Nigerian Journal of Science Vol. 36 No. 1 (2002) 97-104

Assessment of Energy and Selected Nutrient Intakes, Basal Metabolic (BMR) and Body Composition of Nigerian Female Adolescents

Cole, A. H.; Tomori, O. F.; Odumbaku, S. O. and Aminu, F. T.
Human Energy Metabolism Laboratory, Department Of Human Nutrition, College of Medicine, University of Ibadan, Ibadan, Nigeria

Abstract

There have been scanty reports on the adolescences' energy intake (EI), selected nutrients intake (SNI) and body composition (BC) in the subjects of developing countries. The relationship between EI and BC in adolescence is important because the adolescence years are periods of great physical and emotional changes during which a child develops and enters adulthood Cole et. al. (1997). The aims of the present study were first to obtain information on EI, SNI and BC of thirty four apparently healthy Nigerian female adolescents aged 11-17 years residing in a residential institutionalized boarding school and to compare the information obtained with international standards or with other countries in the industrialized world. The food intake (FI) of the individual subjects was assessed by direct weighing for seven consecutive days including weekends, and its energy value (EV) was determined by means of ballistic bomb calorimeter. Basal metabolic rate (BMR) values were calculated according to standard equations of Food and Agriculture Organization, World Health Organization/United Nations University FAO/WHO/UNU, (1985). Percentage total body using population specific equations. The subjects means daily EI was found to be 6.9 MJ/d or 0.15 Mj/kg body weight, which is lower than the calculated energy requirements (ER) of 8.8. Mj/d for female adolescents aged 12-14 years FAO/WHO/UNU, (1985). The contributions of the specific nutrients and each meal to the total EI were carbohydrate, protein and fat 13.0, 17.0 and 10.0% and breakfast, lunch and supper 20.5, 56.4 and 23.1% of energy. However, the mean BMR was 5.5 Mj/d, which is comparable with that given by FAO/WHO/UNU, (1985) for female adolescents aged 13-14 years and that reported by Cole et al., (1997) for female adolescents aged 11-17 years. The mean TBF % was found to be 22.2 and the mean body mass index (BMI kg/m^2) was 19.2 kg/m^2 respectively. The study shows that the comparatively low mean EI of the female adolescents in the present study may be indicative of energy deficiency in their meals. This assumption is also reflected in their BC values Therefore, the study suggests more extensive studies in Nigerian population of EI, energy expenditure (EE) and BC, which take into account differences in methodology, social status, education, age, sex, ethnicity and geographical region.

Introduction

A study of adolescence nutrition and eating habits is an important task because nutrition is a determinant of people's state of health, particular during adolescence. Nutrition has also been recognized as one of the necessary ingredients of normal growth during adolescence, either influencing the development or preventing some degenerative diseases. There is good evidence that poor eating habits and nutrition are closely associated with common health problems in Nigeria such as malnutrition (stunting and wasting) among infants and children, coronary heart disease, high blood pressure and diabetes in adults.

According to Food and Agriculture Organization FAO/WHO, (1973) estimates, energy requirements (ER) for adolescent girls 10-12, 13-15 and 16-19 years are 9.8 MJ (2342 kcal)/d, 10.4 MJ (2486 kcal)/d and 9.7 MJ (2318 kcal)/d respectively. However, EI values published by FAO/WHO/UNU, (1985) for female adolescents aged 14-15 years are 9.8 MJ (2342 kcal)/d which are slightly lower than FAO/WHO, (1973) values.

The aim of this present study was primarily to obtain information on EI and the contribution of different energy-yielding nutrients to the total EI of the female adolescents. The results are compared with FAO/WHO, (1973) and FAO/WHO/UNU, (1985) recommended values. The percentage total

body fat (TBF %) was also assessed through SFT measurements, using population specific equations derived from a survey of European female adolescents as a basis for prospective computations.

Materials and Methods

Subject

Thirty-four apparently healthy institutionalized female adolescents of Saint Anne's School, Molete, Oyo State, Nigeria aged between 11 and 17 years were the subjects of the study. They were selected at random (1 in 5), from 170 boarders at the school, who belong to families of different ethnic and socio-economic groups and were considered to be typical for an average Nigerian girl. Characteristics of the subjects are given in Table 1.

