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Nutritional Assessment of the Adolescents in the Northern State of Sudan

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Abstract: An investigation of the adolescents nutritional status in the Northern State was carried in urban and rural areas. 515 household chosen, populated by 1929 subjects. Adolescents aged (10<20 years) constituting 20.8% were selected from the households. Information on socioeconomic status, anthropometric measurements (BMI-for age), food habits and intake was collected by means of a questionnaire. Prevalence of under weight was a problem among adolescents in the state; which was highest in Albakri (28.6%), similar in Dongla and Marawi, lowest in Karima (16.9%). It was highest among males (29.4%) compared with (17.5%) among females. The gender difference was significant (p<0.021). The strongest predictor of under weight among adolescents was the household energy intake which contributed to about 77% of the variability, then came rural residency. Wheat was the staple food consumed mainly as gurasa. Meat as beef/mutton was used in small amounts to prepare the traditional meat/vegetable stew Mean energy intake was 1734 kcal/day, highest in Karima lowest in Albakri. Location differences were significant (p<0.004) but no urban/rural differences. Protein intake was adequate in 69.5% of the households, animal protein contributed 21.6% to total protein, highest in Karima and lowest in Albakri. Fat intake was inadequate in 83.9% of the households and carbohydrates were in excess in 62.5%. Albakri had the worst food intake because 74.0% of its households lived below the poverty line. The nutritional situation in the State needs further investigation particularly underweight among the adolescents.

Key words: Adolescents nutritional status, malnutrition, food consumption pattern

INTRODUCTION

Sudan is a large country in Africa, has a climate that is ranging from very arid in the Northern part, to Savannah in the Central and most of the Southern parts (FAO, 2005). There is a high potential for future agricultural production as only 20% of the arable land is cultivated (FAO/ WHO, 2007). In addition, agriculture (crop and livestock sectors) and the agro based industries provide employment for 65% of the population and 50% of the raw materials for the local industry (MAF, 2008). In spite of these, the agricultural sector faces chronic problems, that results in food deficits. Large irregularities in access to food exist as more than 90% of the population suffers from poverty and food insecurity (FAO, 2005), which resulted in large scale malnutrition in the country. Poverty and food insecurity are strong indicators of malnutrition which is reflected in the high prevalence of chronic and acute malnutrition among the <5 years old children (SHHS, 2006), classified as high according to the WHO epidemiological criteria. Anthropometry was reported only for under 5 years old children and no information available about the nutritional status for older children or adolescents. There is therefore a need to conduct a systematic investigation on the whole nutritional situation in the Northern State to identify the nutritional status of older age groups and study the differences (if any) due to location, age or sex.

The purpose of this investigation was to study the nutritional situation of adolescents (aged 10-<20 years), both sexes in the Northern State using anthropometry and food intake pattern. Relevant socioeconomic factors affecting nutrition were also included. The quetelet's index which became known as the body mass index:

$$[BMI = Weight (kg) / Height (m^2)]$$

BMI correlates well with weight but was independent of height (Khosha and Lowe, 1967) and also correlates well with body fat (Norgan and Ferro-Luzzi, 1982).

Specific objectives:

1: Assess the nutritional status of all individuals aged (10<20 years) by anthropometry and identify malnutrition (under or excess), if any, among this age group
2: Evaluate the food consumption pattern at the household level quantitatively (24 h recall)
3: Detect any differences in (1) and (2) between urban, rural and sex differences
4: Investigate which socioeconomic indicator(s) influences (1) and (2) in the State

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Nutrition is an important determinant of human life through all the physiological stages. Proper food and good nutrition are essential for growth and survival, mental development, performance, productivity and well being of the individual.

MATERIALS AND METHODS

Five locations in the Northern State were chosen: Karima, Marawi, Dongola, Albakri and Karamalnuzul. To avoid confusion, Karamalnuzul will be referred to as Nuzul in this study. Karima, Marawi and Dongola represented urban areas while rural areas included Albakri, Nuzul and scattered villages around Dongola.

Population figures and number of households in the different locations in the Northern State were obtained from the CBS (1993) census. Sampling was carried out in two stages. Stage 1 to determine the primary sample according to the population figures.

Sample calculation covered populations in urban (towns) and rural (villages) locations. Cluster of villages around Dongola were chosen randomly from the local information provided. Stage 2 was the selection of households in each location or village. It was randomly done starting from a point determined by the local authorities. All the individuals aged 10-<20 in the total households. 401 individuals aged 10-<20 years both sexes were included in this study.

A questionnaire was designed which included:

a: Demographic and socioeconomic data
b: Anthropometric measurements
c: Household food intake

Anthropometry: Weight and height were measured, age and sex recorded. Weights measured to the nearest 0.1 kg and height to the nearest 1 cm using standard procedures (Jelliffe, 1966). Body mass index (BMI-for age) indicator was used in the nutritional assessment of the adolescents (de Onis *et al*., 2007).

