International Journal of Human Resources Management (IJHRM)
ISSN(P): 2319-4936; ISSN(E): 2319-4944
Vol. 5, Issue 5; Aug - Sep 2016; 29-34

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

ERGONOMIC ASSESSMENT OF WOMEN LABOURERS IN HEAD LOAD CARRYING ACTIVITY AT CONSTRUCTION SITES IN HARYANA

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ABSTRACT

In India women labour constitute a major role in the construction industry and it was found that most of the female were engaged in head load carrying activity. So a study was conducted to assess the ergonomic parameter for their WMSDs among 30 female labourers involved in carrying cement mixture on their head. They belonged to age group of 20-40 years with 8-10 years of work experience. It was found that after carrying the head load, highly significant increase was observed in pulse rate (27.9 b.min^{-1}), HR (32.7 b.min^{-1}), EE (6.4 kJ.min^{-1}). Oxygen uptake volumes of respondents were found to be decreased after the work. On the basis of RPE, load carrying was perceived as moderately heavy activity (3.7) Grip strength of right hand (19.7%) as well as left hand (15.4%) was reduced after performing the activity. Deviation in spinal angle in terms of lumbar region was 2.7 percent (exterior posterior) and cervical region by 3.1 percent (anterior posterior) was observed during carrying the load on head. This study also revealed that women workers had to work in a very high temperature, humid weather, dirt etc. so that they suffered many health problems due to unsuitable work place environmental parameters.

KEYWORDS: Construction Female Labourers, Head Load, Heart Rate, Working Environment

INTRODUCTION

The landless labourers and marginal farmers come into the cities in search of work and they work as labours where any building is being constructed. Women perform various unskilled jobs like cleaning building sites, carrying bricks, gravel, mortar and water up to the skilled carpenters and masons, irrespective of the number of years they work, they are not upgraded from unskilled to skilled labourers in comparison to male contra part **(Jhabvala and Kanbur, 2002)**. As they are unskilled and have no training before the recruitment, they are unaware about the ergonomic risks related to the work.

It was found that in 15 minutes, about 55 bundles, each weighing 7-8 kg, passed through the hands of women. Women carried 9-12 bricks (each weighing 2.5 kg) on their head. During earth work women carried 15 kg. of mud on their head and walked 30 feet to deposit the mud and return. In an activity of one hour this was repeated 180 times **(Madhok, 2005).** The safe load limit for adult female worker has been described as 30kg **(Dwivedi, 2000)** which is higher than Recommended weight limit (RWL) of 23kg suggested by NIOSH committee The RWL for Indian women should be 15kg

(Maiti *et al.*, 2004a). The environmental heat significantly influences the cardiovascular and thermoregulatory systems in workers performing both light and heavy work tasks **(Chad and Brown 1995).**

The present study was conducted with following specific objectives:

- WMSDs of women labourers in head load carrying activity.
- To assess the working environmental parameters.

Methodology

A sample of 30 physically fit women respondents falling in the age group of 20-40 years of age were selected for the study. The data comprised of 15 women each engaged in construction activity at residential and commercial site respectively. Field experiment was conducted for the ergonomic evaluation of the head load carrying task(cement mixture). Work sheets comprising various ergonomic parameters were employed using various scales to assess the work related discomfort of women labourer in head load carrying activity. Respondents were allowed to perform the activity in their normal setting and as their normal routine and their ergonomic parameters were recorded under physical parameters, work parameters, physiological, biomechanical and environmental parameters. The experiment was conducted in the months of March-May. For determining the physical fitness of subjects, a wooden step stool ergometer was used. BMI was derived by measuring weight and height of the subjects using Quetelet's Index by the following formula given by **Garrow (1981).**

$$\text{Quetelet's Index} = \frac{\text{Weight (kg)}}{\text{Height}^2\ (\text{m}^2)}$$

Heart rate of the subject was measured with the help of heart rate monitor at rest, during the period of the activity and recovery thereafter.From the values of heart rate following parameters were calculated using their respective formulas:

Energy expenditure rate (EER) (kJ.min^{-1}) = 0.159 $\times$ Avg. Working H (b.min^{-1}) – 8.72

Spitometer was used for lung function capacity.

For grip strength was calculated with the help of following method:

Grip fatigue (%) = Sr-Sw x 100 /Sr

Sr = Strength of muscles at rest.

Sw = Strength of muscles after work

RESULTS

Results in Table 1 reveal the physical parameters of respondents which were selected for further study. The mean age of the respondents was 31.4 $\pm$4.9; height of the respondents was 149.60±10.31 cm with mean weight of 50.30±5.83 kg. Mean LBM (Lean body mass) of the respondents was 50.01 $\pm$ 5.69 and mean body mass index was 22.05 ± 2.83 kg/m^2 with mesomorph body type, respectively. An average women labourer worked for 6-8 hours per day and travelled a distance of 2-3 km in one hour at construction site.

