

Seasonal variation in physical activity patterns, energy expenditure and nutritional status of women in a rural village in Tanzania

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Objectives. To examine the influence of season on the nutritional status, physical activity patterns and energy expenditure of rural women in Tanzania.

Design. A longitudinal study design was carried out to monitor seasonal changes in physical activity pattern, energy expenditure and nutritional status in 100 non-pregnant non-lactating women living in a rural setting. Body weight, circumferences, and skin-fold measurements were measured for a period of 10 months. Height was measured once at the beginning of the study. Energy expenditure while women were engaged in various activities was measured once in 3 different months using the activity diary method. Seasons were defined as the wet season from February to May and the dry season from June to January.

Results. Seasonal change in body weight was 1 700 g. Mean body weight was lower during the wet season (53.2 kg) than

during the dry season (54.9 kg) but the difference was not statistically significant. Physical activity patterns and energy expenditure varied with season, averaging 2 775, 2 420 and 2 020 kcal per day in April, July and October, respectively. Levels were significantly ($p = 0.01$) higher during the wet season (April) than during the dry season (October). There were no significant variations in upper thigh and buttock circumference measurements, suggesting that these areas of the body are not easily affected by fluctuations in the level of energy expenditure.

Conclusion. Season had a statistically significant influence on energy expenditure, but a non-statistically significant effect on nutritional status (weight) of women in Dumila village. However, further studies are needed to elucidate how these changes affect production efficiency and reproductive performance of rural women.

In developing countries women play a very important role in agricultural production, domestic tasks including child care, and care for the elderly and the sick. They are also involved in small income-generating activities. Most of the activities are arduous and time consuming and some of them, especially agricultural activities, require high levels of energy expenditure. Energy expenditure of women in rural African communities is considered to be higher than that of men.

Since agricultural activities tend to be seasonal, the overall energy expenditure of women tends to vary with the season. It is higher during the rainy season and relatively low during the dry season. In this regard, season has been identified as one of the factors influencing level of energy expenditure and therefore nutritional status of rural African subsistence farm women.¹ For example, Bleiberg *et al.*² observed that energy expenditure in rural women from Burkina Faso increased by 25% from the dry to the rainy season. A similar observation was made by Schultink *et al.*³ and Atebo⁴ in Benin. During the

rainy season the volume of activities increased and it was considered to be the most hectic time of the year for farmers. In most rural as well as urban low-income communities, the rainy season usually coincides with periods of low food stocks, hence higher food prices, and low food intake. The consequence of energy imbalance between food intake and energy expenditure during the rainy season is reduction in body weight. However, the consequence of this imbalance in the functional capacity of rural women has not been clearly elucidated. It has been reported, however, that weight decline during the rainy season reduces work output. This has significant economic implications for rural communities because it tends to affect overall agricultural production and therefore food availability in the next rainy season. This perpetuates the cycle of transitory food insecurity in both rural and urban communities.

The aim of the present study was to examine the influence of season, in terms of rainfall pattern and agricultural activities, on the nutritional status of women living in a rural community in Tanzania. The study was designed to answer the following questions: (i) what is the level of physical activity of women in rural Tanzania, taking Dumila as a case study?; (ii) how does the activity pattern affect the level of energy expenditure and nutritional status of women?; and (iii) what is the magnitude of change in nutritional status between seasons?

Methods

The study was carried out in Dumila village, situated approximately 260 km west of Dar es Salaam along the Dar es Salaam-Dodoma highway.

The village has a bimodal type of climate with two distinct seasons. The wet or rainy season starts in February and ends in late May. The dry season starts in June and ends in January. Agricultural activities include field preparation just before the rainfall, weeding, scaring away birds and harvesting. The traditional hoe is commonly used for most field operations. The agricultural activity calendar is shown in Table I.

Table I. Calendar of agricultural activities in Dumila

Type of crop	Land preparation	Planting	Weeding	Harvesting
Maize	February	March	April	July/August
Sorghum	February	March	April	August
Rice	December	December	March/April	June/July
Groundnuts	February	March	April	July
Cotton	February	February/March	May	September

Subjects

One hundred women were recruited to participate in the study after obtaining permission from the village authority and consent from the women. Women were selected according to the following criteria: farming as main occupation, aged from 18 to 50 years, non-pregnant and non-lactating, mother of at least one child, and a permanent resident of Dumila village. The data for 2 women who became pregnant during the study were not included in the analysis. All women were in good health without clinical signs of major nutritional deficiencies and none were physically handicapped. The women were asked by the authors to state whether they were pregnant or lactating. No pregnancy test was performed.