Food intake: The Twenty four hours recall method was used for household food intake assessment. Intake was recorded in household measures, converted to weights which were divided by the number of individuals consuming each meal to obtain individual intake. Individual food intake was converted to nutrients intake (protein, carbohydrates, fat and energy) using food composition tables (Boutros, 1986).

Energy and protein requirements: Two levels for energy requirements were used. First the FAO (2001) figures for energy requirements were used to obtain the total energy for all household members (excluding <5 years old children) which was divided by their number to obtain average energy requirement per household. The second level was based on the population energy requirement set at 2110 kcal/day (FAO, 2004). Household protein requirement was calculated in a similar way. Household energy and protein intakes were compared with the above requirements to assess adequacy.

Statistical analysis: Chi-square, t-test and step wise multiple regression analysis to test statistical significance between the different variables using SPSS computer program.

RESULTS

Households distribution, subjects and occupancy: Table 1 shows the number of households by location and family size. A sample of 515 households were chosen from 5 locations in the Northern State representing urban and rural settings. Locations were: Karima (29.5%), Marawi (9.1%), Dongola town and village (40.0%), Albakri (9.7%) and Nuzul (11.7%). The average family size was 3.7. A total of 401 adolescents; 37.91% in Dongola 30.92% in Karima compared to 13.97% in Marawi (Table 2).

Parents' education: Fathers' education is shown in Table 3. Illiteracy among the fathers was: 26.7% in Albakri, 15.6% in Dongola, 15.1% in Nuzul but none was found in Karima and Marawi. The differences between the locations were highly significant ($p<0.000$). Mothers' education (Table 4) showed the highest illiteracy rate in Albakri (54.2%) followed by Nuzul (33.3%), Dongola (32.4%), Karima (10.9%) and Marawi (2.0%).The differences between the locations were highly significant ($p<0.000$). Illiteracy among mothers was higher in rural compared to urban households (41.2% vs., 16.2%) (Table 5).

Monthly income (SDG): 51.5% of the households had incomes = 300 SDG/month: 74.0% in Albakri, 58.7% in Dongola, 44.6% in Marawi, 41.4% in Karima and 38.3% in Nuzul (Table 6).

Table 1: Households distribution and family size

Location	No. (%)	Family size
Karima	152 (29.5)	3.8
Marawi	47 (9.1)	3.7
Dongola	206 (40.0)	3.9
Albakri	50 (9.7)	3.9
Nuzul	60 (11.7)	3.2
Total	515 (100)	3.7

Table 2: Distribution of subjects by location and age

Location	10-<20 years No. (%)	Total No (%)
Karima	124 (30.92)	576 (29.86)
Marawi	56 (13.97)	172 (8.92)
Dongola	152 (37.91)	797 (41.32)
Albakri	28 (6.98)	195 (10.11)
Nuzul	41 (10.22)	189 (9.79)
Total	401 (100%)	1929 (100%)

Table 3: Fathers' education

Level	Karima No. (%)	Marawi No. (%)	Dongola No. (%)	Albakri No. (%)	Nuzul No. (5)	Total No. (%)
Illiterate	0 (0.0)	0 (0.0)	30 (15.6)	12 (26.7)	8 (15.1)	50 (10.9)
Khalwa	3 (2.4)	1 (2.4)	19 (9.9)	6 (13.3)	1 (1.9)	30 (6.6)
Intermediate	50 (39.4)	13 (31.7)	96 (50.0)	14 (31.1)	25 (47.1)	198 (43.2)
Secondary	56 (44.0)	20 (48.8)	36 (18.8)	7 (15.6)	18 (34.0)	137 (29.9)
University	18 (14.2)	7 (17.1)	11 (5.7)	6 (13.3)	1 (1.9)	43 (9.4)
Total	127 (100)	41 (100)	192 (100)	45 (100)	53 (100)	458 (100)

p<0.000

Table 4: Mothers' education

Level	Karima No. (%)	Marawi No. (%)	Dongola No. (%)	Albakri No. (%)	Nuzul No. (5)	Total No. (%)
Illiterate	16 (10.9)	1 (2.2)	65 (32.4)	26 (54.2)	20 (33.3)	128 (25.5)
Khalwa	2 (1.4)	0 (0.0)	7 (3.5)	0 (0.0)	0 (0.0)	9 (1.8)
Intermediate	54 (37.0)	22 (46.8)	80 (39.8)	8 (16.7)	21 (35.0)	185 (36.8)
Secondary	58 (39.7)	12 (25.5)	31 (15.4)	9 (18.8)	16 (26.7)	126 (25.1)
University	16 (10.9)	12 (25.5)	18 (8.9)	5 (10.5)	3 (5.0)	54 (10.8)
Total	146 (99.9)	47 (100)	201 (100)	48 (100)	60 (100)	502 (100)

p<0.000

Table 5: Mother education in urban rural settings No. (%)

