

Assessment of energy balance of Indian farm women in relation to their nutritional profile in lean and peak agricultural seasons¹

Dr Suman Singh^{a*}, Dr Sushma Sinwal^b and Dr Hemu Rathore^b

^a Associate Professor, FRM Department, College of Home Science, Maharana Pratap University of Agriculture and Technology, Udaipur, INDIA.

^b FRM Department, College of Home Science, Maharana Pratap University of Agriculture and Technology, Udaipur, INDIA.

Abstract. In India, the farm women are not only involved in household activities but also contribute in various farm operations, animal husbandry. The objective was to assess nutritional profile of the farmwomen and their occupational health problems, to compare the physiological workload in lean and peak seasons and to find out relationship between physiological workload and nutritional intake. The study was conducted on a sample of 90 farmwomen. Energy Intake was calculated using physiological fuel values of carbohydrate, fat and protein. Energy Expenditure Rate (EER), Total Energy Expenditure (TEE) and Energy Balance were calculated. The physiological workload was assessed using sub-maximal workload technique. The results revealed that all the respondents of all categories were, more or less, performing all the agriculture, allied and household activities. In all the agriculture activities physiological hazards such as body pain and fatigue were dominant. Dietary, nutritional and energy intake was lower for heavy workers, from all landholding and BMI categories. HR and OCR were in linear relationship in all BMI categories. Physical work capacity increased with good nutritional status and decreased with age. Regression equations were suggested for calculating oxygen consumption (y) at their known heart rate (x) during various agriculture operations.

Keywords: Dietary adequacy, energy expenditure, hazard prone, energy intake, work capacity

1. Introduction

India's ancient scripture ascribed a divine status to women; Laxmi, Durga, and Saraswati are the three great goddesses of prosperity, power and wisdom. The ancient scripture declared that GOD live where women are worshipped. Some historians believe that it was women who first domesticated crop plants and thereby initiated the art and science of farming. While men went out for hunting in search of food, women started gathering seeds from the native flora and began cultivating from the point of view of food, feed, fodder, fiber, and fuel.

The women play a significant and crucial role in

agricultural development and allied fields including crop production, livestock production, horticulture, agro/social forestry, fisheries etc. is a fact long for taken for granted and also ignored. The nature and extent of involvement in agriculture, no doubt, varies widely among different ecological sub-zones, farming system, caste, classes, and stages in the family cycle. But regardless of these variations there is hardly any activity in agricultural production, except ploughing, in which women are not actively involved.

In India, although women perform many fold tasks at working sites as well as at home, even a major portion of food is served first to adult males whether

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* E-mail : sumanfrm@rediffmail.com

earning or not. The remaining amount of food is than distributed to women and children of the family although earning. As a results diet becomes deficient not only quantitatively but also qualitatively. Nutrition plays an important role in the efficiency and welfare of worker as adequate diets are essential for optimum output. Work either light or heavy calls for additional supply of energy or other nutrients. Low intakes of nutrient reduce the physical capacity to work and increase the extent of fatigue accident rate and sickness. Improvement in work efficiency and output require adequate diet, sufficient not only in calories but also protein, minerals and vitamins which must be made available. But women are discriminated against in access to basic necessities such as food and medical care. When family resources are meager, the short fall in the women's food intake is likely to be twice as high as for the male members of the household. Amongst children, consistently higher proportions of girls are found to be malnourished, with the situation particularly acute amongst the landless families. Giving the link between nutritional deficiency and susceptibility to infection, this leads on to a higher incidence of illness amongst female children, which coupled with less access to medical treatment for girls, results in higher mortality rates for young girls than for boys. Among adults, a greater percentage of women than men receive no medical treatment in the event of illness and among those treated, the reliance on traditional medicine is higher amongst women whereas men receive more expensive modern medical treatment [1].