The Ethical Committee of the College of Medicine, University of Ibadan, Ibadan, Nigeria approved all experimental procedures and protocols before the commencement of the study. Informed consent of the girls was sought and obtained before the start of the experiments.

The study was carried out between March and April of the 1990-91 session at Saint Anne's Secondary School in Ibadan South Local Government Area of Oyo State, Nigeria Ibadan, the capital of Oyo State, has approximately a population of 1,075,807 (one million seventy five thousand eight hundred and seven). The annual rainfall between March and April was 16.4 mm with an average daily temperature of 22^{0}C.

Food Intake (FI)

The subjects ate their meals (breakfast, lunch and supper) in the school cafeteria on each of the seven consecutive days of the study. Fresh green vegetables or fruits were not included in the menu. There was no evidence of consumption of fruits such as fresh bananas (*musa spec*), pineapples (*ananae comosus*), mangoes (*mangifra indica*), oranges (citrus), papaya or apples. Bulky staple foodstuffs such as yam (*diascores spec.*), yam flour (amala), cassava (*manihot esculenta*), starch (fufu) were served. The consumption of snacks between meals was so minimal and did not contribute to EI.

In Nigeria, especially among the Yoruba people of the South-west where the present study was conducted, staple diet consists of items such as maize (*zeamays* 1) flour (eko tutu), cassava (*manihot esculenta*) flour (gari) and yam (*dioscorea spec.*) boiled or pounded. For details of the dietary patters of Yoruba see Cole and Ogungbe (1987)

Food Intake Measurements

At meal times (07.00-07.30 hours breakfast, 14.00-14.30 hours lunch and 18.00-18.30 hours supper), the investigators and two female field officers from our laboratory in Ibadan assembled in the cafeteria of the school to record FI. For details of method see Cole et al. (1997)

Chemical Analysis of Samples

The food samples were analysed for energy, fat and protein according to methods recommended by AOAC (1980). Carbohydrate was calculated by difference. Coefficients of variation (%) for these analysis were for fat 8.5, for protein 15.3 and for carbohydrate 10.0. The chemical analysis, except for moisture determination, was carried out on oven-dried samples. The materials were dried at 10-800C for 20 hours and then at 110-1150C for 24 hours for a constant weight using Gallenkamp moisture extraction oven, model OV 446 (Gallenkamp & Co.; London). For details see Cole et al (1997)

Anthropometry

The ages of the subjects were supplied by individual girls and confirmed from school records. Height (m) measurements were taken with vertical rods comprising fixed metal scales, designed by Cole, A H. (unpublished results). Body weight (kg), without shoes and in light clothing, was measured using a portable floor Salter Scale, model 109 (Salter Industrial Measurement Ltd., Shropshire).

Skinfold Thickness (SFT)

SFT was measured to the nearest mm, except for low values (usually 5 mm or less) when it was taken to the nearest 0.5 mm. These readings were made at three sites, tricepts, subscapular and suprailiac, on all adolescent girls using "Somet" caliper manufactured in Czechoslovakia. These three SFT values were used to estimate TBF % of the subjects. The measurements, made by two investigators, were usually done on the right side of the body with the girls standing in a realized position. Equations developed by Johnson and Scholz (1989) for adolescent girls in a European country were adopted to predict TBF % as follows:

1. Females 11-13 years

$$\text{TBF \%} = -7.39 + 6.91 \times \ln \text{SFT (triceps)} + 5.35 \times \ln \text{SFT (subscapular)} + 0.74 \times \ln \text{SFT (suprailiac)}$$

2. Females 15-17 years

$$\text{TBF \%} = -11.82 + 4.39 \times \ln \text{SFT (triceps)} + 4.69 \times \ln \text{SFT (subscapular)} + 4.14 \times \ln \text{SFT (suprailiac)}$$

3. The weight of the body fat (TBF kg) was estimated by means of the equation

$$\text{TBF kg} = \frac{\text{Total body fat (\%) x actual body weight (kg)}}{100}$$

4. Lean body mass (LBM kg) was assumed to be the actual body weight (kg) minus total body fat (TBF kg). The optimum weight (OPW kg) table for age and height of adolescents derived from Ketz, H. –A. (1990) was used and where the value could not be found in the table, the value was derived from the quoted data of Baldwin (1925) as reproduced by Jelliffe, D. B. (1966).

$$\text{RW \%} = \frac{\text{actual body weight (kg) x 100}}{\text{optimum weight (kg)}}$$

5. The BMR values were calculated using FAO/WHO/UNU (1985) equations for the prediction of BMR for adolescents and adults.