Study design

A longitudinal design was used to assess body weight, body circumferences and skin-fold thickness and activity pattern in one agriculture cycle. Parameters mentioned above were measured monthly for the first 4 months of the study (April - July) and again in October of the same year and in January of the following year. The subjects were split into 10 groups of 10 subjects each. One assistant was assigned to follow one group for the entire period of the study. The assistants were trained on how to measure weight, height, circumferences and skinfolds and on how to record time spent by women while doing various activities. The same person took all measurements throughout the period of the study. The measurements were taken in triplicate for weight and skinfold, and in duplicate for height and circumferences. An average

value from the three or two measurements represented the measurement for weight, height, circumferences and skinfold thickness. The inter-assistant coefficient of variation for height was 3%, for weight 2%, and for skinfold thickness 4%. The intra-assistant coefficient of variation for height was 1%, for weight 2% and for skinfold thickness 3%, which was considered to be within the acceptable range.

Body weight

Body weight was measured in the morning between 06h00 and 07h00 at the subjects' households after the subjects had voided. Weight was measured using a SECA electronic bathroom weighing scale (0 - 150 kg) (SECA, Germany) placed on a flat surface. The weighing scale was calibrated each morning and adjusted accordingly before the next measurement. The subjects were measured while wearing light indoor clothing (usually one piece of 'khanga', a typical African clothing). Triplicate measurements were done and an average represented the measurement for weight. Body weight was recorded to the nearest 0.1 kg. No correction for the weight of the cloth was done.

Height

Height of the subjects was measured once at the start of the study (on the assumption that women would not change height significantly during the study). Readings were recorded to the nearest 0.5 cm using a portable Harpenden stadiometer (Holtain Ltd, UK). Duplicate measurements were recorded while the subject stood without shoes on a horizontal surface against a wall with heels together; stretched upwards to full extent with the head in the Frankfurt plane. Each subject was watched to make sure that her heels did not leave the ground and that the head was maintained in an upright position.

Body composition

Body composition was assessed by measuring skinfold thickness at four body sites, namely biceps, triceps, subscapular and supra-iliac, using Holtain skinfold callipers (Holtain Ltd, UK, pressure 10 g/mm², precise at 0.2 mm). During each measurement and for each site, triplicate readings were taken. The average of the three records represented the skinfold measurement for each site. Measurements of skinfold thickness were taken on the left side of the body while the subject was standing relaxed. Fat mass (FM) was estimated using the equation developed by Durnin and Womersley⁵ in combination with Siri's equation.⁶ Fat-free mass (FFM) was calculated as the difference between the subject's body weight and body fat mass.

Fat distribution

The circumference of five sites, namely mid-upper arm circumference (MUAC), calf, upper thigh, buttock and waist were measured. MUAC was measured using a non-stretchable nylon tape on the left arm midway between the acromion and the olecranon process while the subject's arm was hanging freely at the side of the body. Readings were recorded to the

nearest 0.1 cm. Calf circumference was measured while the subject was sitting on a chair with the knee bent at 90°. Reading of the maximum circumference was recorded to the nearest 0.1 cm. Upper thigh, buttock and waist circumferences were measured while the subjects were standing. Readings were recorded to the nearest 0.1 cm from an average of triplicate measurements.

Body mass index (BMI)

BMI was obtained by dividing the weight of the subject (in kg) by the square of the height in metres.⁷ BMI was used to classify subjects into various categories, either chronically energy deficient, normal weight, overweight or obese. The cut-off points used were: < 20 underweight, 20.1 - 25 normal, 26 - 30 overweight, and > 30 obese.

Energy expenditure

The total daily energy expenditure was determined using the activity diary or time-motion method. The time spent on each activity was recorded minute by minute for the whole day from 06h00 to 22h00. Each assistant was trained on how to record time for each activity and was provided with 100 activity diaries or time motion diaries and an electronic watch. The assistant observed and recorded in detail all activities and their duration (in minutes) and the posture and tool used to perform the activity.