Table 1: Physical Parameters of the Selected Women Labourer at Construction Sites N=30

Physical Characteristics	Mean ± SD
Age (year)	31.40 ± 4.91
Height (cm)	149.60 ± 10.31
Weight (kg)	50.30 ± 5.83
BMI (kg/m^2)	22.05 ± 2.83
LBM	50.01 ± 5.69
Body type	Mesomorph

Figure 1 elucidate physical fitness of the respondets. It was found that half of the respondents (50%) belonged to the low average category,followed by those (36.66%) who came under poor health category,whereas more than 10 percent (13.33%) belong to the high average category.

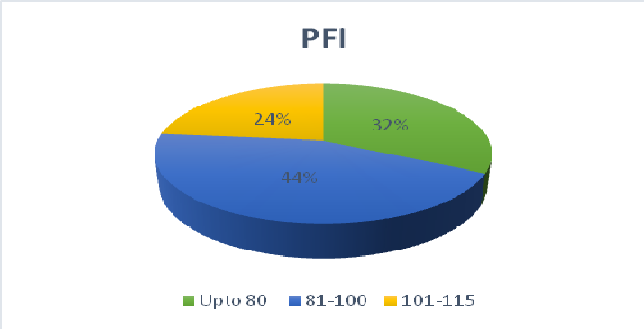

Figure 1: Physical Fitness Index

Table 2: Physiological Parameters Before and after Carrying the Head Load N=30

Parameters	Before Carrying Load	After Carrying Load	Difference	%Change	t-Value	Remarks
Pulse rate (b.min^{-1})	81.9	106.8	↑27.9	34.10	7.3**	Heavy
Heart rate (b.min^{-1})	96	128.7	↑32.7	36.4	16.4**	Heavy
Energy expenditure (kJ.min^{-1})	6.5	12.9	↑6.4	49.6	18.8**	Very heavy

*Significant at 5 % level

Table 2 shows that after carrying the head load, highly significant difference was observed in all the parameters like pulse rate, energy expenditure, heart rate. Pulse rate increased by 27.9 b.min^{-1}, heart rate by 32.7 b.min^{-1}, energy expenditure by 6.4 kJ.min^{-1}. Increase in heart rate, pulse rate and energy expenditure depicted that the body had to work more while carrying head load On the basis of the classification given by Varghese *et al.* (1994) for energy expenditure and heart rate, the workload of carrying head load was determined to be heavy.

Table 3: Comparison of Lung Function Capacity N=30

Value	FVCL (l/m)	FVC 1 (l/s)	FVC (%)	PEF (l/s)	VMX_{25} (l/s)	VMX_{50} (l/s)	VMX_{75} (l/s)	SVC (l/s)	ERVL (l/s)	MVV (l/m)
Predicted value	3.01	2.6	86.4	6.9	6.1	4.2	1.9	2.9	1.5	85.2
Pre value %	2.5(78.1)	1.9(74.7)	79.5(91.3)	5.0(68.4)	4.2(59)	2.2(47.4)	1.0(57.5)	2.7(54.8)	1.4(96.1)	47.8(56.7)
Post value %	2.6(67.3)	1.8(73.6)	73.4(82.6)	5.7(64.1)	2.6(48.3)	2.4(56.7)	1.6(61.06)	2.5(59.2)	2.4(89.5)	46.8(64.4)

Data in Table 3 represents the lung function capacity of the construction women labourer in three parameters; Predicted lung function capacity (the capacity of lungs calculated by software on the basis of age, weight, height and gender), pre lung function volume (the capacity of lungs at rest) and post lung function volume (reflect the lung capacity after doing work).

From the Table 3 it can be concluded that the pre and post value of lung function capacity of the respondents were less as compared to predicted value. Regarding FVC (forced vital capacity) an amount of air exhales effort in one minute. According the finding in table the pre and post volume (2.5 l/m, 2.6 l/m) of the lung capacity of the respondents were similar but less than the predicted value (3.01 l/m). FEC 1 depicts the volume of air exhaled within one second. Data in table divulges that the predicted value (2.6 l/s) was maximum and the pre and post value of respondents 1.9 l/s, 1.8 l/s respectively less. Table 4.2.4 discloses the FEC% lung function capacity which means forced expiratory volume in 1 second to FVC ratio, as a percent. The FEC% ratio was high in pre value (79.5%) as compare to post value (73.4%) but less than the predicted value (86.4%). Results exposed the PEF value means highest forced or peek expiratory flow during air exhalation. Regarding the table the post value (5.7 l/s) was higher than the pre value (5.0 l/s) but less than the predicted value (6.9 l/s). Data again gave a detailed view of VMX $_{25}$, $_{50}$ and $_{75}$ (it is forces expiratory flow, calculated to the total lung function capacity on the actual volume of the lung, means amount of air volume remaining when measurement was made). The pre value (VMX_{25}:4.2l/s, VMX50: 2.2l/s and VMX_{75}: 1.0l/s) and post value (VMX_{25}:2.6l/s, VMX50: 2.4l/s and VMX_{75}: 1.6l/s) were less than the predicted value (VMX_{25}:6.1l/s, VMX50: 4.2l/s and VMX_{75}: 1.9l/s). The predicted values (2.9 l/s) of SVC (Slow vital capacity) of the respondents were higher than the pre value (2.7l/s) and post value (2.5l/s). ERVL represents residual volume, is the amount of air that remains in lung at the end of the maximum expiratory. The post value (2.4l/s) was much higher than the pre value (1.4l/s) but it was also less than the predicted value (1.5l/s). Regarding MVC (maximum ventilation volume) the pre and post value were similar with the slight difference 47.8l/m, 46.8l/m respectively but these were less than the predicted value (85.2l/m). **Maiti (2008)** reported that average maximum oxygen consumption rate (VO_{2max}) was obtained as 1.52l/s, which was less than the predicted value of 9.54kcal/min mentioned in NIOSH equation (Eastmen Kodak Company, Ergonomics Group 1986).

