Nutrient Intake, Physical Activity, and Behavioral Patterns of Adults Living in Three Contrasting Ecological Zones in Rural Zambia

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Abstract

We reported in a previous project seasonal variations in the body weight of adult villagers living in three contrasting ecological zones (Lowland, Hillside, and Upland) in the southern province of Zambia. The report revealed differences in the nutritional status of adults and in patterns of seasonal variation in body weight between the three zones, suggesting characteristic lifestyles of the people living in each zone even though the zones were not geographically distant. Based on these findings, we conducted a field survey on diet, physical activity, and behavioral patterns to investigate the lifestyles of the three populations between August 2010 and September 2010. The subjects were chosen from participants of the preceding growth monitoring survey. This article describes differences in lifestyle, from the viewpoints of diet, physical activity, and behavioral patterns, of adult men and women living in the three zones, with special attention paid to regional and sex differences.

Daily energy intake (neither absolute values nor standardized ones by fat-free mass) did not differ between the three regional groups for either sex. However, regional characteristics of dietary patterns were observed from the results on nutrient intake, energy percent of macronutrients, the proportions of specific food groups contributing to energy, and all macronutrients. Moreover, regional differences in physical activity and behavioral patterns were observed.

Significant sex differences were found in the diet and physical activity patterns in the Lowland group, which can be explained by the fact that many men living in the lowlands had a side occupation besides farming and spent most of their time outside the home in the dry season. The contribution of fish consumption to dietary intake was highest in the Lowland group because of its geographical proximity to Lake Kariba. The lowland men also consumed a home-made fermented alcoholic drink. As for the Hillside group, their behavioral area used in daily life was the largest and their physical activity the highest, the latter particularly so for the women. Only the Upland group consumed sweet potato. The men and women living in the Uplands showed similar patterns in both space use and level of physical activity as the couples work together farming during the dry season.

1. Introduction

Seasonal variation in food availability is said to influence the nutritional and health condition of populations in many developing countries (Wandel and Holmboe-Ottesen 1992).

Schofield reported that seasonality affects food intake especially in areas where the distribution of rainfall is unimodal (Schofield, 1974). Moreover, it was revealed that the factors affecting the food and nutritional situation are not only pre-harvest food shortages but high agricultural workloads (Chambers et al. 1979).

Some studies of African rural populations have demonstrated that food intake decreased and physical activity increased during the rainy season when agricultural work output is at a peak, and physical activity decreased after the harvest season (Schofield 1974; Wandel et al. 1992). It was also shown that the post-harvest body weight of adults was heavier than the pre-harvest body weight (Wandel and Holmboe-Ottesen 1992).

In a project report last year, based on longitudinal anthropometric data, we reported seasonal variation in the weight of adult villagers living in three contrasting ecological zones in the southern province of Zambia (Yamauchi and Kon 2010). We found distinct patterns of seasonal variations: weight peaked around June during the dry season and was lowest in February to March during the rainy season. These variations were similar to those for adult Tanzanians reported by Wandel and Holmboe-Ottesen (1992). In addition, we found differences in nutritional status and patterns of seasonal variation in weight between the three zones.

The results raised some questions. First, it cannot be said the differences in nutritional status are attributable to geographic distance because two villages which are located within these areas and farthest each other are at least about 20km away. Moreover, the results of seasonal variations in weight which showed parallel patterns between the sexes in each area and showed a difference in patterns between the three zones may suggest that the residents in each zone have a characteristic lifestyle. Thus, studying the lifestyle of populations living in different ecological zones that are in close geographical proximity will help us to learn how the people, especially those living with unsteady agricultural production, maintain their health and nutritional condition.

We conducted surveys of the diet, physical activity, and behavioral patterns to investigate the lifestyle of the three populations; individual subjects were chosen from the samples participating in longitudinal anthropometric surveys. This article describes the result of these surveys focusing on differences in lifestyle by zone and sex.

