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Ergonomics of rural women for selected dry farming operations

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Abstract : An investigation was undertaken to estimate the energy expenditure of rural women involved in dry farming operations. Pertinent anthropometric parameters of twelve well-versed women engaged in dry farming operations were measured. Among them two subjects having certain similar and variable anthropometric parameters were selected. The energy expenditure for the different operations was estimated with respect to time through closed circuit indirect calorimetry. The work-rest schedule required and effective working time in a day for different operations without inducing fatigue on the subject was assessed. The effective working time for the operations was around 300 min. The energy expenditure for dibbling seed, crop thinning, hoeing, cotton harvesting and sunflower stalk pulling were estimated as 1600, 1700, 1750, 1300 and 1900 kcal day^{-1} respectively. At this level of energy expenditure, fatigue induced to the subjects was minimum. The study concluded that dibbling the seed, crop thinning, hoeing and sunflower stalk pulling activities were heavy and inducing fatigue to the women work force.

Key words: Ergonomics, Indirect colorimetry, Anthropometry, Fatigue.

Introduction

The role of rural women for doing different farm activities in India varies from region to region. The women generally help the men to carry out farm operations. The contribution of farm women in Indian agriculture is estimated to be 50 to 60 per cent (Anon, 1981). They do different farm operations like seed dibbling, crop thinning, transplanting, weeding, harvesting, stalk pulling and winnowing. These tasks demand a high level of physical activity causing drudgery. Mostly the farm operations performed by men labourers were mechanized to improve the work efficiency and reduce the drudgery. Though women's contribution in agricultural production is significant, the introduction of machinery for women dominated operations is very low. By estimating the energy expenditure of the activities the rural women perform in the farm, it is possible to suggest a work-rest schedule to reduce their fatigue. Also suitable simple farm tools can be designed and introduced for the operations demanding high energy. Hence a study was conducted in Ikkari Boolvampatty village of Coimbatore district, Tamil Nadu, during 1998 to estimate the energy expenditure of rural women for the farm activities namely dibbling seeds, hoeing, crop thinning, cotton harvesting and sunflower stalk pulling.

Materials and Methods

Anthropometric Characteristics

Pertinent anthropometric parameters of twelve well-versed women engaged in dry farming operations were measured using harpenden sitting height table, portable harpenden stadiometer, harpenden anthropometer, precision balance and measuring tape. The data were analysed and two subjects having certain similar and variable anthropometric parameters were selected. This was done to know the variation in the energy demand of the subjects, while certain anthropometric characteristics are changed. The basal metabolic rate of the subjects were estimated by using a Benedict-Roth apparatus. The experiment was conducted in the early morning. During the experiment, the subjects were in a post absorptive state. Before beginning a measurement, the spirometer was filled with oxygen. The mouth piece and nose clip were put in place and the subject was allowed to breath normally through a by pass in the mouth piece. Once the subject was accustomed to the system, the by pass was closed and the subject was connected to the bell. Ideally, the subject was unaware of the switch. The expired gas on its way to the chamber passed through soda lime, which removed carbon dioxide. The cycles of inspiration and expiration appear as vertical oscillations of the bell. The experiment was continued until six minutes of satisfactory

Table 1. Anthropometric measurements

Measurements, cm	Subject I	Subject II
a. Similar		
Chest width	20.0	19.0
Hand muscle circumference	17.0	16.5
Shoulder width	42.0	41.0
Wrist to finger tip length	17.0	17.0
Hand width	9.0	9.5
Thigh clearance	12.0	12.0
Knee height	42.5	42.0
Popliteal height	46.5	47.0
Lap height	55.5	56.0
Elbow room	42.0	42.0
Buttock popliteal length	45.0	46.0
Sitting height	75.0	75.0
b. Variable		
Height	147.0	156.0
Eye height	135.0	144.0
Lumber height	67.0	59.0
Hand length	65.0	72.0
Shoulder to elbow length	27.0	30.0
Elbow to wrist length	39.0	42.0
Buttock knee length	48.0	54.0
Elbow wrist height	70.0	58.5
Seat breadth	37.0	32.0
Chest circumference	92.5	78.0
Weight (kg)	50.0	42.0

uninterrupted recording were obtained (Roth, 1922). The volume change was read from the graph. The oxygen consumed was converted in to energy using the relation of 1 litre of oxygen = 4.825 kcal.