Residency	Illiterate	Khalwa	Intermediate	Secondary	University	Total
Urban	52 (16.2)	9 (2.8)	124 (38.7)	96 (30.0)	39 (12.2)	320 (99.9)
Rural	76 (41.2)	0 (0.0)	61 (33.5)	30 (16.4)	15 (8.2)	182 (99.9)
Total	128 (25.4)	9 (1.8)	185 (36.8)	126 (25.1)	54 (10.7)	502 (99.9)

Table 6: Monthly income (SDG)

Income	Karima No. (%)	Marawi No. (%)	Dongola No. (%)	Albakri No. (%)	Nuzul No. (%)	Total No. (%)
<200	16 (10.5)	0 (0.0)	42 (20.4)	12 (24.0)	5 (8.3)	75 (14.6)
200-300	47 (30.9)	21 (44.6)	79 (38.3)	25 (50.0)	18 (30.0)	190 (36.9)
301-500	61 (40.1)	16 (34.0)	63 (30.6)	12 (24.0)	28 (46.7)	180 (35.0)
>500	28 (18.4)	10 (21.3)	22 (10.7)	1 (2.0)	9 (15.0)	70 (13.6)
Total	152 (99.9)	47 (99.9)	206 (100)	50 (100)	60 (100)	515 (100)

p<0.000

Table 7: Monthly income (SDG)-urban and rural households

Income	Urban No. (%)	Rural No. (%)	Total No. (%)
<200	32 (9.7)	43 (23.2)	75 (14.6)
200-300	116 (35.2)	74 (40.0)	190 (36.9)
301-500	125 (37.9)	55 (29.7)	180 (35.0)
>500	57 (17.3)	13 (7.0)	70 (13.6)
Total	330 (100.1)	185 (99.9)	515 (100)

p<0.000

For the = 300 SDG/month category, it was 61.7% in Nuzul, 58.4% in Karima, 55.3% in Karima, 41.3% in Dongola and 26.0% in Albakri. Households in urban areas had significantly (p<0.000) higher incomes compared to those in rural areas (Table 7).

Nutritional status of the adolescents: BMI-for-age was the indicator used to assess the nutritional status. 75.6% had normal nutritional status, 22.2% suffered underweight and 2.2% were obese (Table 8). Females had better nutritional status than males as 17.5% suffered underweight compared with 29.4% males and also lower rates of severe underweight (4.6 and 10.6% respectively)-the gender difference was significant (p<0.021).Table 10 shows the comparison between the 5 locations. Prevalence of underweight was highest in Albakri (28.6%), lowest in Karima (16.9%) and was similar in Dongola and Marawi. However, the difference in underweight was not significant (p<0.188). No

Table 8: Nutritional status (B.M.I for-age) of the 10-<20 years old and by gender

Status	Total	Males	Females
Normal	303 (75.6)	111 (69.4)	192 (79.7)
Underweight:			
Moderate	61 (15.2)	30 (18.8)	31 (12.9)
Severe	28 (7.0)	17 (10.6)	11 (4.6)
Obese	9 (2..2)	2 (1.3)	7 (2.9)
Total	401 (100)	160 (100)	241 (100)
Global underweight	(22.2)	(29.4)	(17.5)

p<0.021

significant difference in underweight was noticed between urban and rural adolescents (Table 9).

Nutrients intake

Mean nutrients intake/day: Mean daily nutrients intake is shown in Table 10. Mean energy intake was 1734 kcal/day, was highest in Karima (1906 kcal) and lowest in Albakri (1527 kcal). Similar energy intakes were obtained in Dongola and Nuzul and a slightly higher figure in Marawi. There was a significant difference in energy intake between locations (p<0.002). Mean protein intake was 55.3 g/day, highest in Karima (59.3 g) and lowest in Albakri (47.9 g), the difference between locations was significant (p<0.004). Mean animal protein intake was 11.95 g/day, also highest in Karima (14.97 g) and lowest in Albakri (8.81 g) and the difference between locations was highly significant (p<0.000). Ratio of