2. Subjects and Method

2.1 Research Area & Subjects

The study was conducted at four villages (Sianemba village, Siameja village, Kanego village, and Siachaya village) located in Sinazongwe district of the southern province of Zambia. These villages can be divided into three contrasting ecological zones: Sianemba and Siameja are in the lower flat land zone (Lowland), Kanego is in the middle slope zone (Hillside), and Siachaya is in the upper flat land zone (Upland). Eight households comprised the sample for the Lowland group, and 7 households each comprised those from the Hillside and Upland groups. A total 26 men and 30 women aged over 18 years old in sample households were examined.

2.2 Measurements

1) *Anthropometry*

Height, weight, mid-upper-arm circumference, and the triceps and subscapular skinfold thickness were measured. Body mass index (BMI; kg/m^2) was calculated as weight in kg / (height in m)^2. Sum of the two-site skinfold thickness was put into the equation of Durnin and Womersley (1974) to calculate body density, then the equation of Siri (1956) was used to estimate body-fat percentage (%fat). Mid-upper-arm muscle area (MUAMA) was calculated using the triceps skinfold thickness and mid-upper-arm circumference (Frisancho 1990).

2) *Food Consumption*

Food intake was recorded using a weighed dietary record. We visited sample households to measure their meal before preparing breakfast (generally at 07:00) and stayed until subjects had eaten their supper (generally between 20:00 and 21:00). Food consumption data were converted into quantities of energy and nutritional intakes using the Zambia Food Composition Tables, 4th edition (The National Food and Nutrition Commission of Zambia 2009). In addition, percentages of energy and macronutrients as derived from 7 food groups were calculated.

3) *Physical Activity*

Physical activity was monitored using a uniaxial accelerometer sensor. Subjects attached the device to their waist during 5 consecutive weekdays and data recorded during the middle 3 days were analyzed. Physical activity recorded by the device was categorized into one of 11 activity levels (0, 0.5, and 1–9) based on accelerometric signal patterns. Total energy expenditure was calculated using these activity levels.

4) *Behavioral Area*

Behavioral area used in daily life was investigated using portable GPS. Subjects wore portable GPS with accelerometer sensors for 3 days corresponding to the middle 3 days of wearing the aforementioned accelerometer sensor. Latitude, longitude, and elevation of each subject's location, and distance from last point, cumulative distance, movement bearing, and speed of movement were recorded. Behavioral tracks were identified using Google Earth software, then behavioral radius, the center of which was the subject's home, was measured.

2.4 Data analysis

All data are expressed as means and SDs. Regional differences were examined by ANOVA and multiple comparisons. Gender differences were examined using the unpaired t-test. All analysis was performed with the JMP 8.0.2J software package (SAS Japan), with statistical significant set at $P<0.05$.

3. Results and Discussion

3.1 Anthropometry

Age and anthropometric measurements are given in Table 1. Age, body size, and body

Table 1 Age, body size, and body composition of adults living in three contrasting ecological zones of Zambia

a) Male

	Lowland (n = 7)		Hillside (n = 10)		Upland (n = 9)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	47.3	18.1	36.9	13.1	36.7	18.6
Height (cm)	171.5	4.7	169.3	6.0	165.5	6.6
Weight (kg)	61.1	2.4	58.4	2.0	57.8	2.2
BMI (kg/m^2)[1]	20.7	2.2	20.4	1.5	21.0	1.8
%fat (%)[2]	20.0	4.5	16.8	3.2	19.4	6.1
MUAMA (cm^2)[3]	427.2	57.0	438.2	55.9	422.5	95.7

[1] Body mass index : weight (kg) / height $(m)^2$

[2] The equation of Siri (1956) and Durnin & Womersley (1974) was used.