Thus, an overview of data emphasizes that women's access to food within the family or household is below desired levels and significantly less than that of men's. Also, women's energy intake is below their expenditure levels, where as men from the same poor families have intakes equal, or exceeding their expenditure level. The sector that must be given the most importance is being given the least importance. Through the proposed study the investigators endeavored to bring out physiological workload in terms of energy expenditure (EE) of farmwomen in various household and agricultural activities in lean and peak agricultural seasons.

2. Objectives

- a) To assess nutritional profile of farmwomen.
- b) To assess occupational health problems faced by farmwomen.
- c) To compare the physiological workload of farmwomen in lean and peak agricultural seasons.
- d) To find out relationship between physiological workload and nutritional intake of farmwomen.

3. Methodology

The present study was conducted in selected villages of Rajasthan in India. A sample of 90 non-pregnant, non-lactating farmwomen, not suffering from any chronic disease and engaged in agricultural activities from last 10 years were selected purposively i.e. 30 subjects in each landholding category viz. small farmer (SF), marginal farmer (MF) and landless agricultural laborers (LAL).

Activity schedule of the respondents in both lean and peak agriculture season was gathered using observation cum recall method. An Interview schedule was prepared to procure data on type of hazards in each of farm activities carried during Peak season viz. land preparation, sowing, weeding and harvesting. For assessment of hazard proneness of farmwomen, a Scale for Assessment of Occupational Health Hazards (SAOHH) among farmwomen [18] was used. Body measurements which are simple and easy to measure at the same time giving maximum information on nutritional status were chosen viz height and weight.

On the basis of BMI classification a sub sample of 18 subjects was selected i.e. six women from each landholding category representing the different grades of BMI i.e. obese, normal and CED. Dietary survey by 24 hour recall method was conducted using the standardized cup- set to find out the intake of various foods in different meals of the day during both lean and peak seasons. Hemoglobin level of these subjects was estimated with the help of expert. The adequacy of diet was assessed in terms of type of food consumed and the intake of nutrient. The details regarding the consumption of various food items and food groups like cereals, pulses, nuts and seeds, oil and fats, fruits and vegetables, milk and milk products, flesh etc. were recorded. The intake of the food was compared with the average intake as given by NIN [13]. Diet composition was assessed in terms of intake of nutrients and per cent of energy in the diet. Iron, Energy (Kcal) and the nutrients

contributing energy i.e. protein (gm), carbohydrate (gm), and fat (gms) including both visible and invisible fat content of the diet per day was calculated separately and compared with RDA suggested by NIN [13]. Energy was calculated using physiological fuel values of carbohydrate, fat and protein.

For the calculation of Energy Expenditure Rate (EER) of the subjects for every activity performed through out the day during these seasons, heart rate values of all 18 subjects using POLAR heart rate monitor was recorded. After collecting data of HR for every activity performed in a day during lean and peak season it was used to calculate *Energy Expenditure Rate (EER)* of each activity carried out by the women using the formula given by Varghese et al. (1995)

Total Energy Expenditure (TEE) on each activity was calculated using energy expenditure rate of the activity multiplied by time spent on it in minutes.

To calculate **total daily energy expenditure**, energy expenditure on each and every activity of the day was added with Basal Metabolic Rate (BMR) of the subject. Energy Balance was calculated during lean and peak season as:

$$\text{Energy Balance} = \text{Energy intake} - \text{Energy Expenditure}$$

To assess the physiological workload of the respondents, an experiment on treadmill was designed using sub-maximal workload technique for determining the aerobic capacity of farmwomen and also to develop regression equations for estimating oxygen consumption at their known heart rate. For calculating the aerobic capacity and oxygen consumed at various heart rates the estimated oxygen uptake at heart rate of 110-180 beats/min for subjects from CED, Normal and Obese category was plotted and regression equation was developed for farmwomen from different BMI class viz. CED, Normal and obese and also a general equation for farmwomen. The relationship between physiological workload in terms of heart rate and aerobic capacity (during sub-maximal workload on treadmill) and nutritional status in terms of weight, hemoglobin level, iron, protein intake, and energy intake was also determined using co-relation coefficient.