Statistical Analysis

Values are given as means and standard deviations. The Pearson Correlation Coefficient was employed to assess the relationship between the predicted body composition from SFT and EI. The 0.05 level of probably was used to assess statistical significance.

Results

Anthropometry

The physical characteristics of thirty four female adolescents are presented in Table 1. The BMI was 19.2 kg/m2. Correlation coefficients between BMI and other anthropometric variables were significant; Table 2.

BMI correlated more strongly with TBF % (r 0.75; $P<0.05$) and LBM kg (r 0.71; $P<0.05$) and body weight kg (r 0.65; $P<0.05$). There was a strong correlation between BMI and TBF kg (r 0.82; $P<0.05$), but a weaker correlation with height (m) (r 0.15; $P<0.05$). There was also a significant correlation between BMI and RW % (r 0.66; $P<0.05$).

Skinfold Thickness

SFT values for the group were variable (Table 1), indicating different extents of subcutaneous fat deposition and different distribution pattern. Triceps SFT correlated more strongly with TBF % (r 0.87; $P<0.05$) than TBF kg (r 0.68; $P<0.05$) while suprailiac SFT correlated with TBF % (r 0.84; $P<0.05$) and correlated even more strongly with TBF kg (r 0.88; $P<0.05$). Subscapular SFT also correlated more strongly with TBF kg (r 0.73; $P<0.05$) than with TBF % (r 0.63; $P<0.05$).

Table 1: The Physical Characteristic Anthropometry and Body Composition of Nigerian Female Adolescents (Mean Values and Standard Deviation for Thirty-four girls)

CHARACTERISTICS	X	+S
A. 1. Age (Years)	14.8	1.9
2. Body Weight (kg)	46.9	8.2
3. Body Height (m)	1.56	0.1
4. Body mass index (kg/m^2)	19.2	5.6
5. Basal metabolic rate (Mj/d)	5.5	0.4
(Kcal/d)	1315	100
B. Anthropometry Skinfold Thickness (mm)		
6. Triceps	11.8	5.2
7. Subscapular	11.0	5.2
8. Suprailiac	13.8	6.5
C. Body Composition		
9. Total Body Fat (%)	22.2	4.7
10. Total Body Fat (kg)	10.6	3.7
11. Lean Body Mass (kg)	36.3	5.3
12. Optimum Weight (kg)	46.9	6.9
13. Relative Weight (%)	100.9	11.7

Body Composition (BC)

BC values are displayed in Table 2. TBF % in the girls ranged between 11.9 and 29.4%, while the analogous LBM range was 24.0 – 48.9. The results indicate that the female adolescents who possessed higher triceps SFT also displayed high LBM values, while tall individuals in the group possessed also greater LBM than short subjects.

BMR

The mean BMR was 5.5 MJ (1315 kcal)/d for the group of female adolescents and EI:BMR ratio was 1:3. Nine female adolescents (26.5%) recorded EI values which were less than 1.3 times BMR. It was also observed that none of these thirty four adolescents were short for their age. However, two adolescents were under weight according to Johnson and Scholz (1989) relative standard.

The correlation coefficients of BMR and other variables were evaluated. MBR values (MJ/d) correlation highly with body weight (r 1.00; $P<0.05$) and LBM (r 0.93; $P<0.05$) but less strongly with TBF % (r 0.61; $P<0.05$). There was significant correlation between BMR and EI (r 0.5; $P<0.05$) and between age and BMR (r 0.57; $P<0.05$).

Table 2: Correlation Coefficient between physical characteristics and body composition variables for a group of thirty-four Nigerian female adolescents in Ibadan, Nigeria

	Age (Years)	Body Wt (Kg)	Body ht (m)	BMI (kg/m^2)	TBF (%)	TBF (Kg)	LBM (kg)	OW (kg)	RW (%)
Age (Years)	-								
Body wt (kg)	0.54	-							
Body ht (m)	0.43	0.64	-						
BMI (kg/m^2)	0.44	0.65	0.15	-					
TBF (%)	0.02	0.60	0.077	0.75	-				
TBF (kg)	0.29	0.87	0.40	0.82	0.91	-			
LBM (kg)	0.69	0.94	0.79	0.71	0.21	0.66	-		
OW (kg)	0.73	0.78	0.87	0.52	0.14	0.50	0.87	-	
RW (%)	0.10	0.44	0.14	0.66	0.68	0.63	0.33	0.19	-

