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Physiological workload of farm women in paddy storage activity of Assam

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ABSTRACT

Storage of paddy grains is one of the most drudgery prone post harvest activity of Assam, which is predominantly performed by rural women. Assessment of exposure to physiological workload, postural stress and work related musculoskeletal disorders (WMSDs) risk factors can be an appropriate base for planning and implementing interventional ergonomics programmes. In developing countries like India the workers suffer from assorted health problems due to awkward postures and carrying heavy loads (Mukhopadhyay, 2008; Sett and Sahu, 2008). They concluded that WMSDs resulted from frequent trunk bending, twisting and repetitive handling of load at a time and women have a higher prevalence rate of WMSDs than that of men. An attempt was made to assess physical fitness of participants, to determine physiological workload involved in storage of paddy grains and to ascertain muscular and postural stress involved in the activity. Thirty subjects in the age group of 25-35 years who are having normal, non-pregnant, and non-lactating having normal blood pressure and without any major illness were selected for the purpose of the study. Electronic tread mill was used for assessing physical fitness of the respondents. Heart rate was recorded with heart rate monitor and postural stress in different region was measured with inclinometer. For postural analysis Ovaku Work Posture Analysis System (OWAS) method was used. Rating of perceived exertion (RPE) was calculated by using 5 point rating scale developed by Varghese *et al.* (1994). Body map was used to identify the body part discomfort (BPD) in different parts of the body. The findings on physical characteristics of the respondents revealed that mean age of the respondent farm women was 32 years of age. Average height of the respondent farm women was 151.42 cm, average weight was 45 kg. Lean body mass (LBM) of the respondents was 32.35 kg. Body mass index (BMI) of the selected respondents was 20.87 and Vo_2 max ($ml/kg^{-1}.min^{-1}$) was found to be 26.73, respectively. Fat percentage of the respondents was 28. Most of the respondents (47 %) belonged to 'ectomorphic' group. Thirty three per cent of farm women had 'very good' level of physical fitness. The physiological workload of farm women in storing paddy was categorized as 'heavy' activity. It was found that work postures have a distinctly harmful effect on musculoskeletal system of the farm women. The angles of average flexion was highest in upper arm (90.62^0) and extension was in thoracic and it was observed to be 115.30^0 indicating deviation of body parts. The farm women perform the storage activity under acceptable level of

temperature and humidity except illumination. Ergonomic Interventions is necessary for lowering physiological loads and for improving productivity and comfort to the farm women.

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INTRODUCTION

Storage of paddy grains is one of the most drudgery prone post harvest activity of Assam, which is predominantly performed by rural women. Post harvest activities where farm women are involved in India includes threshing, sun-drying, sieving, winnowing, cleaning, collecting and storage of seed, storage of produce, grading and packing for sale. In Assam, more than 70 per cent of farm women are involved in post harvest activities such as threshing, sun-drying, sieving, winnowing, cleaning and storage of paddy grains. In developing countries like India the farm workers suffer from assorted health problems due to awkward postures and carrying heavy loads (Mukhopadhyay, 2008; Sett and Sahu, 2008). The work related musculoskeletal disorders (WMSDs) resulted from frequent trunk bending, twisting and repetitive handling of load at a time. Poor work posture constitute one of the main risk factor for work related musculoskeletal disorders (WMSDs), ranging from minor back problems to severe handicapping. Poor posture increases the physiological cost of work and energy expenditure. Knowledge on physiological cost of work in terms of heart rate and energy expenditure of farm women is of great use in providing necessary changes required in the work environment, work place and method of performing the tasks. 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. The assessment of ergonomic cost of existing tools in farm activities will help to bring necessary modification in available tools or evolve needed technologies to reduce the drudgery of farm women. Keeping this in mind the study was carried out with the following objectives:

– To assess the physiological workload of farm women while storing paddy grains in conventional method.

– To find out the postural stress and ranges of motions of farmwomen in storing paddy grains in conventional method.

MATERIAL AND METHODS

Selection of subjects :

Thirty subjects in the age group of 25-35 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 muscles with 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 electronic Tread mill. 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 the test. 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 storing paddy grains 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. The physiological workload was determined as per the physiological workload index developed by Varghese *et al.* (1994) 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).

