International Journal of Applied Home Science ***RESEARCH PAPER***
Volume 3 (5&6), May & June (2016) : 205-213 ISSN : 2394-1413
Received : 10.05.2016; Revised : 19.05.2016; Accepted : 24.05.2016

Physiological workload and postural stress of farm women in harvesting of paddy grains

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ABSTRACT

In Assam about 70 per cent of the farm women participate in harvesting of paddy grains with traditional tool. Work related Musculoskeletal Disorders (WMSDs) are common health problem among the workers. Assessment of exposure to physiological workload, postural stress and WMSDs risk factors can be an appropriate base for planning and implementing interventional ergonomics programs in the workplace. Therefore, work related musculoskeletal disorders (WMSDs) are related to working in bad posture. Thus, to improve the efficiency of the farm women their physiological workload and posture needed to be assessed and corrective measures should be suggested to avoid the musculoskeletal disorders. Chaudhary *et.al* (2007) opined that harvesting and post- harvesting operations were reportedly more suited to the physical health of the women. The agricultural operations like reaping of crops, storage of food grains, storage of seed and processing were reported to be mostly done by women. An attempt was made to assess physical fitness of participants, to determine physiological workload involved in harvesting of paddy and to ascertain muscular and postural stress involved in the activity. Nordic Musculoskeletal Questionnaire (NMQ) was used to determine the prevalence of WMSDs. Thirty subjects in the age group of 21-45 years was purposively selected. Stepstool technique was adopted for assessing physical fitness of the farm women. Heart rate was recorded with Polar Heart Rate Monitor (Polar Sports Tester – PE 4000) and angle of deviation in different parts of the body was measured with Dual Inclinometer during the operation. Rating of Perceived Exertion (RPE) was calculated using Borg's 5 point rating scale while Body Map was used to identify pains in different body parts. The average resting heart rate values of participants was 87.28 $b.min^{-1}$. Average working heart rate values in harvesting activity were 119.23 $b.min^{-1}$ in the morning and 121.82 $b.min^{-1}$ in the afternoon and average energy expenditure were 9.86 kJ/min in the morning and 10.23 kJ/min in the afternoon respectively. Physiological workload of harvesting of paddy grains on the basis of heart rate and energy expenditures were found to be 'Moderately Heavy' in the morning hours and 'Heavy' in the evening hours. Perceived exertion of participants in harvesting activities (RPE) was rated 4.1 on a 5 point scale. Both static and dynamic movements are adopted in harvesting activity. The posture assumed by the farm women in paddy harvesting is standing in forward bending position .The range of motion in cervical, thoracic and elbow shows that the angle of average flexion was 58.91^0 and average extension was 51.74^0 in cervical,

Cite this Article: Borah, Ruplekha and Kalita, Mira (2016). Physiological workload and postural stress of farm women in harvesting of paddy grains. *Internat. J. Appl. Home Sci.,* **3** (5 & 6) : 205-213.

while for thoracic it was observed to be 13^0 and 22.6^0. The angle of average flexion was 48° and average extension was 24° in elbow indicating deviation in the different body parts. The incidences of work related musculo skeletal problems were observed to be 'severe' to 'moderate' in harvesting activity. Cut and wounds are the major occupational health hazards of the farm women. The use of Personal Protective Equipments (PPE) is not common among the farm women for reduction of occupational health hazards. Ergonomic interventions through designing of PPE will improve work performance and enhance productivity of farm women.