[3] Mid-upper-arm muscle area : The equation of Frisancho (1990) was used.

b) Female

	Lowland (n = 10)		Hillside (n = 9)		Upland (n = 11)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	36.5	15.2	37.9	8.2	35.9	11.9
Height (cm)	159.9	5.2	157.0	4.3	156.8	5.6
Weight (kg)	60.0*	9.8	50.3	4.0	54.2	7.4
BMI (kg/m^2)[1]	23.4	3.9	20.4	1.2	22.1	2.9
%fat (%)[2]	33.5	5.5	28.7	3.9	32.5	4.2
MUAMA (cm^2)[3]	346.5	43.4	362.0	45.7	322.8	44.4

[1] Body mass index : weight (kg) / height $(m)^2$

[2] The equation of Siri (1956) and Durnin & Womersley (1974) was used.

[3] Mid-upper-arm muscle area : The equation of Frisancho (1990) was used.

* Significantly higher than in Hillside and Upland ($P<0.05$)

composition did not differ significantly between the three zones for either sex. Average BMI in all zones and for both sexes were classified as 'normal' ($18.5 \leq \text{BMI} \leq 25.0$) according to WHO criteria (WHO 2000). Among men and women of the Hillside group, because BMI and %fat were the lowest and MUAMA was the highest of the three zones, they were characterized as having a 'lean' physique. BMI differences between the sexes were not identified in all zones. MUAMA was higher among men than women ($P < 0.01$), whereas %fat was higher among women than men ($P < 0.001$) in all zones.

3.2 Food Consumption

Table 2 shows the energy and nutrient intakes of men and women in the three zones. Daily energy intake and daily energy intake per fat-free mass did not differ between the three zones for either sex. Fat intake and fat energy percent among men in the Lowland group were significantly lower than among men in the other two zones, while carbohydrate energy percent was the highest of the three zones. Among women, fat intake, carbohydrate intake, and energy percents of fat and carbohydrate did not differ between the three zones. Only protein energy percent was

Table 2 Comparison of daily energy and nutrient intakes of adults living in three contrasting ecological zones of Zambia

a) Male

	Lowland (n = 6)		Hillside (n = 10)		Upland (n = 8)	
	Mean	SD	Mean	SD	Mean	SD
Energy (kcal)	2266.7	465.7	3032.0	719.6	2863.4	539.2
Energy (kcal/FFM[1]kg)	48.3	10.7	62.0	11.4	61.6	10.4
Protein (g)	53.7	21.1	75.4	24.5	62.0	13.4
Energy %	9.1	2.1	9.9	1.6	8.6	0.3
Fat (g)	20.3*	6.9	56.6	17.4	46.7	13.6
Energy %	7.8*	1.5	17.1	4.9	14.9	4.2
Carbohydrate (g)	472.1	87.0	557.1	140.3	540.4	99.2
Energy %	83.8**	3.0	73.3	4.4	75.6	7.3
Calcium (mg)	299.9	210.0	432.7	299.1	634.5	405.4
Iron (mg)	16.8	3.4	21.0	5.3	20.2	4.1
Vitamin A (μg)	1850.6	2200.9	4532.7	3330.1	5163.2	2874.2
Vitamin C (mg)	44.5	28.1	26.8	24.6	32.6	21.8

[1] Fat fee mass

* Significantly lower than in Hillside and Upland (*P*<0.01)

** Significantly higher than in Hillside and Upland (*P*<0.01)

b) Female

	Lowland (n = 10)		Hillside (n = 9)		Upland (n = 11)	
	Mean	SD	Mean	SD	Mean	SD
Energy (kcal)	2681.1	602.6	2595.4	359.6	2476.9	621.4
Energy (kcal/FFM[1]kg)	68.4	16.0	72.6	9.3	68.0	15.3
Protein (g)	73.0	23.8	66.4	10.1	56.9	16.8
Energy %	10.7*	1.8	10.3	1.2	9.1	0.8
Fat (g)	35.6	18.8	43.1	10.1	42.4	20.0
Energy %	11.4	4.3	15.1	3.7	15.0	4.6
Carbohydrate (g)	505.6	74.2	487.6	78.4	464.3	102.5
Energy %	77.0	8.2	75.0	3.7	75.6	6.6
Calcium (mg)	668.0	395.3	369.5	133.0	516.6	416.8
Iron (mg)	26.1**	11.7	20.3	5.7	16.6	3.7
Vitamin A (μg)	6140.4	6881.8	5044.9	2697.3	3819.1	2199.7
Vitamin C (mg)	75.5***	39.2	26.3	17.1	21.1	16.7