Subjects were strongly encouraged to go about their everyday work normally. There were no indications that the presence of the assistant disturbed or altered the activity pattern of the women. The energy cost of each activity was obtained from the World Health Organisation (WHO) report.⁸ Therefore the daily energy expenditure of women was calculated based on the time spent on the various activities and the energy cost of each activity.

Statistical analysis

The chi-square test was used to compare differences in pre-harvest weight losses and post-harvest weight gains in women, and Levene's test for equality of variance was used to determine any significant changes in weight between seasons. The Student's *t*-test was used to compare differences in weight and energy expenditure between seasons.

Results

Body weight, composition and BMI

The anthropometric characteristics of the subjects on entry to the study (April) are shown in Table II. The data show that on average the women had a mean height of 155 cm, mean weight of 53 kg, mean BMI of 22, and mean fat content of 27%.

Table II. Anthropometric characteristics of non-pregnant non-lactating women (N = 98) of Dumila village at the start of the study

Physical characteristics	Age (yrs)	Weight (kg)	Height (cm)	BMI	Fat (%)	MUAC (cm)	Calf (cm)	Thigh (cm)	Hips (cm)	Bust (cm)
Mean	32	53	155	22	27	28	32	46	91	83
SD	4.5	10	5	4	5.6	4	3.4	5.9	10.5	7
Range	18 - 64	35 - 90	133 - 165	15 - 39	18 - 38	18 - 39	20 - 43	29 - 64	40 - 122	55 - 106

MUAC = mid-upper arm circumference; SD = standard deviation.

Table III. Seasonal changes in physical characteristics of women in Dumila village (mean ± SD)

Physical characteristics	April	May	June	July	October
Weight (kg)	53.2 ± 10.0*	53.1 ± 9.7	53.9 ± 9.7	53.8 ± 9.6	54.9 ± 9.6*
BMI	22.2 ± 4.0 [†]	22.1 ± 5.9	22.5 ± 6.2	22.4 ± 4.0	22.9 ± 5.0 [†]
MUAC (cm)	28.5 ± 3.9	27.9 ± 3.4	27.6 ± 3.4	27.6 ± 3.3	28.2 ± 3.3
Calf (cm)	32.8 ± 3.4	32.3 ± 3.4	32.1 ± 3.4	32.1 ± 3.2	32.7 ± 3.0
Upper thigh (cm)	46.2 ± 5.9	45.6 ± 5.8	45.4 ± 5.6	44.9 ± 5.5	45.6 ± 5.6
Hip (cm)	90.6 ± 10.5	90.2 ± 10.5	89.8 ± 10.5	89.6 ± 10.8	90.2 ± 13.0
Bust (cm)	82.6 ± 7.1	82.3 ± 6.9	82.3 ± 7.2	82.4 ± 6.9	83.3 ± 7.0
Waist (cm)	78.1 ± 10.4 [†]	78.1 ± 8.4	78.2 ± 8.5	77.8 ± 8.5	78.6 ± 9.0 [†]
% Fat	26.9 ± 5.6 [†]	26.8 ± 5.8	26.6 ± 5.8	26.7 ± 5.6	27.1 ± 5.7 [†]
Weight/hip ratio	0.869 ± 0.06 [†]	0.864 ± 0.06	0.870 ± 0.06	0.865 ± 0.06	0.865 ± 0.06 [†]

* Significant differences $p = 0.001$.

[†] No significant differences $p = 0.235$ for % fat, $p = 0.82$ for circumferences.

SD = standard deviation; BMI = body mass index; MUAC = mid-upper arm circumference.

At the beginning of the study 21% of the women had BMI values ranging between 14 and 19, and hence were classified as being chronically energy deficient. Four per cent of the subjects were classified as being obese. The seasonal changes in body weight and other physical characteristics of the subjects are presented in Table III. On average, weight gain was 1 700 g over a period of 4 months (July - October). Weight change was not statistically significant ($p = 0.005$). MUAC showed an increase of about 0.6 cm after July, but decreased after April. Calf circumference also showed some changes with season. It decreased by 0.5 cm in May, June, and July, and increased in October. Upper thigh circumference decreased and reached a minimum value in July and increased in October. The mean value for waist circumference was 78 cm for the entire period of the study.

The number of women with BMI values below 20 increased from April to June but decreased during October and January. The proportion of women with BMI values between 20 and 25 showed a similar trend. However, the number of women with BMI values between 26 and 30 showed no clear pattern (Table IV).