Key Words : PPE, WMSDs, physiological workload, postural stress, NMQ

INTRODUCTION

Rural women in developing countries are predominantly engaged in farm activities besides their obligation in household work. The farm activities performed by farm women demand high degree of physical effort leading to work related musculoskeletal disorders (WMSDs). The main causative factor for work related musculoskeletal disorders (WMSDs) is working in bad working posture, which become harmful and lead to irreparable damage to the body. The National Commission of Self-Employed Women and the Women in Informal Sector (1988) stated that in order to understand the occupational aspects of health, it is necessary to have a detailed examination of women's in terms of physical stress, the postural positions and their effects, and occupational related drudgery. Individual's complaints of tiredness or fatigue while performing an activity which is merely a subjective feeling, provides reliable information for the assessment of workload (Borg, 1982). The drudgery which the women folk suffer can be removed to a great extent by adoption of improved technology. In Assam about 70 per cent of the farm women participate in harvesting of paddy grains with traditional tool. Work related Musculoskeletal Disorders (WMSDs) are common health problem among the workers. Assessment of exposure to physiological workload, postural stress and WMSDs risk factors can be an appropriate base for planning and implementing interventional ergonomics programs in the workplace. Therefore, work related musculoskeletal disorders (WMSDs) are related to working in bad posture. Thus, to improve the efficiency of the farm women their physiological workload and posture needed to be assessed and corrective measures should be suggested to avoid the musculoskeletal disorders. Chaudhary *et al.* (2007) opined that harvesting and post- harvesting operations were reportedly more suited to the physical health of the women. The agricultural operations like reaping of crops, storage of food grains, storage of seed and processing were reported to be mostly done by women. Right from ancient time women of Indian society are fully occupied and overburdened with three fold responsibilities of farm, home and livestock management. There are a number of agricultural tasks being performed by women viz; cleaning field, sowing, weeding, threshing, winnowing, gap filling, transplanting, fertilizer application, harvesting, drying, storage etc. (Gupta et. al. 2004; Cherian et. al. 2000; Sharma et al, 2004). An attempt was made to assess physical fitness of participants, to determine physiological workload and to ascertain muscular and postural stress involved in harvesting of paddy grains.

METHODOLOGY

Selection of subjects :

Thirty subjects in the age group of 21-45 years who are normal, non-pregnant, non-lactating and without any major illness were selected for the purpose of the study.

Physical characteristics and body composition:

Estimation of Lean Body Mass (LBM) was determined from the skin fold thickness at four sites, *i.e.* biceps, triceps, subscapular and superilliac muscleswith the help of skin fold calipers by using the methods prepared by Durnin and Rahman (1967). BMI or Quetlet's Index Weight (kg/height^2 (m) was used to classify the body types as Ectomorph (<20), Mesomorph (20-25) and Endomorph (>25).

Determination of physical fitness :

Physical fitness of the participants was determined by using step-test method. The test was administered according to the designed protocol; working and recovery heart rate was monitored continuously by using Heart Rate Monitor (Polar Sports Tester – PE 4000) during all the three phases. The stepping exercise (30 steps/min.) was continued for a maximum of 5 minutes. The recovery pulse rate was recorded while the subject was sitting on a chair. PFI was measured with the following formula:

PFI = Duration of stepping in sec / Sum of 1st, 2nd and 3rd min. recovery pulse count X 100

The scores thus obtained were interpreted using the Physical Fitness Index (PFI) and categorized as poor, low average, high average, good, very good and excellent the scale proposed by Saha (1996) was used.

Determination of physiological workload :

The workload of the subjects was determined by recording the heart rate responses while uprooting in mat nursery and wet bed by using Polar Heart Rate Monitor (Polar Sports Tester – PE 4000). The heart rate measurements were taken by fitting the monitor to the subject's body to note minute-wise recording for that specified duration *i.e.* 30 minutes. Resting heart rate and recovery heart rates were also recorded. Energy expenditure was estimated from the heart rate responses using the formula by Varghese et al. The physiological workload was determined as per the physiological workload Index developed by Varghese et al. on the basis of heart rate and energy expenditure values of the participants.

The energy expenditure was estimated from the heart rate responses by using the formula of Varghese *et al.* (1994). The formula is given below:

Energy Expenditure (kJ.min^{-1}) =0.159xHR (beats.min^{-1})-8.72.

TCCW=CCW+CCR

Cardiac Cost of Work (CCW) = (Avg. Working HR - Avg. Resting HE) x Duration

Cardiac Cost of Rest (CCR) = (Avg. Recovery HR - Avg. Resting HE) x Duration

Physiological Cost of Work (PCW) = TCCW/ Total Time of Activity

The Physiological workload was determined as per the workload classification developed by Varghese *et al.* (1994).