[1] Fat fee mass

* Significantly higher than in Upland (*P*<0.05)

** Significantly higher than in Hillside and Upland (*P*<0.05)

*** Significantly higher than in Hillside and Upland (P<0.001)

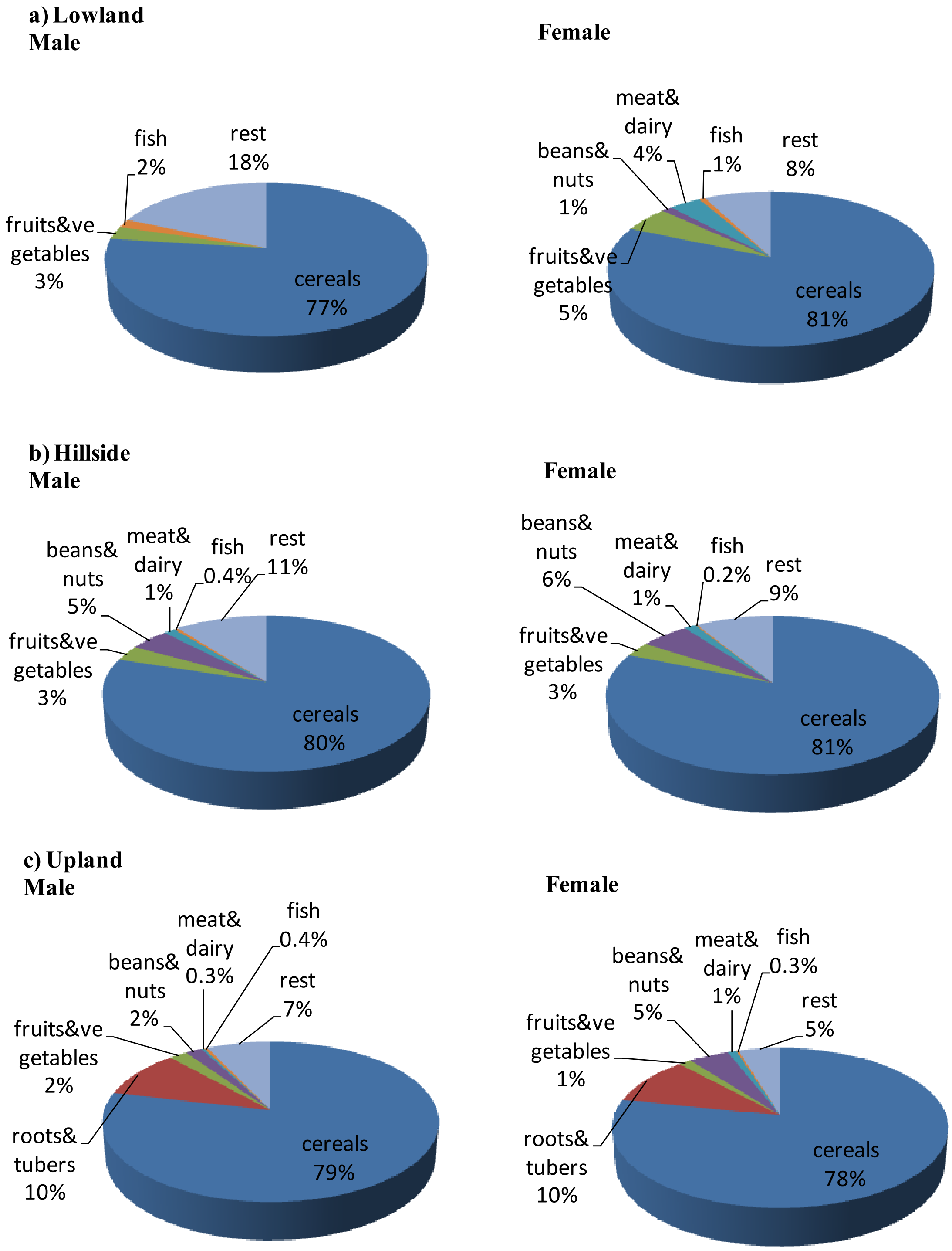

Figure 1 Contribution of specific food groups to daily energy intake

lower in the Upland group compared to the lowland group. Gender differences were not found in the intakes of energy and all nutrients at any of the zones. Figures 1 and 2 show the proportional contribution of specific food groups to the daily intake of energy and protein, respectively, at the three zones and for each sex separately. The proportion of specific food groups contributing to the intakes of energy and all macronutrients were significantly different for all zones, suggesting that there are regional characteristics in dietary patterns. On the other hand, gender differences were not