4. Results and Discussion

4.1. Background Information

The background information of the respondents depicts that majority of the respondents (75%) were in young age group i.e. below 40 years and majority of respondents in all categories were engaged in agriculture activities for about 15 years. Nearly three fourth of the total respondents from all the categories were from medium size families with 5-10 members. A vast majority from MF (93.44%) and SF (100%) had irrigated land.

4.2. Participation of Women in Farm, Allied (dairy) and Household Activities

Women play a significant role in farming and management activities. These women participate in most of the agriculture activities like manuring, land preparation, sowing, weeding, transplanting, hoeing applying fertilizer taking care of standing crops, harvesting, threshing, carrying the produce from farm to home, and storage of food grains. in activities like weeding, land preparation, sowing, threshing, harvesting, maize shelling, groundnut decortications and uprooting of seedlings participation of farmwomen was 100 percent which was unaffected by land holding status. Whereas, time devoted to different activities by respondents of different land holdings was varying as in maize shelling and groundnut decortications time spent by LAL, MF was 240 min per day whereas it was just half i.e. 120 min per day for respondents of SF. And same difference was in time contributed in sowing threshing and harvesting it was 480 min/day in LAL and MF and 240 min/day in SF. Main allied activity carried out by the respondents was animal husbandry. As livestock development has always been a major concern in the Indian economy along with agriculture. Animal care is the domain of farm women. Housework (childcare and house hold chores) and economically extended work (i.e. fetching of water and fuel and making of cow dung cakes) which is crucial for family's survival, is still exclusively a women's responsibility. Except for fetching fuel, it was the female children who extended a helping hand to their mothers for the above tasks. Women absolutely do not get any help from their men folk for domestic activities and economically extended activities.

4.3. Hazard Proneness of the Respondents

Highest percentage of respondents i.e. 60 percent (LAL 50%, MF 60%, and SF 70%) fell in the category of 'moderate' incidence of health hazard while 30 percent (LAL 33%, MF 33% and SF 23%) of total respondents were exposed to 'high' category of hazard proneness and remaining 10 percent were in the severe category of hazard proneness (table-1).

Significant fact observed was that no respondent was reported to be in the 'low' category of health hazards. BMI and hazard proneness of the subjects were negatively correlated which meant that as BMI decreases the incidence of hazard proneness increases. Corroborated findings were reported [19] that most of the rural farm women were in the category of 'High' incidence (74.0 per cent) followed by 'moderate' (34.0%).

Table 1

Percentage distribution of farm women in different categories of hazard proneness

S. No.	Categories of hazard proneness	LAL (n=30)	MF (n=30)	SF (n=30)	Total (N=90)
1.	Low incidence of hazards	0	0	0	0
2.	Moderate incidence of hazards	50.0 (15)	60.0 (18)	70.0 (21)	60.0 (54)
3.	High incidence of hazards	33.3 (10)	33.3 (10)	23.3 (7)	30.0 (27)
4.	Severe incidence of hazards	16.7 (5)	6.7 (2)	6.7 (2)	10.0 (9)

4.4. Nutritional Profile of the Respondents

4.4.1. Anthropometry of the Respondents

The classification of height as the percent of standard depicted that less than half (44%) of the respondents from all the categories were normal in height. Only one fourth (25%) of the total respondents were normal in weight. Less than half (47% in LAL and 43% SF) of the respondents fell in normal grade of BMI (Body Mass Index), while 57 percent of MF had normal BMI, and ample no of the respondents were either chronic energy deficient (33% in LAL, 20% in MF and 30% in SF) or obese (20% in LAL, 23% in MF and 26% in SF), which clearly indicates some kind of nutritional imbalance. It was reported that deficits in growth are readily indicated by decreased values of anthropometric measurements [17]

4.4.2. Dietary Adequacy

The general dietary pattern of farmwomen revealed that three meal pattern was followed by most of the women. Almost all the women were taking tea with or without chapatti (bread). Some of them were taking milk instead of tea. Dietary Intake of 18 farmwomen, selected on the basis of BMI, was studied for their daily food intake by 24 hours recall method. It was revealed that the diet of the farmwomen from all the landholding categories in both the seasons was notably inadequate with comparison to balance diet in all the food groups except that of cereals, roots and tubers, milk and milk products. Daily diet of farmwomen from different land holding categories was cereal based with little consumption of other food items. The daily consumption of almost all the food items in all the

landholding categories was slightly higher during peak season than in lean season. But the difference was non significant in all the food groups.