Table A : Physiological workload index		
Physiological workload	Heart rate (beats/min)	Energy expenditure (kJ/min)
1. Very light	Upto 90	Upto 5
2. Light	91-105	5.1-7.5
3. Moderately heavy	106-120	7.6-10.0
4. Heavy	121-135	10.1-12.5
5. Very heavy	136-150	12.6-15.0

Rating of perceived exertion :

Subjective perception of exertion is a method for providing reliable information for the assessment of workload. Subjective rating of feeling of tiredness was studied by using the Rating scale of Perceived Exertion (RPE) developed by Varghese *et al.* (1994). The exertion perceived by the participants before and immediately after completion of harvesting activity was recorded and categorized as very light, light, moderately heavy, heavy and very heavy based on the scores 1, 2, 3, 4 and 5, respectively.

Postural analysis :

Postural analysis was considered during the performance of harvesting activity with Dual Inclinometer (Dualer IQ™). The spinal curvature of the subjects in erect standing position at the cervical, thoracic and elbow (flexion and extension) was observed. The range of motion (ROM) in cervical, thoracic and elbow were recorded for each subject during the harvesting activity.

Identification on the incidence of musculoskeletal problems :

The prevalence of work related musculoskeletal disorders (WMSDs) was studied by using Nordic Musculoskeletal Questionnaire (NMQ). Nordic Musculoskeletal Questionnaire (NMQ) was used to determine the prevalence of WMSDs symptoms. NMQ comprises information about work experience and problems on the whole body and body part-specific questions (neck, shoulders and lower back). Body map is the technique used for identifying the sites and intensities of pain. To ascertain the musculoskeletal problems in terms of severity of pain in different body parts among respondents, a 5 point scale, ranging from 'very severe', to 'very mild' was used.

Environmental parameters:

Observations on the climatic conditions were important parameters. Measurements on ambient temperature and humidity were taken using digital hygrometer at the place of work.

Statistical analysis :

Mean, standard deviation and test of significance were worked out for different parameters.

RESULTS AND DISCUSSION

Details of study :

Harvesting of paddy grains is a farm activity performs by more than seventy per cent

of Assamese rural women. On an average they spent six to seven hours in a day with a gap of thirty minutes break for harvesting of paddy grains. In harvesting activity farm women spent thirty to forty days in the season in the month of November and December. Farm women harvest the paddy grains by using traditional sickle. The posture assumed by the farm women in paddy harvesting is standing in forward bending position. Both hands are used for cutting and left hand is used for holding the grains and right hand is used for cutting the grains by sickle.

Physical characteristics and body composition :

The mean age of the respondents was 36.8 years (±2.80). The mean height was 150.80 cm (±5.20) and mean weight was 45.47 kg (±4.60). Mean Lean Body Mass (LBM) of an average Assamese woman was 28.90 kg. The fat percentage of the respondent farm women was 18.12. Data on body type shows that majority of the respondents belonged to 'Ectomorphic' (62%) group with slender body type followed by 'Mesomorphic' (26%) and 'Endomorphic' (12%).

Table 1 : Physical characteristics of the respondents

Physical characteristics	Mean ± SD
Age (years)	36.80 ± 2.80
Height (cm)	150.80 ± 5.20
Body weight (kg)	45.47 ± 4.60
LBM (kg)	28.90 ± 3.20
VO_2 max ($ml.kg^{-1}min^{-1}$)	29.10 ± 4.92
Fat percentage (%)	18.12 ± 1.69

Determination of physical fitness index (PFI) :

Physical fitness index (PFI) of the respondents assessed by using step stool ergo-meter revealed that most of the respondents were (45%) were having 'high average' physical fitness followed by 34% in 'below average' category. Only 15% women were having 'good' physical fitness and minimum percentage (6%) had 'very good' fitness.

Classification of physiological workload based on average and peak heart rate:

The physiological workload of harvesting of paddy grains was assessed on the basis of heart rates (beats/min) and energy expenditures (kJ/min) values as classified by Varghese *et al.* (1994). The average and peak heart rate values while harvesting of paddy grains were found to be 119.23 $b.min^{-1}$ in the morning and 121.82 $b.min^{-1}$, respectively in the afternoon (Table 2). The reason for increasing heart rates in the afternoon may be due to the lack of work rest schedule among the farm women during the harvesting activity. The resting heart rate values of rural women were 87.28 $b.min^{-1}$ in the morning and 88.36 $b.min^{-1}$ in the afternoon. Similar findings was also observed by Gite and Agrawal (2000) compared the improved sickle with local one for harvesting of wheat with women workers and reported that mean heart rate during the work was 119.5 beats/min with improved sickle as against 124.2 beats/min for local sickle (Fig.1). They further concluded that improved sickle could help to reduce the drudgery by 16.5 % during wheat harvesting.