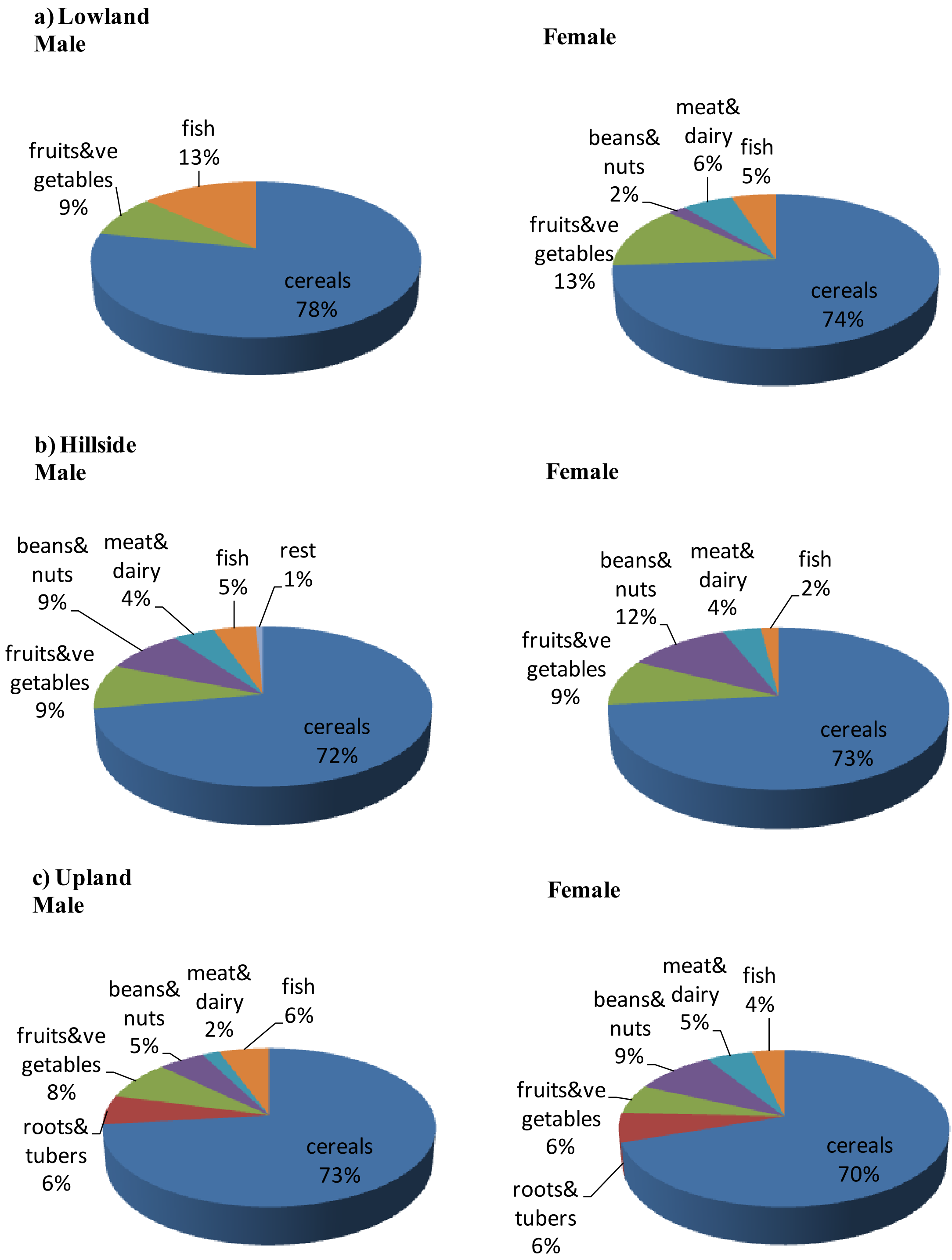

Figure 2 Contribution of specific food groups to daily protein intake

found in the hillside and upland groups, but the proportional contribution of food groups to the daily intake of protein, fat, and carbohydrate were significantly different between men and women in the Lowland group.

These results imply that men and women in the Hillside and Upland groups have similar dietary patterns, but there is gender difference in the dietary pattern of the Lowland group. The occupation of men in the Lowland group may account for this gender difference. Many adult men in the Lowland group work in the kapenta (small fish caught in Lake Kariba) industry and stay overnight near the lake in the dry season when there is less agricultural work to do at home. This resulted in the absence of the male head of the household in the Lowland group during our survey. A few male subjects who were at home during the survey mostly had a second occupation (i.e. job at a local clinic, day laborer). They spent most of the daytime outside the home and ate meals at their workplace, and this might account for the clearer gender difference in diet in the Lowland group compared to the Hillside and Upland groups where subjects of both sexes eat meals together. In addition, some subjects in the Lowland group consumed a home-made fermented alcoholic drink made from tea leaves, yeast, and a high amount of sugar. The food composition of sugar is all carbohydrate. Sugar is classified into 'rest' in this study. This would explain the high proportional contribution of 'rest' to carbohydrate intake (data not shown) and the high intake of carbohydrate (Table 2) among men in the Lowland group.

As to other specific regional dietary patterns, there was a high proportion of consumption of 'roots & tubers' to intakes of energy and protein among both men and women in the Upland group (Figures 1, 2). This is attributed to the intake of sweet potato only in the Upland zone, where sweet potato was eaten for breakfast in almost all cases. The proportion of 'fish' consumption to protein intake was highest among both sexes in the Lowland