Table 9: Nutritional status of the 10-<20 years old by location

	Nutritional status (BMI) for age				
	Underweight				
Location	Normal	Moderate	Severe	Obese	Total
Karima	102 (82.3)	15 (12.1)	6 (4.8)	1 (0.8)	124 (100)
Marawi	39 (69.6)	11 (19.6)	3 (5.4)	3 (5.4)	56 (100)
Dongola	113 (74.3)	24 (15.8)	14 (9.8)	1 (0.7)	152 (100)
Albakri	19 (67.9)	5 (17.9)	3 (10.7)	1 (3.6)	28 (100)
Nuzul	30 (73.2)	6 (14.6)	2 (4.9)	3 (7.3)	41(100)
Total	303 (75.6)	61 (15.2)	28 (7.0)	9 (2.2)	401(100)

p<0.188

Table 10: Nutritional status of the 10-<20 years old by urban/rural settings

	Nutritional status (BMI) for age, No. (%)				
	Underweight				
Location	Normal	Moderate	Severe	Obese	Total
Urban	213 (76.6)	44 (15.8)	17 (6.1)	4 (1.4)	278 (100)
Rural	90 (73.2)	17 (13.8)	11 (8.9)	5 (4.1)	123 (100)
Total	303 (75.6)	61 (15.2)	28 (7.0)	9 (2.2)	401 (100)

p<0.266

Table 11: Nutrients intake (Mean±SD) by location and urban/rural setting

Location	Energy (kcal)	Plant protein (g)	Animal protein (g)	Total protein (g)	Fat (g)
Karima	1906±661	41.43±12.87	14.97±9.05	59.29±20.84	17.56±10.19
Marawi	1727±674	41.83±18.62	11.07±15.62	56.46±7.16	17.52±21.97
Dongola	1678±729	40.14±11.36	10.69±6.96	54.93±18.40	20.61±11.13
Albakri	1527±469	38.39±9.58	8.81±4.40	47.94±15.45	20.13±8.91
Nuzul	1670±596	42.49±15.00	9.93±7.32	52.01±19.58	19.14±9.02
Mean	1734±676	40.78±12.57	11.95±7.93	55.34±19.60	19.24±10.48
p-value	0.002	0.382	0.000	0.004	0.066
Urban	1757±604	40.96±12.70	12.49±8.19	56.82±19.95	19.41±11.37
Rural	1692±788	40.46±12.36	10.77±7.22	52.73±18.72	18.93±8.76
Mean	1733±676	40.78±12.57	11.95±7.93	55.34±19.60	19.24±10.48
p-value	0.295	0.667	0.053	0.024	0.620

animal protein to total protein as a measure of quality was highest in Karima (25.2%), similar in Marawi, Dongola and Nuzul (ca. 19.4%) and lowest in Albakri (18.3%). Therefore, protein intake by households in Albakri was the lowest in both quantity and quality. Mean fat consumption was 19.24 g/day, was slightly higher in Dongola and Albakri (ca. 20 g), lower in Marawi and Karima (ca. 17%) and between the two in Nuzul (19.14 g). However, the difference between locations was not significant (p<.066). Intake of nutrients in urban households was higher than in rural households. Difference in total protein intake was significant (p<0.024) and although it was not significant for animal protein intake (p<0.053), the result showed a trend of higher protein intake in urban areas. Differences in energy and fat intakes were not significant (p<0.295 and p<0.620, respectively).

Adequacy of nutrients intake:

Adequacy in this section meant intake of = 80% of the requirement.

Energy: Adequacy of energy intake was assessed by using 2 references: the population requirement reference of 2110 kcal (FAO, 2005) and a mean household RDA (FAO, 2001) reference calculated for all household members above 5 years old. According to the calculated mean household RDA reference only 35.3% of the households had adequate energy intake (Table 12). Highest adequacy rate was in Karima (45.4%) and the lowest in Albakri (28.0%); Marawi and Nuzul had similar rates (ca. 34.5%) but Dongola a lower rate (30.1%). The difference in adequacy rate between locations was significant (p<0.034). The population requirement reference gave a figure of 47.2% for mean adequacy rate. Rate was also highest in Karima (56.6%) and lowest in Albakri (36.0%); Marawi and Dongola had similar intakes while Nuzul a lower intake.

The population requirement reference gave higher rates of energy adequacy than the calculated mean household reference. There was also a difference in the three locations that had neither the highest nor lowest rate. More urban households had adequate energy intake than rural ones but the difference was not significant (p<0.142).

Protein: Table 13 shows the mean adequacy of protein intake (= 80% of 65 g/day) as 49.6%. Adequacy was exceeded by half the number of households only in Karima (59.2%) and Marawi (53.2%), was 47.6% in Dongola and 45.0% in Nuzul. Albakri showed the lowest adequacy rate as 68.0% had inadequate protein intake.