Energy Intake in LAL was 11260 kJ/day (92 % of RDA), in MF it was 10294 kJ/day (84% of RDA) and in SF it was 10996 kJ/day (90% of RDA) in lean season. Whereas, during peak season energy intake was 11541, 11408 and 10691 kJ/day in LAL, MF and SF respectively, which was 94, 93 and 87 percent of RDA (12168 kJ/day). NIN 1998, have suggested contribution of 10-12, 20-25, and 60-70 percent respectively from protein, fat and carbohydrate in a balance diet. It was 10.6, 14.3 and 74.9 percent of total energy intake during lean agriculture season from protein, fat and carbohydrate respectively and in peak season it was protein (10.9%), fat (13.2%) and carbohydrate (75.9%) of the total energy intake. The contribution of energy from protein was same as per NIN [13] in both seasons but contribution of energy from fat was lower and carbohydrate was higher in the study group than that suggested by NIN, it may be due to higher intake of cereals and potato and low consumption of fats and oils, reason being high cost and low purchasing power.

Average protein intake was 72, 70, and 71 grams/day in respondents from LAL, MF and SF respectively during lean season; it was 144, 140 and 142 percent of RDA. Whereas; in peak agriculture season the daily intake of protein was 74, 72 and 72 grams/day which was 148, 144 and 144 percent of RDA (20 grams). Difference in daily intake during lean and peak season was non-significant.

Visible fat intake was 13.7, 14.15 and 13 grams respectively in respondents of LAL, MF and SF during lean season and which was about 68, 70 and 66 percent of RDA (20 gms/day) and during peak

season the fat intake was 13, 15.15 and 15.9 grams/day which was 65, 75 and 79.5 percent of RDA respectively in LAL, MF and SF categories. But, the difference was non-significant between intake of fat during lean and peak agricultural season in all the three categories of land holding.

Mean intake of carbohydrate by respondents of

LAL, MF and SF was 515, 508 and 489 grams respectively in lean season. Whereas, in peak season it was slightly higher than lean season i.e., intake was 525 grams by respondents from LAL, 517 grams by respondents in MF and in SF it was 491 grams/day. Difference in intake during lean and peak season for all categories was non-significant. (Table 2 & 3).

Table 2

Mean \pm SD nutrient intake of the respondents during lean and peak season

Nutrients	RDA	Categories of landholdings					
		LAL (n=6)		MF (n=6)		SF (n=6)	
		Lean season	Peak season	Lean season	Peak season	Lean season	Peak season
Energy	12168 kJ*	92.53 \pm 6.60	94.84 \pm 6.8	84 \pm 10.36	93.75 \pm 6.4	90.3 \pm 5.5	87.86 \pm 3
Protein	50 grams	144 \pm 10.8	148 \pm 8	140 \pm 7	144 \pm 11	142 \pm 9	144 \pm 8
Fat(Visible)	20 grams	68.5 \pm 15.9	65 \pm 13	70 \pm 9.13.3	75 \pm 13	66.5 \pm 15	79.5 \pm 25
CHO	-	-	-	-	-	-	-
Iron	30 mg	38 \pm .56	37 \pm .39	39 \pm .58	40 \pm .63	41.6 \pm .74	42 \pm .97

RDA as Suggested by NIN (1998) for heavy worker women * (2925 Kcal)

Table 3

Mean \pm SD Percent intake of RDA of the respondents in lean and peak agriculture season