Physiological workload index		
Physiological workload	Heart rate (beats/min)	Energy expenditure (kJ/min)
Very light	Upto 90	Upto 5
Light	91-105	5.1-7.5
Moderately heavy	106-120	7.6-10.0
Heavy	121-135	10.1-12.5
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 storage of paddy 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 paddy storage activity with Dual Inclinometer (Dualer IQ™). The spinal curvature of the subjects in erect standing position at the cervical, thoracic, lumbro sacral and upper extremities (flexion and extension) was observed. The ranges of motion (ROM) in cervical, thoracic, lumbro sacral and upper extremities were recorded for each subject during the paddy storage activity. Ovaku work posture analysis system (OWAS) is a practical method for analyzing and controlling poor working postures of the workers which recommends the changes to be made in the body posture of the farm women while working with post harvest activities especially storing of paddy grains**.**

The OWAS action categories for evaluation of working postures

OWAS Scores	OWAS categories	Description
1	Action category I	Work postures are considered usually with no particular harmful effect on musculoskeletal system No actions are needed to change work postures
2	Action category II	Work postures have some harmful effect on musculoskeletal system Light stress, no immediate action is necessary, but changes should be considered in future
3	Action category III	Work postures have a distinctly harmful effect on musculoskeletal system. The working methods involved should be changed as soon as possible
4	Action category IV	Work postures with an extremely harmful effect on musculoskeletal system. Immediate solution should be found to change these postures

Environmental parameters :

Observations on the climatic conditions were important parameters. Measurements on ambient temperature, humidity and illuminance level were taken using digital hygrometer and lux meter at the place of work. The duration of the activity was 30 minutes and activity is performed in the house.

Loading paddy gains

Carrying paddy grains

Unloading paddy grains to the storage place

Statistical analysis :

Mean, standard deviation and correlations were worked out for different parameters and data were interpreted accordingly.

OBSERVATIONS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Details of study :

Storage of paddy grains is performed by more than 70 per cent of the rural Assamese women. After proper sun drying, paddy is stored in storage structures such as *Bhoral*, *Mer*, *Duly*, gunny bags etc for consumption or for commercial purposes. 'Bamboo basket' is a conventional tool used for carrying the grains from yard to the place of storage structures. The storage activity comprises of three sub activities which are performed in sequence. This includes loading grains, carrying grains to the structures and unloading the grains in the storage structures. Mode of carrying the grains is along the waist side or it is a two handed asymmetrical manual handling task. Standing and bending postures were adopted by farm women in the paddy storage activity. Bending posture was adopted for collecting the grains to the basket and standing posture was adopted for carrying and unloading the grains. The farm woman usually carried more than 16 kg of grains at a time and during the operation they are adopting an awkward posture which is above the permissible limits (ILO).

Physical characteristics and body composition :

The mean age of the respondents was 32 years (±5.50). The mean height was 151.42 cm (±4.12) and mean weight was 45 kg (± 4.85). Mean lean body mass (LBM) of an average Assamese woman was 32.35 kg (± 4.21). The aerobic capacity of the respondents is considered to be the best measure for an individual's capacity for doing task and VO_2 max (ml kg^{-1} min^{-1}) was found to be 26.73 (ml.kg^{-1} min^{-1}), respectively indicating high average level of physical fitness of the respondents farm women. The fat percentage of the respondent farm women was 26.73 **(**±5.17). Data on body type shows that majority of the respondents belonged to 'Ectomorphic' (47%) group with slender body type followed by 'Mesomorphic' (22%) and 'Endomorphic' (13%) which are presented in Table 1.

Table 1 : Physical characteristics of the respondents

Physical characteristics	Mean ± SD
Age (years)	32 ± 5.50
Height (cm)	151.42 ± 4.12
Body weight (kg)	45 ± 4.85
LBM (kg)	32.35 ± 4.21
VO_2 max (ml.$kg^{-1}$$min^{-1}$)	26.73± 5.17
Fat percentage (%)	26.73 ± 5.17

Determination of physical fitness index (PFI) :

Data on physical fitness index (PFI) revealed that 33 per cent of farm women had 'very good' 'physical fitness followed by 30 per cent belonged to 'good' and 27 per cent belonged to 'high average' physical fitness. Only 10 per cent farm women had 'low average' group and none of the respondents were found to be 'poor' physical fitness.