group compared to other two zones. Although kapenta caught in Lake Kariba were processed and eaten in all zones, fresh fish was sold only in the lowlands close to the lake and were cooked and consumed by the sample households in this group, thus accounting for their high proportion of 'fish' consumption to dietary intake.

3.3 Physical activity & behavioral area

Table 3 shows the estimated basal metabolic rate and indices of physical activity and behavioral area. TEE, energy balance, and PAL did not differ significantly between the three zones for either sex. Energy balance was within the proper range (± 1MJ = 239kcal) for men in the Hillside group and men and women in the Upland group. A minus energy balance was found among men in the Lowland group, and women in the Lowland and Hillside had excess energy intake. Mean PAL was classified as 'active' (FAO/WHO/UNU 2004) for all zones and both sexes.

Although there was no significant difference in daily steps or daily total moving distance between the three zones for either sex, the behavioral radius was significantly larger for both men and women in the Hillside group (Table 3). However, 5 male subjects in this group attended a major Christian meeting in Batoka town about 35 km away from their village, where many Tongan Christians met during the survey period. This may have expanded their behavioral area compared to other subjects who did not attend the meeting or who attended another such meeting outside the survey period. If we calculate the mean behavioral radius of the 5 male subjects excluding the day they attended the meeting, the mean value and SD is 8.2 ± 8.9. Performing the statistical comparison again, we find no difference between the three zones. The mean behavioral radius among men in the Hillside group was still the largest of all groups despite the re-calculation, that among the women was also significantly larger than for the other sites. Both this finding and those of daily steps and daily total moving distance show that the behavioral area of hillside subjects is the largest and that their degree of activity is also the highest, especially for the women.