Nutrients	Categories of landholdings (N=18)									
	LAL (n=6)			MF (n=6)			SF (n=6)			
	Lean season	Peak season	t-values	Lean season	Peak season	t-values	Lean season	Peak season	t-values	
Energy (kJ)	11260 \pm 804	11541 \pm 740	0.174 NS	10294 \pm 1067	11408 \pm 779	0.252 NS	10996 \pm 670	10691 \pm 441	0.311 NS	
Protein (gms)	72 \pm 5.4	74 \pm 4.6	0.82 NS	70 \pm 5.7	72 \pm 5.16	0.464 NS	71 \pm 4.6	72 \pm 4.5	0.119 NS	
Fat (gms)	Total	39 \pm 17	41 \pm 8	0.365 NS	44 \pm 9.8	42 \pm 3.6	0.359 NS	44 \pm 9.2	34 \pm 2.63	0.933 NS
	Visible	13.7 \pm 3.18	13 \pm 2.67	0.212 NS	14.15 \pm 2.66	15.15 \pm 2.6	0.216 NS	13 \pm 3.01	15.9 \pm 5.16	0.059 NS
Carbohydrate	515 \pm 35	525 \pm 32	0.129 NS	508 \pm 36	517 \pm 84	0.312 NS	489 \pm 16	491 \pm 17	0.371 NS	
Iron (mg)	11.33 \pm 1.5	11.16 \pm 1.3	0.53 NS	11.76 \pm .76	11.83 \pm .89	0.63 NS	12.5 \pm 1.26	12.56 \pm 1.23	0.93 NS	

NS - Non Significant

4.4.3. Hemoglobin Level

No respondent from any of the land holding categories were normal and all were suffering from some degree of anemia. In LAL 66 percent, MF 100 percent and SF 83 percent were suffering from moderate anemia. And very few LAL (34%) and SF (17%) were suffering from mild anemia. Similar findings were also observed in other studies [15] noted that only 11.5 percent women had normal Hemoglobin level of 12-14 grams/100 ml blood. A study conducted in Mumbai, India reported that 82.2 per cent of non-pregnant women fell below recommended level of Hemoglobin [6]. [19] and [5]) reported that all the subjects under the study exhibited lower Hemoglobin range than standards. Above results shows that iron deficiency anemia is common among adult women in India.

5. Energy Expenditure of the respondents

Energy Expenditure was calculated from heart rate data of the activities.

5.1. Agriculture activities

In Land Preparation average energy expenditure was highest in MF (4485kJ/day) because average time devoted to the activity by them was highest i.e. 443minutes/day. In Sowing, average working heart rate (AWHR), time spent and energy expenditure (EE) on the activity was highest in LAL i.e. 93 beats/minute, 448 minutes/day and 2730 kJ/day. In Weeding AWHR was almost equal in all the categories of landholdings 108 beats/min in LAL and MF and 110 beats/min in SF. AEER was almost equal in all three categories but, energy expenditure

was highest in LAL 3348 kJ/day. AWHR was highest in SF i.e. 118 beats/min. Whereas, EE was highest in LAL (4058 kJ/day) followed by MF (3200 kJ/min) and lowest was in SF (1476 kJ/min) as time spent on the activity was also decreasing in the same order i.e. 433, 346 and 146 min/day in LAL, MF and SF respectively. According to [4] AWHR for stubble collection was 111 beats/min, Average Energy Expenditure rate (AEER) was 8.94 kJ /min with TCCW-1022 beats and PCW- 34.07 beats/minute.

It emphasized the fact that energy expenditure was highest for every activity among respondents of LAL and the probable reason was they spent more time on all agriculture activities because they worked as paid laborer and had to work for 8 hours or more per day. And among all activities AWHR was highest in land preparation, followed by weeding, than harvesting and lowest in sowing. Energy expenditure also followed same pattern i.e. highest in land preparation (3668 kJ/day) and lowest in sowing (1648 kJ/day). More time was spent on land preparation but lowest on weeding. In nut shell it can be concluded that, land preparation was most time consuming, labour consuming and heavy activity followed by harvesting, weeding and sowing which was least time and labour consuming.