Table 12: Adequacy of energy intake by location and urban/rural setting

	Population requirement		Mean household RDA		
Location	Adequate	Inadequate	Adequate	Inadequate	Total
Karima	86 (56.6)	66 (43.4)	69 (45.4)	83 (54.6)	152
Marawi	21 (44.6)	26 (55.3)	16 (34.0)	31 (66.0)	47
Dongola	94 (45.6)	112 (54.4)	62 (30.1)	144 (69.9)	206
Albakri	18 (36.0)	32 (64.0)	14 (28.0)	36 (72.0)	50
Nuzul	24 (40.0)	36 (60.0)	21 (35.0)	39 (65.0)	60
Total	243 (47.2)	272 (52.8)	182 (35.3)	333 (64.7)	515
p-value	0.054		0.034		
Urban	163 (49.4)	167 (50.6)	-	-	330
Rural	80 (43.2)	105 (56.8)	-	-	185
Total	243 (47.2)	272 (52.8)	-	-	515
p-value	0.142				

Table 13: Adequacy of protein intake (<65 g/day) by location and urban/rural setting

Location	Adequate	Inadequate	Total
Karima	90 (59.2)	62 (40.8)	152 (100)
Marawi	25 (53.2)	22 (46.8)	47 (100)
Dongola	98 (47.6)	108 (52.4)	206 (100)
Albakri	16 (32.0)	34 (68.0)	50 (100)
Nuzul	27 (45.0)	33 (55.0)	60 (100)
Total*	256 (49.6)	259 (50.4)	515 (100)
Urban	175 (53.0)	155 (47.0)	330 (100)
Rural	81 (43.8)	104 (56.2)	185 (100)
Total**	256 (49.7)	259 (50.3)	515 (100)

*p<0.011 **p<0.048

Table 14: Macronutrients contribution (%) to total energy intake by location and urban rural setting

Location	Protein	Fat	Carbohydrates	Total
Karima	12.4	8.3	79.3	100
Marawi	13.1	9.1	77.8	100
Dongola	13.1	11.1	75.8	100
Albakri	12.5	11.8	75.7	100
Nuzul	12.4	10.3	77.3	100
Average	12.7	10.0	77.3	100
Urban	12.9	9.9	77.2	100
Rural	12.4	10.0	77.6	100
Average	12.6	9.9	77.4	100
Adequacy (%)*	10-15	15-30	55-75	

*Source: WHO (2002)

Difference in protein intake between locations was significant (p<0.011). There was also a significant difference (p<0.048) in adequacy of protein intake between urban and rural households, the former had higher intake rates.

Energy balance: Energy balance in this section means within the recommended range. Contribution of the macronutrients to the energy balance of diets consumed is shown in Table 14. Protein intake was within the recommended range, fat intake lower and carbohydrates intake above the range. Fat contribution to the total energy was adequate in only 15.9% of the households (Table 15), was highest in Albakri (28.0%) and Dongola (22.3%) but was less than 10% in other locations. The differences in adequacy highly significant (p<0.000). Consequently, inadequacy was highest in Marawi, Karima and Nuzul (93.6, 91.4 and 90.0%, respectively). Adequacy was slightly higher in urban than rural households but the difference was not significant (p<0.695). Carbohydrates contribution to the total energy was adequate in 35.2% of the households (Table 16); it was highest in Albakri (46.0%) and Dongola (45.6%) followed by Nuzul (33.3%), Marawi (29.8%) and Karima (19.7%). The difference in adequacy was highly significant (p<0.000).

Socioeconomic factors affecting the nutritional status: The effects of selected socioeconomic factors and households energy intake (independent variables) on the nutritional status were studied. Factors were location (urban or rural area), age household income and mother's education. Multiple stepwise regression analysis was used.

Adolescents (10-<20 years old): Energy intake was investigated in addition to the above factors (Table 17). Energy intake as percent of household RDA was the major factor contributing to about 76% of the variability in underweight (R square 0.764, significance 0.000) while rural residency contributed to about 72% of the variability (R square 0.718, significance 0.000). The contribution of energy intake and rural residency to the variability was 78% (R square 0.776, significance 0.000). The contribution of energy intake+rural residency+mother's education was 77% (R square 0.768, significance 0.000). Mother's education+rural residency+town residency contributed to 77% of the variability (R square 0.772, significance 0.000) but mother's education+rural residency+urban residency+household income was weakly correlated with underweight (r = 0.145, significance 0.004). This shows that household income had indirect effects on the nutritional status since it affects several aspects of the adolescent life other than energy intake.