TBF = Total Body Fat (%, kg)
LBM = Lean Body Mass (kg)
OW = Optimum Weight (kg)
RW = Relative Weight (%)

Energy Intake

Table 3 shows the mean EI and percentage of energy obtained from protein, fat and carbohydrate Substantial variations were observed in EI during the seven consecutive days of the study. The average EI was about 0.15 MJ (35.9 kcal) d per kg body weight. Mean BMR was 5.5 MJ (1315 kcal)/d. The EI between 8.7 MJ (2079 kcal)/d and 4.5 MJ (1076 kcal)/d.

Table 3: Mean daily energy intake and percentages contribution of carbohydrate (CHO), fat and protein to total energy intake during the study period in thirty-four Nigerian female adolescents (Mean values standard deviation and ranges)

	Energy Intake		Distribution % of energy		
Body Wt. (kg)	(MJ/d)	(MJ) body Wt	CHO	Fat	Protein
X 46.4	6.9	0.15	43	40	17.0
+S 8.2	1.2	0.02	4.3	3.4	2.6
Range 32.0-58.0	45.0-8.7	0.10-23.0	35.5-51.1	30.0-44.9	13.3-26.7

Contributions made by breakfast, lunch and supper to total energy are given in Table 4.

Table 4: Contribution of breakfast, lunch and supper to total energy intake during the study period in the thirty-four Nigerian female adolescents (Mean values, standard deviations and ranges)

	Distribution %		
	Breakfast	Lunch	Supper
X	20.5	56.4	23.1
+S	2.3	5.9	2.6
Range	14.7-24.5	49.6-62.1	19.0-53.0

Discussion

Energy and Selected Nutrient Intake

The EI values observed in the present study were low. However, they are higher than in previously reported studies by Cole et al (1997). FAO/WHO/UNU (1985) recommendation specified that female adolescents 11-17 years require, on average, 7.9 MJ (1988 kcal)/d. This is significantly higher than the EI observed for female adolescents in the present study which was 6.9 MJ (1649 kcal)/d. However this does not necessarily indicate that the subjects were energy deficient, since the subjects' level of activity may not have warranted a higher EI. Durnin (1990) measured the EI of a group of adult Indian women living in a rural area who did not engage in any physical activity at leisure time, and found it to be 7.1 MJ (1697 kcal)/d, which is not significantly different from the value of the present study. Similarly, Bleiberg et al estimates intakes of 8.9 MJ (2127 kcal)/d for male and 6.3 MJ (1506 kcal)/d for female farmers in Upper Volta (now Burkina Faso). It is interesting to note that EI of female Burkinable farmers was lower than that of our subjects. Lower or similar EI values have also been found for pregnant women in Gambia by Prentice et al. (1981).

It is possible that our subjects may have deliberately consumed less than their normal EI during the study. However, personal contact with the girls suggests that no difference in behaviour occurred as a result of participation in the study. Alternatively, the food supplied by the cafeteria may not have been adequate. It is not possible to ascertain whether the measured EI reported in the present study approximate the normal EI of the girls in their homes.

The assessment of specific nutrient intakes and individual meals showed that carbohydrate, protein and fat contributed 43.0, 17.0 and 40.0% of energy respectively (Table 3), while the contributions of breakfast, lunch and supper were 20.5, 56.4 and 23.1% respectively (Table 4). In a previous study in Ibadan, Oyo State by Cole et al. (1997) and in rural and urban adolescent females in Borno State in the Northern part of Nigeria by Oguntona et al. (1987) subjects in Oguntona study obtained higher proportions of energy from fat than subjects in the study by Cole et al (1997) and also in the present

study. The discrepancy is probably explained by the different dietary habits of Nigerians in the North and the South of the country. In the North, millet, maize, rice, sorghum and meat or fish and fresh mil predominate in the diet, with only small amounts of fat and oil being consumed. In the South-West foods such as cassava (*manihot esculenta*), yam (*dioscorea esculenta*), meat, fish and oil are common. These differences may explain the variation in energy contribution of carbohydrate, protein and fat to the total EI of the three groups of Nigerians.