Table V shows that there was no significant variation ($p = 0.338$) in the number of women who were classified as having chronic energy deficiency during the entire period of the study.

Body weight and composition

One hundred non-pregnant non-lactating (NPNL) women were followed for 8 months to establish whether there were any changes in body weight and body composition with season. The results showed that the body weight of NPNL women changed with the season. Body weight was significantly higher ($p = 0.001$) during the dry season than during the wet or rainy season. Taking weight recorded in April as baseline weight, there was a mean net weight gain of 1.70 kg (1 700 g) during the entire period of the study. Season also influenced body fat stores. Concomitant with the increase in body weight, there was a small but not statistically significant ($p = 0.235$) increase in body fat stores (Table III, Figs 1 - 3). Body circumferences did not show any significant change ($p = 0.82$) with season. The results of the BMI showed that the majority of the women in Dumila village have a normal BMI (Table IV). However, BMI values also varied with season. For some subjects, BMI values

Table V. Classification of chronic energy-deficient women into different grades

BMI	Grade	April	May	June	July	Oct	Jan
18.5 - 19	1	10	9	14	14	9	10
17.0 - 18	2	5	7	3	3	0	2
< 16.9	3	4	1	2	1	5	3
Total		19	17	19	18	14	15

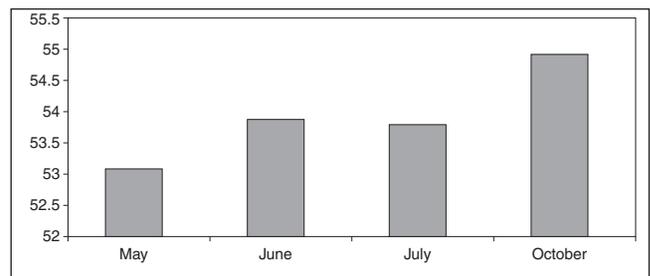


Fig. 1. Seasonal weight changes among Dumila women (N = 98).

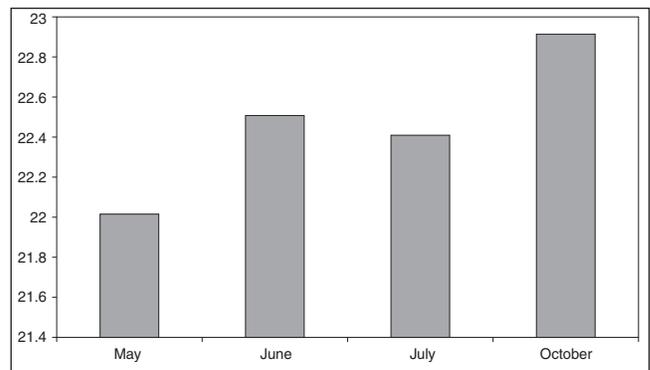


Fig. 2. Seasonal BMI changes among Dumila women (N = 98).

fluctuated between normal and either underweight or overweight during the study.

Physical activities

The time spent by Dumila women on various activities is shown in Fig. 4 and Table VI. Nearly 5.5% of the time was spent on sitting activities (e.g. talking and weaving) during the

Table IV. Classification of women (%) according to their nutritional status expressed as body mass index (BMI) in different months (N = 93)

BMI	Interpretation*	Months					
		April	May	June	July	Oct	Jan
< 20	Underweight	21	19	20	19	15	17
20 - 24	Normal	59	64	61	62	68	66
25 - 30	Overweight	16	14	15	16	15	14
> 30	Obese	4	2	2	2	2	2

* WHO International Nutrition Data classification.

Table VI. Time spent by Dumila women on various activities in 3 different months

Activity	April		July		October	
	Mean time (min)	% of total	Mean time (min)	% of total	Mean time (min)	% of total
Agricultural work	480*	33	350	24	208	14.4*
Food preparation	100	6.9	120	8.3	130	9.0
Housework including child care	120	8.3	135	9.3	150	10.4
Sitting talking	50	3.4	80	5.5	130	9.0
Walking	130	9.0	132	9.2	94	6.5
Fetching water	35	2.4	47	3.3	50	3.5
Personal hygiene	25	1.7	26	1.8	29	2.0
Weaving	30	2.1	100	6.9	149	10.3
Sleeping	470	32.6	450	31.2	500	34.7
Total	1 440	100	1 440	100	1 440	100