5.2. Allied (Dairy) Activity

In Cutting and Collecting Fodder AWHR (121 beats/min), time spent (87 minutes in lean season and 57 minutes in peak season), AEER (10.6 kJ/min), EE/day (925 kJ), TCCW (933 beats) and PCW (31 beats/minute) was almost equal for all respondents from all land holding categories. Similar finding were reported in [3] for cutting and collecting fodder viz. AWHR- 116.7 beats/min, AEER- 9.8 kJ/minute, TCCW- 2531 beats and PCW- 34.32 beats/min. For cleaning animal shed on an average AWHR, AEER, time spent, EE, TCCW and PCW was 112 beats/minute, 9.1 kJ/minute, 30 minutes, 268 kJ/day, 754 beats and 25.23 beats/minute, respectively. Collaborating finding were reported for cleaning animal shed viz. AWHR was 116 beats/minute, AEER was 9.7 kJ/min, time spent (84 minutes), TCCW 430 beats and PCW 19.5 beats/minutes[20]

In Milking AWHR (112.7 beats/min), AEER (9.2 kJ/min), time spent (40 min), EE (368 kJ/day), TCCW (770 beats) and PCW (25.7 beats/min) were almost same for all the respondents. AICRP (1996-2001) in a report stated that AWHR for milking was 108 beats/ min; AEER was 8.39 kJ/ min. For feeding

animals on an average AWHR was (84.5 beats/min), AEER (4.7 kJ/min), time spent (46 min in lean season and 25 min in peak season) was same for all categories. For making dung cakes AWHR was approximately same in all categories, LAL (84.7 beats), MF (85.8 beats/min) and SF (87.3 beats/min), AEER was 4.7, 5.1 and 5.2 kJ/min respectively in LAL, MF and SF, time spent was same (30 minutes) during lean and peak seasons in all categories.

5.3. Household activities

From daily performed household activities cooking was most time consuming (120 min/day in lean season) whereas; washing clothes and fetching water were most energy consuming activities with AWHR 113 beats/min and 114 beats/min and lowest AWHR and EER was observed in personal care (80 beats/min) and child care (81 beats/min). Cutting and collecting wood was the most energy (4906 kJ/day) and time consuming (480 min/day) activity in weekly performed activities.

6. Total Daily Energy Expenditure (TDEE)

6.1. Lean Season

Perusal of data explained that washing clothes among household activities was most energy consuming (838 kJ/day) activity and fodder cutting was most energy consuming (926 kJ day) activity in dairy, irrespective of landholding categories. Cooking (625 kJ), fetching water (569 kJ), sweeping (602 kJ) were also amongst high energy demanding activities. Whereas; child care (258 kJ) and personal care (241 kJ) were comparatively low energy demanding activities. Highest total energy expenditure was among MF (11056 kJ/day), followed by LAL (11041 kJ/day) and lowest was in SF (10793 kJ/day). And in BMI categories highest TEED was in Obese (11750 kJ in LAL, 12339 in MF and 11535 in SF), followed by Normal (11185 kJ in LAL, 10629 kJ in MF and 10986 kJ in SF) and lowest in CED (10188 kJ in LAL, 10199 kJ in MF and 9858 kJ in SF).