DISCUSSION

Socioeconomic background

Household distribution and family size: The number of households in each location was determined by the population density e.g. Dongola, the largest locality in

Table 15: Adequacy of fat contribution (%) to total energy (15-30%) by location and urban/rural setting

Location	Lower than (15%)	Adequate (15-30%)	Higher than (30%)	Total
Karima	139 (91.4)	13 (8.6)	0 (0.0)	152 (100)
Marawi	44 (93.6)	3 (6.4)	0 (0.0)	47 (100)
Dongola	159 (77.2)	46 (22.3)	1 (0.2)	206 (100)
Albakri	36 (72.0)	14 (28.0)	0 (0.0)	50 (100)
Nuzul	54 (90.0)	6 (10.0)	0 (0.0)	60 (100)
Total	432 (83.9)	80 (15.9)*	1 (0.2)	515 (100)
Urban	277 (83.9)	277 (83.9)	0 (0.0)	330 (100)
Rural	155 (83.8)	155 (83.8)	1 (0.2)	185 (100)
Total	432 (83.9)	432 (83.9)**	1 (0.2)	515 (100)

p<0.000 *p<0.695

Table 16: Adequacy of carbohydrates contribution (%) to total energy by location and urban/rural setting

Location	Lower than 55%	Adequate 55-75%	Higher than 75%	Total
Karima	5 (3.3)	30 (19.7)	117 (77.0)	152 (100)
Marawi	1 (2.1)	14 (29.8)	32 (68.1)	47 (100)
Dongola	4 (1.9)	94 (45.6)	108 (52.4)	206 (99.9)
Albakri	1 (2.0)	23 (46.0)	26 (52.0)	50 (100)
Nuzul	1 (1.7)	20 (33.3)	39 (65.0)	60 (100)
Total	12 (2.3)	181 (35.2)*	322 (62.5	515 (100)
Urban	10 (3.0)	113 (34.2)	207 (62.7)	330 (99.9)
Rural	2 (1.1)	68 (36.7)	115 (62.2)	185 (100)
Total	12 (2.3)	181 (35.2)**	322 (62.5)	515 (100)

*p<0.000 **p<0.264

Table 17: Association between underweight among adolescents (10- <20 years) and selected socioeconomic variables by multiple regression coefficient analysis

			F		t		Partial
Model	R	R square	Value	Signific.	Value	Signific.	correlation
Energy	0.874	0.764	1282.357	0.000	35.81	0.000	-
Rural	0.847	0.718	1018.004	0.000	31.906	0.000	-
Energy+rural	0.881	0.776	685.840	0.000	9.985	0.000	-
	-	-	-	-	4.673	0.000	-
Energy+rural+	0.876	0.768	659.663	0.000	12.089	0.000	-
Mother's education	-	-	-	-	9.258	0.000	-
Mother's education+	0.879	0.772	450.340	0.000	3.134	0.002	-
Rural+urban	-	-	-	-	9.724	0.000	-
	-	-	-	-	2.851	0.005	-
Mother's education+	-	-	-	-	3.859	0.000	0.191
rural+urban+income	-	-	-	-	2.907	0.004	0.145
	-	-	-	-	4.673	0.000	0.229
	-	-	-	-	3.992	0.000	0.197

the state had 41,715 households out of a state total of 91,578 (CBS, 1993). Dongola location constituted 40.0% of the households in this study (Table 1). The second largest locality was Marawi, represented by Karima and Marawi towns (29.5% and 9.1% of the households respectively). Albakri and Nuzul locations represented rural settings. Family size (3.7) was lower than that reported by CBS family expenditure survey for the state and lower than the average for north Sudan states. The Northern State is the least populated state (664,000) because of lowest population growth and highest migration rate (CBS, 2008).The highest migration rate could be due to the fact that many leave the state searching for better jobs for themselves or better education chances for their children especially at higher education level.

Distribution of subjects by location, age and gender: The distribution of subjects was random, since, once a household was selected then all the adolescents were included in the study (Table 2). Females were more among this age group (60.0%) as extracted from table 8. A similar finding was reported by Ibrahim (2008).

Parents' education: The general illiteracy rate in this study (18.5%) was lower than the national average of 39% (Mustafa and Alsiddig, 2007; UNDP, 2009), the state average of 24% (FSU, 2005) and that of 52.5% in west Kordofan (Ibrahim, 2008). In Marawi and Karima, illiteracy was not reported among the fathers and was 2.2 and 10.9%, respectively among the mothers. However, it was generally high in Albakri (40.8%), Dongola and Nuzul (ca. 24%). In these three locations it was nearly double among the fathers compared to the mothers (Tables 3 and 4). Illiteracy was higher among rural compared to urban mothers and secondary/university education was lower (Table 3), the differences were highly significant (p<0.000) which

reflects less chances for education. Similar high significant differences were reported by Ibrahim (2008) between urban and rural women in illiteracy (49.5% vs., 84.1%) and in secondary/university education (17.2% vs., 0.8%). The major problem in the Northern State is women education especially illiteracy in rural areas. Previous studies showed that controlling the income, the energy content of the diet of children tended to be better for those whose mothers were literate compared to the illiterate ones (Brahman, 1988) undernutrition among children in India, Pakistan, Sri Lanka and Thailand correlated with the level of maternal education and that the highest incidences of undernutrition correlated with illiterate mothers (Osmani, 1997). Thus female education, by at least eradicating illiteracy, improves household nutritional status especially that of children.