* There was a significant difference in the time spent on agricultural work, $p = 0.001$

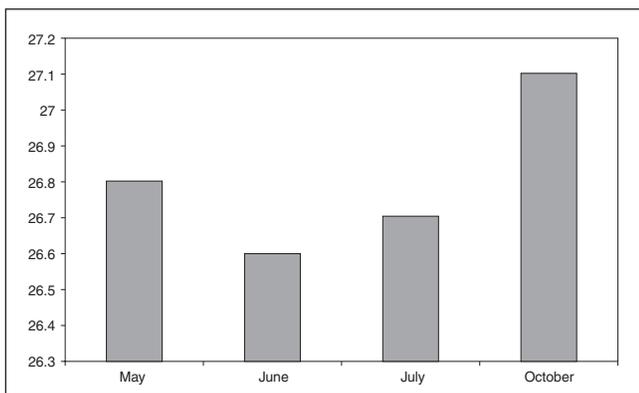


Fig. 3. Seasonal body fat changes among Dumila women ($N = 98$).

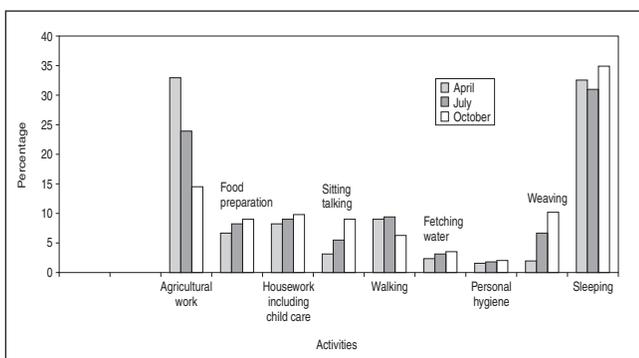


Fig. 4. Time spent by women on various activities.

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rainy season compared with about 12.4% spent on similar activities in July and 19.3% in October. The main activities performed by women included cooking, cleaning (house, compounds, dishes and clothes), fetching water and collecting fire wood, which accounted for about 18% of the total time. Weaving and selling of local brew are usually done during the

dry season (mainly in October) to generate income. The time spent on weaving in October was 10.3%, compared with 2.1% and 6.9% in April and July, respectively.

The study has shown that women participate in all farm operations such as clearing of the previous season's crop from the fields, digging, planting, weeding, scaring away of birds, harvesting, threshing and also carrying of produce from the fields to households.

Energy expenditure

The mean 24-hour energy expenditure of women was 2 775 kcal/day in April, 2 420 kcal/day in July and 2 020 kcal/day in October. There was a considerable reduction ($p = 0.001$) in total daily energy expenditure from April (rainy season) to October (dry season).

Discussion

Physical characteristics

Dumila women were short, with a mean height of 155 cm and mean weight of 53 kg. Despite the short stature, about 14 - 19% of the women had BMIs ranging between 14 and 19, hence they were classified as chronically energy deficient (CED). These women weighed less than 49 kg. This is much lower than the recommended weight for an average woman of that height, i.e. 55 kg.^{9,10} This is very risky for women living in precarious conditions of low food intake, high physical activity and disease. The study has shown that there was weight variation with season. Body weight was low during the month of April, increased slightly in June, declined again in July and increased in October (Fig. 1). The mean net weight change during the study period was 1.70 kg (1.42%), ranging from a loss of 15 kg to a gain of 14 kg. Other studies have observed varying weight

gains in different areas of Africa. For example, Schultink³ observed an increase of 2% between seasons in a study conducted in Benin.