The corresponding energy expenditures values revealed that average and peak energy expenditures of farm women in harvesting were 9.86 kJ.min^{-1} and 11.20 kJ.min^{-1} in the morning and 10.23 kJ.min^{-1}and 11.86 kJ.min^{-1} in the afternoon respectively (Table 2 and Fig. 2). The physiological workload of harvesting of paddy grains on the basis of average heart rate (beats/min^{-1}) and energy expenditure (kJ/min^{-1}) was categorized as 'moderately heavy' in the morning and as a 'heavy' activity in the afternoon. And on the basis of peak heart rate (beats/min^{-1}) and energy expenditure (kJ/min^{-1}) the activity was categorized as 'heavy' activity for both in the morning and in the afternoon.

The average total cardiac cost of work (TCCW) were found to be 1445.20 (beats) in the morning and 1608.54 (beats) in the afternoon respectively while harvesting paddy grains. The physiological costs of work (PCW) were found to be 32.65 (b.min^{-1}) in the morning and 36.45 (b.min^{-1}) in the afternoon respectively.

Rating of perceived exertion :

Perceived exertion of respondents was assessed by using 5 point modified RPE scale. Data revealed that average rating of perceived exertion were as 4.0 in the morning and 4.1 in the afternoon 5 point scales indicating that the exertion perceived by women was reasonably high throughout the harvesting activity (Table 2).

Postural stress and range of motion (ROM) :

Postural stress was studied on the basis of total range of motion of cervical, thoracic, and elbow region while harvesting of paddy grains. The ranges of motions were recorded with the help of Dual Inclinometer. Both static and dynamic movements are adopted in harvesting activity. The posture assumed by the farm women in paddy harvesting is

Table 2 : Average and peak heart rate, energy expenditure and classification of physiological workload

Parameters		Morning Mean ± SD	Afternoon Mean ± SD
Resting heart rate (beats.min^{-1})	Average	87.28 ± 4.23	88.36 ± 5.24
Working heart rate (beats.min^{-1})	Average	119.23 ± 3.84	121.82 ± 3.80
	Peak	127.24	129.33
Energy expenditure (kJ.min^{-1})	Average	9.86 ±2.11	10.23 ± 2.45
	Peak	11.20	11.86
Classification of workload	Average	Moderately Heavy	Heavy
	Peak	Heavy	Heavy
Rating of Perceived Extension (RPE)	Average	4.0	4.1
TCCW (beats)	Average	1445.20 ±216.45	1608.54 ± 301.12
PCW (b.min^{-1})	Average	32.65 ± 4.96	36.45 ± 5.86
Environmental parameters			
Humidity (%)	Average	48	46
Temperature (°C)	Average	29	30