Household monthly income (SDG) and poverty level: In Sudan, no agreed upon definitions for poverty is yet available, so different criteria are used e.g. UN poverty line, that of the Zakat Chamber, that of the Ministry of Finance etc. The UN poverty line is defined as an income of one US$/head/day. Using the official rate of 2.4 SDG/1 US$ (Al Ta'yar newspaper, No.316, 2009) the poverty line was 270 SDG/household/month for 3.7 occupants. Therefore, it was reasonable to assume 300 SDG/household/month as the poverty line in this study. 51.5% of the households in this study (Table 6) had monthly incomes below the poverty line (<300 SDG/month) which was within the poverty range for north Sudan reported by the Ministry of Finance and National economy, MFNE (2006) as 50-60% and the UNDP (2008) as 50%. A small proportion of the households (13.6%) had incomes of >500 SDG/month which for some could be lower than the lowest mean of 663 SDG/month reported by the family expenditure survey (CBS, 2007). The survey placed the Northern State within the same degree of poverty as conflict areas in east, west or south Sudan but for different reasons e.g. natural disasters such as floods or droughts that added to the general underdevelopment that affected all aspects of life in the state. Poverty was highest in Albakri (74.0%) and Dongola (58.7%) compared with Karima and Marawi (*ca.* 42%), but the lowest rate was in Nuzul (38.3%). 63.2% of rural households had monthly incomes of <300 SDG compared with 44.9% in urban areas (Table 7), the difference was highly significant ($p<0.000$). This agreed with similar studies (Mustafa and Siddi, 2007; Ibrahim, 2008; UNDP, 2008) that reported higher poverty rate in rural compared with urban household due to underdevelopment and inequality of access to resources and services. Poverty (hunger) and malnutrition are linked in a sort of a vicious circle where any one of them once started can lead to the other and at the same time investment and intervention in any one will reduce the burden of the other.

10-<20 years old (Adolescents): Reference is made to Tables 8, 9 and 10. The general profile (Table 8) shows 22.2% underweight and 2.2% obese. The underweight figure is slightly lower than the 27.0% reported by FAO (2005). Incidence of CED (Chronic Energy Deficiency) among females was lower than among males especially severe cases and the gender differences in nutritional status was significant ($p<0.021$). Nutritional status by location showed highest incidence of CED in Albakri (28.6%), similar rates in Marawi and Dongola (*ca.* 25%) and in Karima and Nuzul (*ca.* 18%). No location differences in nutritional status was observed ($p<0.188$). However, in terms of absolute number of adolescents the underweight problem is in Dongola, Karima and Marawi respectively because of larger representation in this age group. Similarly no difference was observed ($p<0.266$) between urban and rural residency (Table 11). This study agreed with Ibrahim (2008) in the high prevalence of underweight among this age group and that females had better nutritional status than males although severe underweight was higher in west Kordofan. It seems that the major nutritional problem that needs urgent attention among this age group is underweight. Underlying factors should be investigated in-depth as the adolescents are the future of the country.

Energy and protein intakes

Energy intake: Mean energy intake in this study was 1734 kcal/day. It was 96.2% of that reported for west Kordofan (Ibrahim, 2008), 80.5% of that of FSU (2005) and 82.2% of the FAO (2005) mean population requirement. Energy intake by location was highest in Karima (1906 kcal/day), followed by Marawi/Dongola/Nuzul and was lowest in Albakri (1527 kcal/day). Differences between locations were significant ($p<0.002$) but not between urban/rural settings ($p<0.295$). Thus households in Albakri had a problem of low energy intake a finding supported by the highest rate of underweight among adolescents (28.6%). In addition, Albakri had the highest number of households living under the poverty line (74.0%). Further analysis of adequacy of energy intake was carried out using two procedures: FAO (2005) population energy requirement and the calculated mean household intake. FAO procedure showed adequate intake by 47.2% of the households; the best situation was in Karima (56.6%), similar situations in Marawi/Dongola but the lowest rate was in Albakri (36.0%). Differences were not significant ($p<0.054$). Mean household requirement procedure showed only 35.3% of the household had adequate energy intake, Karima had the highest rate (45.4%) and Albakri the lowest (28.0%) but the differences between locations were significant ($p<0.034$). No difference was observed when urban/rural energy intake was assessed using FAO procedure ($p<0.142$) but a trend of higher

intakes was noticed in urban areas. From the results it is evident that the FAO (2005) population energy requirement gave higher rates of energy adequacy compared to the mean household requirement. This is understood within the context that FAO procedure is meant for use in emergency situations.