The present study has also shown that there was no significant seasonal change in hip and upper thigh circumferences, meaning that women did not lose much fat from these parts of the body. It has been indicated¹⁰ that it is often difficult for women (especially those of African origin) to lose fat deposited around the hip and upper thigh regions. It is suspected that this acts as an energy buffer, and is therefore useful during times of food shortage and high activity level. It may also suggest a genetic adaptation after generations of exposure to repeated episodes of food shortage. Most probably this helps to maintain reproductive performance during precarious situations of food insecurity and heavy physical activity. There is a need, however, for further studies to elucidate what actually happens during such situations. The waist-hip ratio (WHR) of the women averaged 0.86, slightly higher than that considered to confer risk for cardiovascular disease. WHR is used as one of the methods of identifying individuals with abdominal fat accumulation. Values above 0.85 suggest that an individual is at a high risk of cardiovascular disease and diabetes.^{1,11-13}

Physical activity pattern and energy expenditure

The study also aimed to determine the level of physical activity and energy expenditure of women in a rural area in Tanzania. The study has shown that women in Dumila village spend different amounts of time performing different activities depending on season. During the month of April women spent 33% of the time on agricultural activities. This was the most time spent on agricultural activities, i.e. more than the time spent during the months of July and October. This is the period for weeding rice fields, which is done exclusively by women. When a woman is sick the husband or male members of the extended family may assist. To reduce or lighten the workload, women from nearby fields usually share the task by shifting from one field to another. During the same period women attend to their other small fields, which are planted with minor crops such as beans, cowpeas, and sweet potatoes.

During the month of July, women spent only 24% of the time per day on agricultural activities for harvesting of maize and rice. During the month of October women spent 14% of the time on agricultural activities. Most of the time was spent at home doing housework.

Men do participate in agricultural work, but not to the same extent as women. This was observed in another study conducted in the same village (Bukuku, U — unpublished data, 1996). The study showed that men spent 19% of their time on agricultural activities during the month of April compared with 33% spent by women during the same month.

Time spent by women on other activities such as housework also varied seasonally. For example, time spent sitting, including child care activities, was higher in October than in April and July. Other studies conducted in other rural areas of developing countries,^{2,4,14-16} observed a similar pattern.

Energy expenditure

Total daily energy expenditure was assessed by the activity diary method. It was observed that there was a significant difference ($p = 0.01$) in the level of energy expenditure according to season. The level of energy expenditure was high in April and was attributed to heavy agricultural activities, but declined in July and October. In Dumila village, as in many areas experiencing two clear seasons (rainy/wet and dry seasons), the level of energy expenditure tends to vary seasonally. Studies^{2,16} have shown that total daily energy expenditure is higher during the rainy season than during the dry season.

Although women may engage in some income-generating activities such as making and selling local brew or weaving mats, the level of energy expenditure on these activities is not as high as that on agricultural work.

This study has shown that women are repeatedly exposed to situations of both high and low physical activity and energy expenditure. The level of energy expenditure was high during April and relatively low in July and October. These observations are similar to those made by Norgan *et al.*,⁹ Bleiberg *et al.*,² Lawrence and Whitehead,¹⁷ Schultz and Jequier,¹⁸ and Brun.¹⁹ There is a need to conduct further studies to elucidate the physiological changes that take place in women during such periods with regard to metabolism and hormonal adjustments.

In a study conducted in the same village (Bukuku, U — unpublished data, 1996), it was found that the mean 24-hour energy expenditure of men was 2 400 kcal/day in April. This is slightly lower (by 375 kcal) than the energy spent by women. This implies that the level of energy expenditure in women was higher than that of men. The difference observed was due to the tendency by men to avoid weeding and harvesting activities and not to perform housework at all. This reflects the social customs, norms and beliefs that govern gender participation in various household activities and field operations in Dumila village.

Food security, physical activities and physical characteristics

The study started in April during the period of widespread food insecurity and heavy agricultural activities. The number of women weighing below 49 kg was high. As the food situation improved (July - October) the number of women

weighing below 49 kg decreased. The high number of women with low weight during April was attributed to the high level of energy expenditure on agricultural activities, and to food insecurity. However, early green maize is usually ready by the end of May and tends to improve the food situation in the village. In June food security improves significantly and because of low levels of agricultural activity, the body weight of women improved. Although the food security situation is better in July, body weight decreases slightly due to the heavy physical activity of harvesting. During this month women become actively involved in harvesting of maize and rice and carrying of harvested crops to the households. During the month of October there are fewer agricultural activities, so it is considered a resting month. Women perform light activities at home such as child care, washing, cooking, weaving and cleaning compounds. During this month the food security situation in the village improves. This could have contributed to the increase in weight among the women. October is also the month for festivals, which contributes significantly to increased food intake. However, it is often associated with food insecurity in the later months of the year because a lot of food is wasted during the festivities.