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

Classification of the physiological workload of storage 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 storing paddy grains were found to be 127.09 b.min^{-1} and 132.66 b.min^{-1}, respectively (Table 2 and Fig. 1). The resting heart rate values of farm women were found to be 77.85 b min^{-1}. The average and peak energy expenditures in storing paddy grains were found to be 11.48 kJ/min and 12.37 kJ/min, respectively (Table 2 and Fig. 2).

The physiological workload of storing paddy grains on the basis of average and peak heart rates (beats/min) and energy expenditures (kJ/min) were categorized as 'heavy' activity indicating that design modification of conventional basket is required for storing paddy grains. Similar findings were observed by Singh and Sarmah (2004), who found that the load carrying farm activity like storing grains was a 'heavy activity' (125-150 beats min^{-1}) depending upon time spent, amount of load, posture adopted and mode of carrying load while performing the storing activity. The average total cardiac

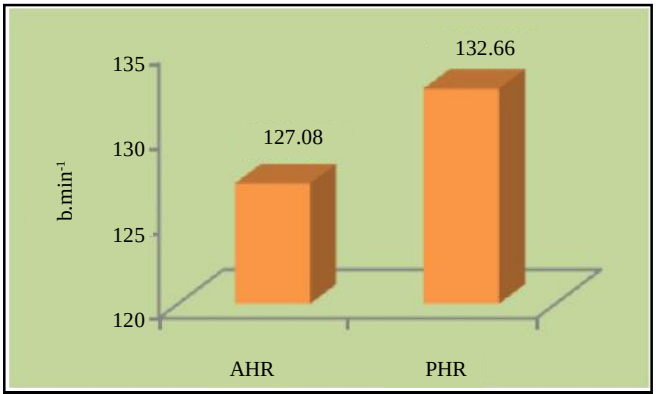


Fig. 1 : Average and peak heart rates

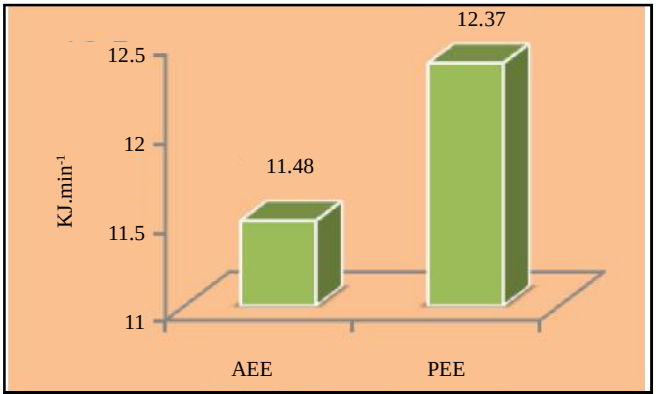


Fig. 2 : Average and peak energy expenditures

Table 2 : Physiological parameters of storage of paddy by conventional basket (n=30)

Physiological parameters		Conventional basket	Mean ± SD
Average resting heart rate (b.min^{-1})		77.85	77.85 ± 4.79
Average working heart rate (b.min^{-1})		127.09	127.09 ± 2.60
Average peak heart rate (b.min^{-1})		132.66	
Average energy expenditure (kJ. min^{-1})		11.48	11.48 ± 0.41
Peak energy expenditure (kJ. min^{-1})		12.37	
Total cardiac cost of work (TCCW) (beats)		2337.54	2337.54 ± 357.10
Physiological cost of work (PCW) (b. min^{-1})		61.51	61.51 ± 9.39
Average RPE		4.22	4.22 ± 0.32
Physiological workload			
Average		Heavy	
Peak		Heavy	
Total time taken for the experiment (min)		30 min	
Out put parameters			
Actual experimental time (min)		38 min	
Environmental parameters			
Mean temperature (°C)		22	
Mean relative humidity (%)		49	
Illuminance level (lx)	Loading grains	95	
	Carrying grains	83	
	Un-loading grains	21	

cost of work (TCCW) and physiological cost of work (PCW) were found to be 2337.54 (beats) and 61.51 (beats/min), respectively while storing paddy grains.