Table 3 Basal metabolic rate and indices of physical activity and behavioral area of adults living in three contrasting ecological zones of Zambia

a) Male

	Lowland (n=7)		Hillside (n=10)		Upland (n=9)	
	Mean	SD	Mean	SD	Mean	SD
Weight (kg)	61.1	2.4	50.3	4.0	57.8	2.2
BMR[1]	1479.0	225.1	1552.7	122.3	1513.5	148.0
TEE (kcal)[2]	2535.4	471.9	2790.3	302.5	2728.6	279.4
Balance[3]	-345.2	699.4	241.7	649.4	177.0	534.2
PAL[4]	1.71	0.08	1.79	0.09	1.81	0.13
Steps (steps/day)	12111	3980	15828	4932	17226	7208
Distance (km/day)	9.5	6.3	20.6	13.0	11.3	5.5
Behavioral radius (km)	4.9	3.7	21.8*	15.4	2.6	2.1

[1] Estimated basal metabolic rate (FAO/WHO/UNU 2004)

[2] Total energy expenditure

[3] TEI - TEE

[4] Physical activity level; TEE / BMR

* Significantly higher than in Lowland (*P*<0.01)

b) Female

	Lowland (n=10)		Hillside (n=9)		Upland (n=11)	
	Mean	SD	Mean	SD	Mean	SD
Weight (kg)	60	9.8	50.3	4	54.2	11.9
BMR[1]	1307.1	128.9	1249.5	36.6	1288.7	62.3
TEE (kcal)[2]	2224.2	253.9	2241.6	113.1	2280.3	152.0
Balance[3]	456.9	494.4	353.8	395.9	196.6	584.0
PAL[4]	1.70	0.11	1.79	0.08	1.77	0.05
Steps (steps/day)	13681	7589	18643	5604	16414	3004
Distance (km/day)	8.6	5.4	11.6	3.4	9.6	1.7
Behavioral radius (km)	1.8	1.8	4.7*	3.3	2.9	1.6

[1] Estimated basal metabolic rate (FAO/WHO/UNU 2004)

[2] Total energy expenditure

[3] TEI - TEE

[4] Physical activity level : TEE / BMR

* Significantly higher than in Lowland (*P*<0.05)

Among the women in the Lowland group, PAL, behavioral radius, and daily steps were the lowest of the three zones, although not significantly so. Women in the Lowland group are likely to be more sedentary than those in the other two zones. Moreover, while male subjects in the Lowland group had a minus energy balance, the women there showed a plus value, which was also the highest of the three zones.

Among the Upland subjects, there was no gender difference in daily steps, daily total moving distance, or behavioral radius. In fact, most of the sample households in this group farm even during the dry season and we found many couples working together in their fields during the survey. This working together of spouses differs from the situation in the other two zones, suggesting that men and women in the Uplands have similar patterns of both use of place and amount of physical activity expended.

4. Summary

The findings suggest gender differences in dietary and physical activity patterns in the Lowland population because many of the adult men have a second occupation and spend most of the daytime outside the home in the dry season. In the Lowland group, the proportion of 'fish' consumption to dietary intake was higher in both sexes because of the geographical proximity to the lake, and some male subjects consumed a home-made fermented alcoholic drink. The subjects in the Hillside group had the largest behavioral area and highest rate of physical activity, especially among the women. The unique dietary characteristic of the Upland group was that they ate sweet potato. Moreover, as many couples work together farming in the rainy season in the Upland group, it is suggested that they have similar patterns of both use of place and amount of physical activity expended.

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