This study has shown that Dumila women are repeatedly exposed to high physical activity levels during periods of food shortage, hence affecting their physical characteristics such as weight and body fat content. This situation may have an influence on reproductive performance. For example, in a study conducted to examine seasonal variations in birth weight in Morogoro,²⁰ it was observed that babies delivered from April to June had lower birth weight compared with those delivered from September to November, irrespective of date of conception, suggesting that season has a significant influence on reproductive performance or outcome. It was recommended that couples should be advised to plan the time of conception so that deliveries can take place during the period when there is adequate food supply and less physical activity. Food insecurity and heavy physical activities even during the last few weeks of pregnancy were found to have a significant influence on birth weight.

Conclusion

The study has shown that season has a significant influence on the level of daily energy expenditure among women and on their weight. Season has a very small effect on thigh and buttock circumferences.

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References

1. Ashwell M, McCall SA, Cole TJ, et al. Fat distribution and its metabolic complications: interpretation. In: Norgan NG, ed. *Human Body Composition and Fat Distribution*. Euro-Nut Seires Report 8 1985: 227-242.
2. Bleiberg F, Brun TA, Gohman S. Duration of activities and energy expenditure of female farmers in dry and rainy season in Upper-Volta. *Br J Nutr* 1980; **43**: 71-82.
3. Schultink WJ, Klaver W, Van Wijk H, Van Raij JMA, Hautvast JGAJ. Body weight changes and basal metabolic rates of rural Beninese women during seasons with different energy intakes. *Eur J Clin Nutr* 1990; **44**: suppl 1, 31-40.
4. Ategbo EAD. Food and nutrition security in northern Benin, impact on growth performance and on year-to-year nutritional status of adults. PhD Thesis: Wageningen Agricultural University, The Netherlands, 1994.
5. Durnin JVGA, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness measurement on 471 men and women aged 16 - 72 years. *Br J Nutr* 1974; **32**: 77-97.
6. Siri EW. The gross composition of the body. *Adv Biol Med Phys* 1956; **4**: 239-280.
7. Garrow JS, Webster J. Quetelet's Index (W/H²) as a measure of fatness. *Int J Obesity* 1985; **9**: 299-306.
8. World Health Organisation. Energy and protein requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. *World Health Organisation Tech Rep Ser* 1985; No. 724.
9. Norgan NG, Ferro-Luzzi A, Durnin JVGA. The energy and nutrient intake and the energy expenditure of 204 New Guinean adults. *Philos Trans R Soc Lond B Biol Sci* 1974; **268**: 309-348.
10. Dowling HJ, Pi-Sunyer FX. Race-dependent health risk of upper body obesity. *Diabetes* 1993; **42**: 535-543.
11. Bjorntorp P. Portal adipose tissue as a generator of risk factors for cardiovascular diseases and diabetes. *Arteriosclerosis* 1990; **10**: 493-496.
12. World Health Organisation. Obesity: *Preventing and Managing the Global Epidemic*. Report of the Consultation on Obesity. Geneva: WHO, 1998.
13. Lawrence M, Coward A, Lawrence F, Cole TJ, Whitehead RG. Fat gains during pregnancy in rural African women: the effect of season and dietary status. *Am J Clin Nutr* 1987; **45**: 1442-1450.
14. Painter-Brick C. Seasonality of energy expenditure during pregnancy and lactation for rural Nepal women. *Am J Clin Nutr* 1993; **33**: 892-902.
15. Tin-May-Thau. Energy expenditure; duration of activities and physical work capacities of Burmese women weavers. *Food Nutr Bull* 1988; **10**: 48-50.
16. Torun B, McGuire J, Mendoza RD. Energy cost of activities and tasks of women from rural region of Guatemala. *Nutr Res* 1982; **2**: 127-136.
17. Lawrence M, Whitehead RG. Physical activity and total energy expenditure of child bearing Gambian women. *Eur J Clin Nutr* 1988; **42**: 145-160.
18. Schutz Y, Jequier E. Failure of dietary fat intake to promote fat oxidation: a factor favouring the development of obesity. *Am J Clin Nutr* 1989; **50**: 307-314.
19. Brun T. The assessment of total energy expenditure of female farmers under field conditions. *J Biosoc Sci* 1992; **24**: 325-333.
20. Kinabo JL. Birth weight distribution in Morogoro, Tanzania. *East Afr Med J* 1993; **70**: 752-759.