Energy sources: WHO (2002) recommended contributions to total energy as 10-15% from proteins, 15-30% from fat and 55-75% from carbohydrates. In this study contributions were: protein 12.6%, fat 9.9% and carbohydrates 77.4%. It is obvious that fat contribution was very low and carbohydrates were higher than the recommended range. FSU (2005) reported contributions as: protein 11.9%, fat 23.1% and carbohydrates 65% all within the recommended range. In contrast to this study, fat contribution in west Kordofan (Ibrahim, 2008) was high (32.3%) while that of protein low (9.5%) compared to the recommendations. Fat contribution was inadequate in about 91.5% in Karima, Marawi and Nuzul. However, higher adequacy rates were noticed in Albakri (28.0%) and Dongola (22.3%) due to higher fat intakes (Table 15). Differences in fat contribution to total energy by location was highly significant ($p<0.000$) but not by urban/rural settings ($p<0.695$). More than 75% carbohydrates contribution to total energy was observed in Karima (77.0%), Marawi/Nuzul (ca. 66.5%) but lower rates in Dongola/Albakri (52%); the differences were highly significant ($p<0.000$). The differences between urban/rural settings were not significant ($p<0.264$).

Protein intake: Mean total protein intake was 55.34g/day which was 85.1% of the calculated average household protein requirement (65 g/day). Intake was 90.6% of the FSU (2005) and 131.7% of that reported for west Kordofan (Ibrahim, 2008). Intake was highest in Karima (59.29 g), followed by Marawi/Dongola (ca. 55 g), then Nuzul (52.0 g) and lowest in Albakri (47.9%). The differences between locations were significant ($p<0.004$). Intake in urban households was significantly higher than in rural ones ($p<0.024$). Adequacy of protein intake calculated as 80% of the household protein requirement was 49.6%; highest in Karima (59.2%), then Marawi (53.2%), was similar in Dongola/Nuzul (ca. 46%) but was low in Albakri (32.0%).

Contribution of animal proteins to total proteins in this study was similar to that reported by FSU (21.6 and 23.6%, respectively). Both contributions were lower than that reported for west Kordofan (31.2%) by Ibrahim (2008). Animal proteins intake in the different locations differed significantly ($p<0.000$) and urban households' intake was higher than rural ones although the difference was not significant ($p<0.053$). Animal proteins contribution to total proteins was highest in Karima (25.2%), similar in Marawi/Dongola/Nuzul (*ca.* 19%) but low in Albakri (18.3%). Low contribution in Albakri was due to the lowest frequency of intake of the animal protein sources (meat, Terkin, eggs) compared to other locations; as for dairy products, the low intake frequency of zabadi observed can be offset by the highest intake rate of roub.

Conclusion and suggested interventions: There was a high energy deficit due to the low fat intake which was lower than the minimum of 15% recommended by WHO (2002). Carbohydrates were the major source of energy in the diet supplying 77.3%, higher than the 75% suggested by WHO. 78.4% of the proteins consumed were of plant origin which was similar to that reported by FSU (2005) and is mostly from wheat. Therefore, wheat was the major source of energy and protein in the studied areas. The author suggests an increase in animal protein and fat intakes to improve the quality of the protein consumed and increase the total energy intake. Albakri had the lowest intakes of energy, total protein and animal proteins so need special attention by the authorities.

Socioeconomic factors affecting the nutritional status of the adolescents: The strongest predictor of underweight among adolescents was energy intake contributing to about 77% of the variability (Table 18). Adding rural residency increased the contribution to 78% although rural households' energy intake was lower than urban ones. It is logical that energy intake affect the energy balance hence the nutritional status but in this study mean household energy intake was the measure which was less than that of the FAO (2004) for emergencies, therefore, an in depth study is urgently needed to investigate the causes of the high incidences of underweight among adolescents and other socioeconomic factors affecting their nutritional status.

Conclusion and suggested interventions:

- Adolescents nutritional status was one of the important depressing observation in this study, As most of the studies cited linked anemia with low (B.M.I), a through investigation should be conducted in the state regarding micronutrients intake for adolescent and younger age groups
- High illiteracy among women adversely affects the nutritional status as mentioned in this study and also approved by several studies so education is the first priority in the state. The author suggests that promotion of education through co-ordination between compulsory service using university graduates and students males and females in reducing illiteracy rates could be beneficial
- Since malnutrition, poverty and food insecurity are linked, then this should be a major component in all development projects in the state, starting with Marawi Dam project

The main nutritional interventions proposed to enhance food security in the state are:

a: Promotion of food production mainly fresh vegetables and fruits
b: Promotion of cold storage and transportation for foods that are not produced in the state and imported from other states (mainly meat, dairy products and poultry)
c: Promotion and investment in fisheries industry

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