Assessment of Energy Expenditure

The subjects were calibrated by closed circuit indirect calorimetry for the relationship between heart rate and oxygen consumption. An experimental set-up of bicycle ergometer, spirometer and cardiac monitor were used for this purpose. Indirect calorimetry estimated heat production from the measurement of respiratory gas exchange. In a closed circuit system, the subject breathed into a sealed apparatus and the amount of oxygen consumed is measured. The subject was given work through a bicycle ergometer. The heart rate and oxygen consumption were measured with respect to time using a cardiac monitor and spirometer, respectively. A sample spirometer reading obtained is shown in Fig.1. The oxygen consumption thus assessed was converted to equivalent energy and a calibration chart between heart rate and energy spent was established (Fig. 2).

The two subjects were allowed to perform the operations of dibbling the seeds, crop thinning, hoeing, harvesting of cotton and sunflower stalk pulling. The experiments were conducted for a day for each operation. The subjects were allowed to work for 35 minutes for dibbling seeds, 25 minutes each for thinning and hoeing and 30 minutes each for cotton picking and sunflower stalk pulling. The subjects were then

Table 2. Energy requirement

Time min.	Energy spent, kcal min^{-1}									
	Dibbling		Thinning		Hoeing		Cotton harvesting		Stalk pulling	
	Subject									
	I	II	I	II	I	II	I	II	I	II
5	1.00	1.50	1.55	2.70	1.90	2.50	0.65	1.50	1.55	2.75
10	2.65	2.85	3.25	4.20	4.85	4.65	1.55	2.75	4.25	4.95
15	4.40	4.20	6.50	6.05	6.90	6.05	2.65	3.50	6.50	6.85
20	6.05	5.50	8.10	7.35	7.85	7.25	3.80	4.50	7.85	7.75
25	7.10	6.35	9.10	8.20	8.50	7.75	4.55	5.25	8.75	8.65
30	7.85	7.25					5.15	5.80	9.50	9.40
35	7.85	7.25					5.20	5.90		

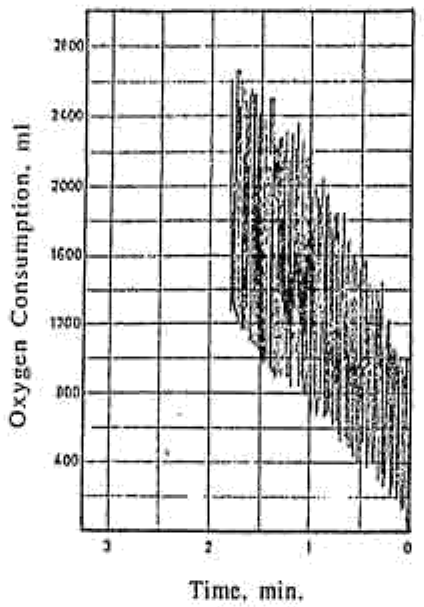

Fig.1. Calibration Chart of Subject-I

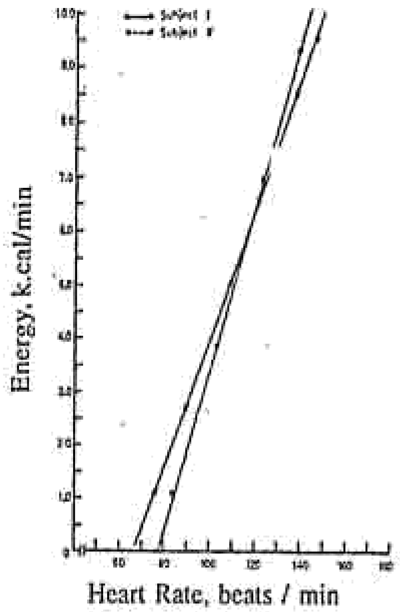

Fig.2. Calibration between heart rate and energy expenditure

Table 3. Endurance of operators

Activities	Work min	Rest min		Work rest ratio		Average energy spent kcal min^{-1}		Effective working time min		Energy expenditure kcal min^{-1}	
		SI	SII	SI	SII	SI	SII	SI	SII	SI	SII
Seed dibbling	35	21	20	1.67	1.75	5.27	4.99	300	305	1645	1583
Crop thinning	25	17	16	1.47	1.56	5.70	5.70	286	293	1685	1725
Hoeing	25	16	15	1.56	1.67	6.00	5.64	293	300	1814	1745
Cotton harvesting	35	11	12	3.18	2.92	3.36	4.17	365	357	1252	1520
Sunflower stalk pulling	30	21	21	1.43	1.43	6.40	6.72	282	282	1880	1975

allowed to rest until their heart rate returned to normal. This time interval was fixed based on fatigue developed by the subjects. The heart rate was measured continuously during the operation. The energy expenditure was derived from the calibration curve of the respective subjects at every five minutes interval of work.