6.2. Peak season

Farm women toil hard in labour from early morning till late night. Demand on their time and energy increases all the more in peak agriculture

season, as during this period in addition to completion of time bound agriculture action there is no escape from daily chores. Highest TDEE was at the time of Land preparation activity (12446 kJ/day) it was depicted that from LAL category women in CED grade spent maximum total energy per day (11839 kJ/day) during land preparation. Obese women from all the land holding categories except LAL spent highest total energy (13361 kJ in MF and 11451 kJ in SF) from their counterparts with normal and CED grade of BMI. Second highest TDEE was in weeding (10947 kJ/day), woman from LAL categories spent maximum mean energy (3573 kJ) in weeding as respondents from this category are hired. This was followed by MF category (1935 kJ) and than SF (1251 kJ). At the third rank was harvesting (10708 kJ/day) similar results as weeding were observed, the LAL category spent maximum energy per day in harvesting activities (3897 kJ/day) as compared to the respondents from MF (3123 kJ/day) and SF (1470 kJ/day) category of landholding. Lowest TDEE was observed during the time of

sowing (10449 kJ) it was evident that in sowing activity respondents from LAL category spent maximum energy per day (2688 kJ) as compared to respondents from MF (1218 kJ) and SF (1032 kJ).

It was evident that 40-50 percent was spent in maintaining Basal Metabolic Rate (BMR) of the body. The energy input by the respondents varied with activity in peak season. The maximum percentage of TDEE was in land preparation (29%), followed by Harvesting (27%), than Weeding (20%) and lowest demanding was sowing (16%) but, they do not refrain from routine activity and spend maximum energy (33% of TDEE) in it during sowing season (table-3). A common phenomenon observed in all seasons was that, if the percent energy expenditure was less in peak season activity the corresponding energy expenditure percent increased in routine activity. This clearly signifies that about 52-60 percent of TDEE was spent by respondents in daily activities whether it was routine or peak agriculture activity and rest 40-50 percent in maintaining BMR.

Table 4

Energy expenditure ratio in lean and peak agriculture season

ENERGY EXPENDITURE	Agricultural Activities (Peak Season)								Lean Season	
	Land Preparation		Sowing		Weeding		Harvesting		kJ/day	%
	kJ/day	%	kJ/day	%	kJ/day	%	kJ/day	%		
Routine Activities	3513	28	3513	33	3513	32	3513	33	5652	52
Peak Activity	3633	29	1646	16	2253	20	2830	27	-	-
BMR	5284	43	5284	51	5284	48	5284	50	5310	48
TDEE	12446	100	10449	100	10947	100	10708	100	10963	100

7. Energy Balance

When energy expenditure is equal to energy intake it is called energy balance whereas, if energy expenditure exceeds energy intake than it shows negative energy balance and if energy expenditure is

lower than energy intake than it shows positive energy balance. Energy balance was positive during lean season irrespective of BMI class. In peak season energy balance was positive during Sowing and Weeding, and balance was negative during Land preparation and harvesting. (Table-5)

Table 5

Data regarding Energy Intake, Energy Expenditure, Energy Balance and percent difference in EI and EE in various BMI classes

Season	BMI class	Energy Intake	Energy Expenditure	Energy Balance	Percentage Difference	
Lean Season	CED	10328	10082	246	2.3	
	Normal	11104	10933	170	1.5	
	Obese	12169	11875	295	2.4	
Peak Season	Land Preparation	CED	10490	11546	-1057	-10.1
		Normal	11304	12721	-1417	-12.5
		Obese	11847	13071	-1224	-10.3
	Sowing	CED	10490	9479	1010	9.6
		Normal	11304	10783	521	4.6
		Obese	11848	11421	426	3.6
	Weeding	CED	10490	10136	354	3.4
		Normal	11304	10866	438	3.9
		Obese	11848	11838	9	0.07

Season	BMI class	Energy Intake	Energy Expenditure	Energy Balance	Percentage Difference
Harvesting	CED	10490	10792	-302	-2.8
	Normal	11304	11550	-247	-2.1
	Obese	11848	12781	-934	-7.8

The results are in close conformity with the findings of [8] who also reported energy intake less than energy expenditure in farm women. In the study group of [10] the mean energy intake was 2085 Kcal and showed a negative balance of 378 Kcal. In male and female rice farmers a low energy intake in comparison to their expenditure was also found [12]. Similarly, negative balance was reported by [14], [7] and [11]

