0.97	106 ±5.0	29.5	38.56± 2.5	44.18*
Kneading	77.70± 0.83	104.7±4.40	27	34.74± 4.6	60.37*
Rolling	77.90± 1.87	91 ±2.56	13.1	16.2 ± 5.2	20.03*
Dish washing	77.50± 0.93	94 ±3.22	16.5	21.29± 3.5	26.32*

* Significant at 1 % level of significance

(TCCW) and physiological cost of work (PCW) were found to be maximum for grating carrots (10.00 kJ\min, 364 beats and 26.26 bmin $^{-1}$ respectively), followed by kneading of dough (9.40 kJ\min, 241beats and 18.43 bmin $^{-1}$ respectively), cutting carrots (9.06 kJ\min, 216 beats and 15.32 bmin $^{-1}$), dish washing (7.30 kJ\min, 213 beats and 13.98 bmin $^{-1}$) and minimum in case of rolling *chapattis* (7.00kJ\min, 201 beats and 13.98 bmin $^{-1}$). So, according to the workload classification given by Varghese et al. (1994), the physiological workload of the activities can be interpreted as light activity for rolling and dish washing, whereas cutting and grating carrots and kneading dough as moderately heavy activity.

Table 2: Energy expenditure, total cardiac cost of work (TCCW) and physiological cost of work (PCW) of the selected activities

Activity	*Energy expenditure (kJ/min)*	*TCCW (Beats)*	*PCW (bmin $^{-1}$)*
Cutting	9.06±1.32	216 ± 10.67	15.32±2.37
Grating	10 ±2.67	364.30± 18.32	26.26±3.76
Kneading	9.4 ±3.55	241.06± 17.66	18.43±3.71
Rolling	7.0 ±2.12	200.81± 16.37	12.82±1.04
Dish washing	7.3 ±2.36	213.07± 15.14	13.98±2.43

Muscular Stress of Selected Subjects

Muscular stress was assessed by measuring the reduction of strength in larger and smaller muscles of hand by using the grip and pinch dynamometer.

i. Reduction in Muscular Grip Strength (Kg) while Performing Selected Activities

The mean values of percentage decrease of the muscular strength for both the hands independently (right hand, left hand) are presented in Table 3.

It indicates that the maximum percentage reduction in both the hands occurred while kneading dough (28.89% and 29% for left and right hand respectively) and minimum was observed after the activity of rolling of *chapattis* (12.85% and13.33% for left and right hand respectively). Further, the data also indicates that the percent decrease in grip strength of right hand was more as compared to left hand. The paired 't' test values were found to be comparatively more significant for right hand (1 % level of significance).

ii. Reduction in Muscular Pinch Strength (Kg) While Performing Selected Activities

Data pertaining to the reduction in pinch strength after performing selected activities where hands, specifically fingers were involved is presented in Table 4. The values of the Table indicate that the maximum percentage reduction in pinch strength of both the hands occurred while grating (44.15% and 47.00%) for left and right hand respectively and minimum after the performance of activity of rolling of *chapattis* (12.50% and15.38%) for left and right hand respectively. Kneading dough was another activity which could be considered as strenuous from this particular parameter point of view as data revealed that about 42.85 per cent reduction in left hand and 45.13 in right hand was observed.

Further the data also indicate that the per cent decrease in pinch strength of right hand was more as compared to left hand. The paired 't' test values were found to be comparatively more significant for all activities for right hand (1% level of significance). Similar results were reported by Maiti et al. (2007) who also found that there are significant differences between pinch strength of left hand and right hand while performing work involving smaller muscles of hand.

Table 3: Reduction in muscular grip strength (Kg) of selected subjects in doing selected activities

Activity	*Left hand (Kg)*				*Right hand (Kg)*			
	Before activity	*After activity*	*Decrease over base*	*% Reduction 't'Value**	*Before activity*	*After activity*	*Decrease over base*	*% reduction 't'Value**
Cutting	18 ±2.97	14.5 ±2.27	3.5	19.44±3.55 8.27*	15 ±2.32	11.78±2.75	3.22	21.33±3.63 10.56*
Grating	14 ±2.75	10.8 ±1.75	3.2	22.85±3.38 7.66*	14.62±2.87	10.62±2.76	4.02	27.36±4.37 14.52*
Kneading	19 ±2.54	13.5 ±1.75	5.5	28.94±4.54 11.56*	17 ±3.15	12.07±3.41	4.93	29.00±2.34 11.83*
Rolling	18.36±2.94	16 ±1.56	2.36	12.85±3.32 3.42*	15 ±2.92	13 ±3.73	2.00	13.33±4.31 8.54*
Dish washing	18 ±2.97	15.14±1.78	2.86	15.88±3.23 3.57*	19 ±2.76	16 ±2.32	3.00	15.78±3.22 3.99*