Work-Rest Schedule

The work-rest required for the different operations without fatigue was assessed based on the procedure suggested by Murrell (1965). Based on this, the effective working time of the subjects in a day was worked out. The energy expenditure per day of operation was calculated, as the sum of effective working time multiplied by average energy spent per minute and rest required multiplied by basal metabolic rate.

Results and Discussion

Anthropometric Measurements

The anthropometic parameters and the observations pertaining to the selected operations are presented in Table 1. The basis of choosing equality of the hand muscle circumference is ensured for equitable application of force on physical activity done by hand. The other parameters like shoulder width, wrist to finger tip length, hand width, thigh clearance, knee height, popliteal height, lap height, elbow room and buttock popliteal length enable comparison of various physical activity of the subjects either in the sitting posture, bending posture and field operation postures. The height of the subject is deliberately changed. This is reflected in variability of hand length, shoulder to elbow height, elbow to wrist length and buttock knee length. Similarly lumber height, sitting height, seat breadth, elbow rest height of the two subjects give rise to variation in the load distribution during physical activity. The sum effect of all these parameters result in change of capacity potential. The basal metabolic rate of the subjects I and II was estimated as 1563 and 1632 kcal respectively (Robinson, 1978, Jean Bogert *et.al.* 1966). The calibration chart obtained (Fig. 2) for the two subjects revealed a linear relationship between heart rate and energy expenditure (Durnin,1978). The mathematical equations obtained from Fig.2 are as follows:

Subject I : $Y = 0.1224\ X - 8.066,\ R^2 = 0.9999$
Subject II : $Y = 0.1513\ X - 11.44,\ R^2 = 0.9981$

Energy requirement

It was observed that for dibbling the seed, the subjects could work up to 35 min continuously for maximum energy expenditure of 7.55 ± 0.30 kcal min^{-1} (Table 2). This indicated the level of work as moderate (Christensen, 1953). If the subjects were allowed to work beyond 35 min without any rest-pause, the operation became heavy. Crop thinning was done for 25 min with maximum energy expenditure of 8.65± 0.35 kcal min^{-1}. The maximum energy expenditure while hoeing was observed as 8.13 ± 0.38 kcal min^{-1}. It induced fatigue to the operators if rest-pause was not allowed beyond 25 min. The subjects could work for more than 35 min while harvesting cotton. The maximum energy spent was 5.55 ± 0.35 kcal min^{-1}. This was graded as moderate work. The reduction in energy spent for this operation may be due to standing posture. The subjects could perform sunflower stalk pulling for 30 min only. The maximum energy spent was observed as 9.45± 0.05 kcal min^{-1}. Performing this task beyond 30 min induced fatigue to the subjects. The average energy expenditure was the highest for sunflower stalk pulling followed by hoeing. Cotton harvesting demanded the lowest energy. It may be noted that the work severity classification given in Christensen (1953) applies to men folk. The work severity of the women based on the observed energy expenditure levels would be much higher with due adjustments of work capacity and body weight.

Work-Rest Schedule

The work-rest ratio, effective working time in a day and energy expenditure during working time are summarized in Table 3. The work-rest analysis showed that rural women could do sunflower stalk pulling effectively for 280 min day^{-1} without fatigue. They could harvest cotton for a maximum of 360 min in a day. Among the operations performed, cotton harvesting exhibited the maximum work-rest ratio of 2.90 - 3.20. This might be due to the lower energy spent per minute. The work rest ratio was minimum for sunflower stalk pulling. This was due to the maximum energy spent per minute. The energy expenditure of the subjects for dibbling and thinning was 1650 ± 50 kcal day^{-1}. Hoeing and sunflower stalk pulling required 1850 ± 50 kcal day^{-1}. Cotton harvesting demanded the lowest energy of 1400 kcal day^{-1}.

Conclusions

The inferences concluded that dibbling seeds, thinning, hoeing and sunflower stalk pulling activities are heavy for rural women. These operations require suitable machinery for reducing the fatigue of the women work force. If the work-rest schedule suggested is followed, the women labour can work without fatigue for a day of 8 hours.

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