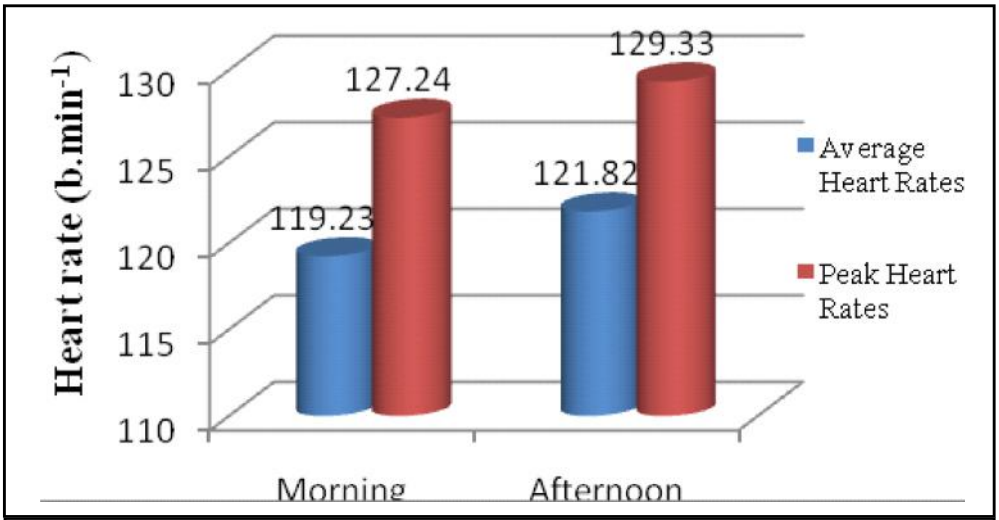

Fig. 1 : Average and peak heart rate

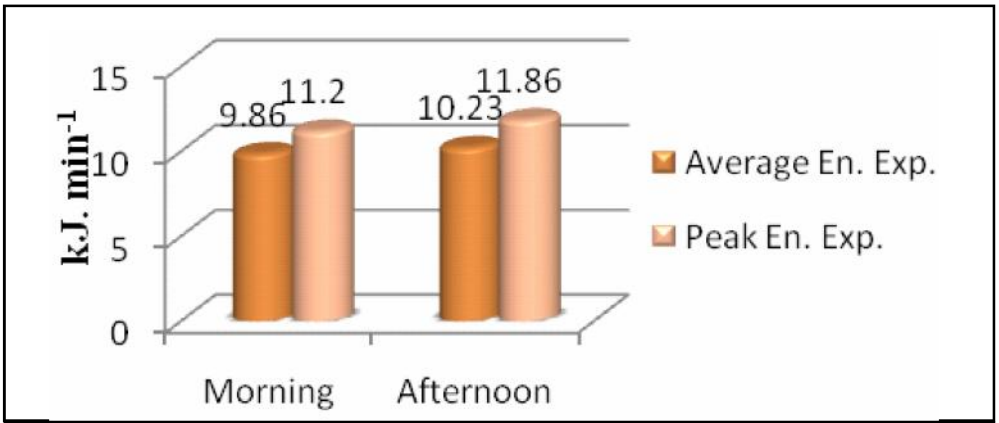

Fig. 2 : Average and peak heart rate

Table 3 : Average flexion and extension of farm women in harvesting of paddy grains		
Body parts	Flexion	Extension
Cervical	58.91^0	51.74^0
Thoracic	13^0	22.6^0
Elbow	48^0	24^0

standing in forward bending position .The range of motion in cervical, thoracic and elbow shows that the angle of average flexion was 58.91^0 and average extension was 51.74^0 in cervical, while for thoracic it was observed to be 13^0 and 22.6^0. The angle of average flexion was 48° and average extension was 24° in elbow indicating deviation in the different body parts (Table 3).

Prevalence of work related Musculoskeletal disorders (WMSDs) :

Prevalence of work related musculoskeletal disorders (WMSDs) of the respondents was assessed by using NMQ method. The highest prevalence of WMSDs symptoms among the farm women were related to body regions such as, neck, low back, ankle, elbow, feet, hand and wrist. The incidences of work related musculo skeletal problems were observed to be 'severe' to 'moderate' in harvesting activity. Cut and wounds are the major occupational health hazards of the farm women. The results showed that the highest prevalence of work related musculoskeletal disorders (WMSDs) were in low-back (82.20 %), shoulder (72.2 %), elbow (70.40 %), wrist (36.8 %), legs (33.3 %), upper back (29.6 %), neck (23.9 %), and knee (22.2 %) and feet (20.7 %).

Environmental parameters :

The temperature and relative humidity was recorded thrice in every 15 minutes during the harvesting activity. The mean temperature was found to be 29°C in the morning hour and 30°C in the afternoon. Mean relative humidity (RH) was observed to be 48 per cent in the morning hour and 46 per cent on the afternoon.

Conclusion:

Ergonomic evaluation of harvesting of paddy grains with traditional sickle shows that it is a 'moderately heavy' activity in the morning hour and 'heavy' activity in the afternoon indicating that of harvesting of paddy grains with traditional sickle and techniques is a drudgery prone activity. Provision of work rest schedule and rotating workers among other farm operation is very important for well being of farm women and reduction of drudgery. The use of Personal Protective Equipments (PPE) is not common among the farm women for reduction of occupational health hazards. Ergonomic interventions through designing of PPE will improve work performance and enhance productivity of farm women.

Acknowledgement :

The author acknowledges the Indian Council of Agricultural Research (New Delhi) for funding the All India Coordinated research Project on 'Ergonomic Study on Farm Women's Drudgery'.

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