* Significant at 1 % level of significance

Table 4: Reduction in muscular pinch strength (Kg) while performing selected activities

Activity	*Left hand (Kg)*					*Right hand (Kg)*				
	Before activity	*After activity*	*Decrease over base*	*% Reduction*	*'t'Value**	*Before activity*	*After activity*	*Decrease over base*	*% reduction*	*'t'Value**
Cutting	4.5±2.18	3.5±1.32	1.0	22.22±3.33	7.14*	5 ±3.51	3.5 ±2.43	1.5	30 ±3.02	10.32*
Grating	4.5±2.01	2.5±2.32	2.0	44.15±3.12	11.69*	4 ±1.27	2.10±3.67	1.90	47.00±4.87	15.75*
Kneading	3.5±3.32	2 ±1.32	1.5	42.85±2.64	7.34*	5.5±1.05	3 ±2.01	2.5	45.13±3.51	7.48*
Rolling	4 ±2.71	3.5±2.55	0.5	12.5 ±3.23	11.00*	6.5±1.32	5.5 ±1.78	1.0	15.38±5.57	12.74*
Dish washing	6 ±2.52	4.5±3.72	1.5	25 ±3.81	6.72*	6 ±1.92	4 ±2.31	2.0	33.33±4.61	7.16*

* Significant at 1 % level of significance

Postural Stress of Selected Subjects While Doing Selected Activities

Posture has a direct relation to the comfort, mechanical efficiency and physiological functioning of the individual. A good working posture is one, which can be sustained with a minimum static muscular effort and in which it is possible to perform the task more effectively and with least muscular effort. It can be seen from the Figure 1 that a change of 5.5° to 21° in thoracic region was observed while doing the various selected activities. The percent deviation in thoracic region was maximum during kneading of dough (10.71 per cent) followed by grating (7.2 per cent) and minimum during rolling of *chapattis* (2.8 per cent). In the lumbar region a change of 5^0 to 23° was seen during various activities. Percent deviation was maximum again during kneading (11.61 per cent) and minimum during rolling (2.5 per cent). It can be concluded that per cent deviation is directly related to the activities where more exertion or force has to be applied by the worker.

Further, it can be noticed that percentage deviation was more in thoracic region as compared to lumbar region for rolling and cutting whereas deviation was found more in lumbar region as compared to thoracic region for kneading dough, grating and dish washing. Differences in the degree of resting and working posture adopted by the homemakers for both thoracic and lumbar region were found to be significant at 1 % level of significance.

CONCLUSION

It is evident from the perusal of the above study that while performing selected activities in the kitchen average heart rate, total cardiac cost of work (TCCW) and physiological cost of work (PCW) were observed to be maximum for grating carrots followed by kneading dough, cutting of carrots, dish washing and minimum was observed for rolling *chapattis*. It can further be concluded from the study that the maximum percent reduction in grip as well as pinch strength of both the hands occurred while kneading and minimum was observed after the activity of rolling. The per cent deviation in thoracic and lumbar region was also found maximum during kneading dough followed by grating carrots and minimum during rolling of *chapattis*.

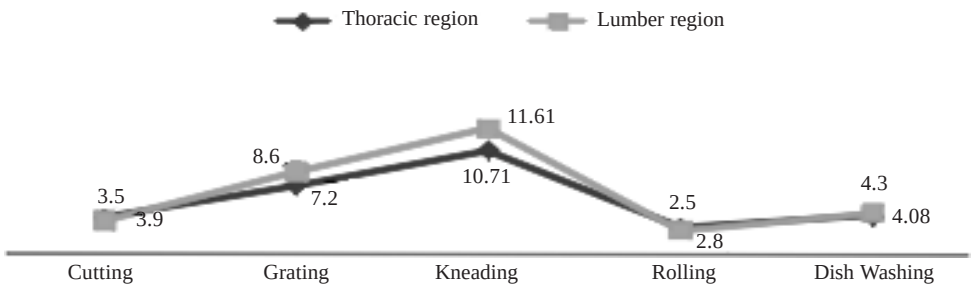

Fig. 1. Percentage deviation of thoracic and lumbar during various selected activities

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