8. Physiological Work Load of the subjects

8.1. Maximum Heart Rate and Aerobic Capacity of the Subjects

The observed data of heart rate and oxygen uptake at all speeds and slope for all categories of BMI during sub-maximal experiment conducted in a controlled environment of laboratory on computerized tread mill showed that with increasing grade, HR and OCR also increased in linear fashion in all respondents falling in different categories of BMI. The data when plotted on graph for extrapolation of oxygen uptake (VO_2 max/ aerobic capacity) at maximal heart rate (MHR) showed that the MHR was 185.14 ± 2.25 beats/min in subjects falling in chronic energy deficient (CED) grade of BMI, 184.45 ± 2.2 in subjects falling in Normal category and 180.80 ± 2.46 beats/min in subjects of Obese category. The aerobic capacity (VO_2 max) was 1.11 ± 0.32 l/min (26.4 ± 7.43 ml/ kg/ min) in CED, 1.25 ± 0.03 l/min (24.071 ± 2.24 ml/ kg/ min) in subjects of Normal category and 1.07 ± 0.12 l/min (16.480 ± 2.85 ml/ kg/ min) in subjects of obese category of BMI.

Detailed Studies of migrant laborers in Brazil have shown an association of poor nutritional status, identified from anthropometry, with lowered work capacity (Desai, 1989). Similar data were emerging from India, where good correlation was found between body weights, BMI, work capacity in undernourished individuals in Hyderabad [16]. In the Indian study, it has shown that their total work capacity reduced with low BMI status. In a study on relation between iron deficiency without anemia and physical performance [21] showed that iron depleted group had a significantly lower VO_2 max.

8.2. Relationship between Physiological workload and Nutritional Profile of the Subjects

The study clearly depicted that Maximum Heart Rate (MHR), Aerobic capacity (VO_2 max) and exercise time decreased with increase in age in all the respondents from all BMI class. MHR and VO_2 max increased with weight in CED and decreased with weight in Obese, whereas; Exercise time decreased with increasing body weight in all respondents of all BMI classes. Maximum Heart Rate, Aerobic capacity and exercise time increased with increase in intake of protein, iron and energy in all BMI classes. And the same trend was emphasized in Hemoglobin level that is as Hemoglobin level increased MHR and VO_2 max also increased in same manner in all categories of BMI (Body Mass Index). It can be concluded that as nutritional status & BMI level improves, capacity to work also increases i.e., worker gets less tired and productivity is increased. Whereas, with increase in age and weight capacity of worker to do work decreases.

8.3. Regression equation

Following equations were suggested for calculating oxygen consumption (y) at the known heart rate (x) during various agriculture operations.

$y = 0.007x - 0.301$	for subjects in CED grade of BMI.
$y = 0.0081x - 0.271$	for subjects in Normal grade of BMI.
$y = 0.0069x - 0.251$	for subjects in Obese grade of BMI.
$y = 0.0086x - 0.469$	for subjects in General category.

There was non-significant difference in estimated and calculated values of oxygen consumption from regression equation at increasing heart rate (110-180 beats/min).

9. Conclusion

Therefore, it can be said that diet of farmwomen is deficient in terms of energy, protein and iron due to

which the physical work capacity is decreased. Agriculture possesses many occupational health hazards to the workers and their hazard proneness is also correlated with their nutritional status in terms of Body Mass Index. As Body Mass Index of a person decreases their hazard proneness increases.

Total daily energy expenditure shows that 40-50 percent of the total energy expenditure was on Basal Metabolic Rate and remaining that is about 52-60 percent of TDEE was spent by respondents in daily activities whether it was routine or peak agriculture activity.

Energy balance in lean season, during sowing was positive in all the respondents of various land holding categories and BMI classes. It was negative during harvesting, land preparation and weeding activity of peak season. It can be said that the homeostatic mechanism which controls and regulates energy balance involves a complex and long term lag mechanism; it is true for the farmwomen of the present study. Obesity is associated with age, education, and reproductive factors in women. Obesity represents a more complex entity where psychological and genetic factors that are difficult to assess may be more important.

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