Rating of perceived exertion :

Subjective perception of exertion is another method for providing equally reliable information for assessment of workload. Perceived exertion of respondents was assessed by using 5 point modified rating of perceived exertion (RPE) scale (Varghese *et al.,* 1994) just after completion of the activity. Data on perceived exertion revealed that average rating of perceived exertion was 4.22 in 5 point scales indicating that the exertion perceived by farm women was reasonably high throughout the storage of paddy grain activity (Table 2).

Postural stress and range of motion (ROM) :

From the analysis of working posture by OWAS method (Table 3) it was further evident that out of the three different types of postures adopted in storage activity the posture adopted in unloading paddy grains need 'corrective measures' as soon as possible while the postures adopted in loading grains required 'no immediate action' but changes are needed in near future. In carrying paddy grains, the adopted posture need not require any change. Thus, it was clear that by remaining in awkward postures repeatedly during those activities, these workers suffered from discomfort affecting different body parts.

The ranges of motions (ROM) were recorded with the help of dual inclinometer. Both static and dynamic movements were adopted during storage activity. The postures assumed by the farm women in paddy storage were standing in forward bending position. The range of motion (ROM) in cervical, thoracic and lumbro scaral showed that the angle of average flexion was 30.60° and average extension was 38.00^0 in cervical, while it was observed to be 62.50° and 115.30° for thoracic and in

Table 3 : Analysis of working posture of farm women in storage activity **(n=30)**

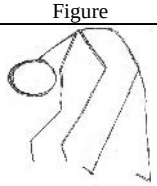
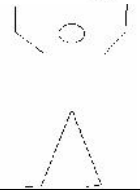
Activity	Figure	Code	Action category	Remarks
Loading grains from the floor		2122	2	Corrective measures in the near future
Carrying grains		3172	1	No corrective measures
Unloading grains		4322	3	Corrective measures as soon as possible

Table 4 : Average flexion and extension of farm women in storage activity **(n=30)**

Body parts	Flexion	Extension
Cervical	30.60°	38.00°
Thoracic	62.85°	115.30°
Lumbro scaral	32.33°	28.83°
Upper extremities		
Upper arm	90.62°	77.12°
Lower arm	35.09°	68.20°
Wrist	57.80°	48.58°

lumbro scaral region average flexion was 32.33° and extension was 28.83°. The angles of average flexion were 90.62°, 35.09°, 57.80° and average extensions were 77.12°, 68.20°, 48.58° in upper extremities indicating deviation in the different body parts (Table 4).

Environmental stress :

The temperature and relative humidity were recorded thrice in every 15 minutes during the storage activity. An observation of the Table 2 showed that the mean temperature was found to be 22°C and mean relative humidity (RH) was observed to be 49 per cent. Farm women performed storage activity within the acceptable limit or comfort zone limit of temperature and humidity is due to fact that the experiment was conducted in winter season. An assessment of visual comfort of the subjects regarding the lighting condition revealed that the illuminance level were 95 lx in loading grains 83 lx in carrying and 21 lx in unloading grains to the storage structure (Table 2). The work place was found to be non-conducive to worker which is below the recommended standards for general work area especially in unloading grains (150 lx). This is due to the fact that there was no provision of windows for natural lighting in the storage structures. Computed 'r' value indicated that there was a positive correlation between heart rate (HR) and relative humidity (RH) r = 0.50, heart rate (HR) and Temperature (r = 0.56), energy expenditure (EE) and temperature (r =0.69) and energy expenditure (EE) and relative humidity RH (r =0.36).

Conclusion :

Ergonomic evaluation of storage of paddy grains shows that the physiological workload of farm women while storing paddy grains was categorized as 'heavy' activity indicating that design modification of conventional bamboo basket is necessary for farm women. From the analysis of postural load it was found that work postures have a distinctly harmful effect on musculoskeletal system of the farm women. The working methods should be changed as soon as possible. For most efficient functioning of muscles, range of motion of body parts should be minimized. Ergonomic interventions are essential for reducing physiological cost, health hazards, improving productivity, comfort and workable life of the farm women during storage of paddy grains.

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