From the Table 4 it was resolved that pre value was found to be non-significant to post value of lung function capacity, FVCL (0.29l/m), FVC 1 (0.04l/s), FVC (0.04%),PEF (0.32l/s), VMX_{25} (0.001l/s), VMX50 (0.29l/s) and VMX_{75} (0.01l/s), SVC (0.39l/s), and ERVL (0.01l/s), MVC (0.22l/m). From all the above results it was concluded that the respondent’s lungs were not working properly and they will face problem in near future.

Table 4: Comparison of Pre Value and Post Value of Lung Function Capacity of Women Labourer at Construction Sites N=30

Value	Pre Value	Post Value	T-Value
FVCL (l/s)	2.53	2.65	0.29
FVC 1 (l/s)	1.99	1.82	0.04
FVC (%)	79.56	73.45	0.04
PEF (l/s)	5.01	5.77	0.32
VMX_{25} (l/s)	4.26	2.64	0.001
VMX_{50} (l/s)	2.28	2.43	0.29
VMX_{75} (l/s)	1.05	1.65	0.01
SVC (l/s)	2.78	2.56	0.39
ERVL (l/s)	1.41	2.42	0.01
MVC (l/m)	47.87	46.82	0.22

*Significant at 5 % level

Table 5: Rating of Perceived Exertion (RPE) for Different Stages of Head Load Carrying Task N=30

Activity	WMS	Rank	Activity Type
Load lifting	3.4	II	Moderately heavy
Load carrying	3.7	I	Moderately heavy
Load landing	2.1	III	Light

Table 5 shows the perceived exertion of the respondents as recorded on the five point rating scale. The complete activity was divided into three parts i.e. lifting, carrying and landing. Among these, load carrying was given the second rank getting a score of 3.7 making it a moderately heavy activity followed by the load lifting activity (3.4) making it a moderately heavy and load landing was (2.1) perceived as very light activity.

Table 6: Biomechanical Parameters Before and after Carrying Head Load N=30

Parameters		Before Carrying Load	After Carrying Load	Difference	Change%
Grip strength (kg)	**Right**	27.4	22	↓5.4	19.7
	Left	23.3	19.7	↓3.6	15.4
Spinal angle (degree)	**Lumbar angle**	185	190	↑5	2.7
	Cervical angle	182	188	↑6	3.2

Table 6 indicate that there was reduction of 19.7 percent in the grip strength of right hand and 15.4 percent in the left hand after performing the activity. There was deviation in spinal angle in terms of lumbar region by 2.7 percent (exterior posterior) and cervical region by 3.2 percent (anterior posterior) during carrying the load on head. . The results are in consonance with the findings by Sharma and Singh (2012) as while carrying the load on head, a deviation of 1.7^0, 2.8^0 and 3.1^0 was observed with a load of 15 kg, 20kg and 25 kg respectively. **Gauvreau *et al.* (2011)** analysed that during walking, the load on the head caused significantly larger upper trunk extension and smaller flexion of the head relative to the trunk. The amplitude of motion of the upper trunk and of the head relative to the trunk, as measured by the standard deviation of walking angles, was found to decrease as a result of carrying a load on the head and compensated by increased motion at the sacrum. **Kumar *et al.* (2004)** emphasized that there was evidence of degenerative disc disease in the vertebral MRI of the workers involved in load carrying activity. **Chattopadhyay *et al.* (2009)** reported that forward bending back was most common and frequent repeated awkward posture carried out by labourer during performance of most of the construction works. Other stressful working postures found during different joint motions were neck flexion or extension, shoulder flexion or extension, hands at or above head, elbow flexion, sometimes backward bending or twisting of back during lifting of heavy loads, radial or ulnar deviation of wrist and bending knees.

CONCLUSIONS

After carrying the head load, highly significant increase was observed in pulse rate (27.9 $b.min^{-1}$), HR (32.7 $b.min^{-1}$), EE (6.4 $kJ.min^{-1}$). Oxygen uptake volumes of respondents were found to be decreased after the work. It was resolved that pre value was found to be non-significand to post value of lung function capacity. On the basis of RPE, load carrying was perceived as moderately heavy activity (3.7) followed by load lifting also moderately heavy activity (3.4) and load landing was perceived as very light activity (2.1). Grip strength of right hand (19.7%) as well as left hand (15.4%) was reduced after performing the activity. Deviation in spinal angle in terms of lumbar region was 2.7 percent (exterior posterior) and cervical region by 3.1 percent (anterior posterior) was observed during carrying the load on head.

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