The low energy intakes observed in the present study might be explained by low energy density diet. In comparison with the diets typical of European, American and some other African countries (e.g. Togo, Ghana), the Nigerian diet contains little fat. In the present study carbohydrate contributed 43% of total energy (Table 3). Consumption of butter and milk was minimal; fat was provided largely by palm and groundnut oil which were used for frying plantains (dodo), bean cake (akara) or eggs, and in preparation of stews. Protein was obtained largely from imported frozen fish (mostly mackerel), beef, poultry, pulses such as beans (*vignia spp*) and eggs.

Carbohydrate

Mean carbohydrate intake was 177.5 g/d which constituted 43% of total EI. Carbohydrates are assumed to be derived mostly from Nigerian staple foods such as eba (cooked gari), amala (yam flour), lafun (cassava flour), agidi (eko tutu), fufu (cassava starch), iyan (pounded yam) and rice, which is now a Nigerian staple food. The level of carbohydrate intake in the present study is low, and this gives cause for concern.

Protein

The mean protein intake 72.7 g/d in the present study is higher than the previously reported protein intakes by Oguntona et al (1987) and Atinmo et al (1988). As a group, our adolescent girls had an adequate protein intake. The protein therefore is not one of deficiency, but rather one at excessive protein intake. Tan et al (1989) pointed out that high protein intake is associated with cancer of colon and higher incidence of urinary stones and gallstones formation.

The Food and Nutrition Board, USA (1980) strongly encourage a reduction in animal protein intake However, this proposal has to be carefully evaluated, as reduction of animal protein also has dietary implications for the total intake of some very important vitamins and minerals Tan, (1988). Iron from animal sources rather than from vegetarian sources is also better absorbed. Tan et al. (1989).

Fat

Fat intake had a mean of 73.3 g/d and constituted 40% of the total energy intake of the girls. Fish, palm and groundnut oil and other vegetable oils are the major sources of fats in Nigerian diets. If other food items such as dairy products (milk, cheese and butter) and meat were adequately included in the diets of our girls, the mean fat intake might have been higher than the present 73.3 g/d.

BMR

The mean BMR in the present study was 5.5 MJ (1315 kcal)/d which is very similar to the average for adolescent girls aged 11-17 years predicted from FAO/WHO/UNU (1985) equations 5.6 MJ (1336 kcal)/d and similar to previous work of Cole et al (1997). The BMR values obtained in the present study were based on equations derived from subjects who probably had a higher percentage of body fat than oru girls, and therefore may not be accurate. There have been numerous, often conflicting, reports of differences in BMR values between different racial with different energy and nutrient intakes, Cole et al (1989). Another factor which affects BMR is the climate, Mason and Jacob (1992). It has been observed that BMR for populations in tropical countries is substantially below that predicted from regression equations from data obtained from subjects from Western countries, Schofield (1985). For these reasons, the application of regression equations derived from one population to another population may lead to errors in the results. For example, Bingham (1987) has suggested that if habitual EI of individuals is found to be less than 1.4 times BMR, it is almost certainly an underestimation, and that such results indicate either under reporting of food intake or a reduction of EI during the experimental period. Other investigators have also suggested that intakes

which are less than 1.2 times the BMR should be excluded from results because they cannot be representative of habitual intake.

Anthropometry

Skinfold Thickness (STF)

The SFT values for the subjects in the present study were comparable with previous findings in terms of fat pattering and distribution, Cronk and Roche (1982). There was a tendency for subcutaneous fat to be deposited preferentially in suprailiac and triceps areas. The triceps SFT values were similar to those of British children, Tanner and Whitehouse (1962) and Nigerian adolescent girls Cole et al (1997). The relative SFT values of various sites have been reported to vary in accordance with fatness of individuals, Edwards (1951); Gan (1985). These differences were pronounced in girls with low subcutaneous fat deposits and those with lean features. However, heavier girls in the group exhibited higher BMI and LBM values than those with low weights. The reason for this can be the development of the muscle mass through nutritional utilization and physical activities. High BMI and LBM reduce the amount of body fat.

Body Composition

For the prediction of percentage total body fat in the present study, it was necessary to adopt population specific equations developed in European adolescent subjects because no Nigerian equations are available. Using European equations, it was possible to obtain values of TBF% for Nigerian adolescent girls. The mean value was very low compared with Europeans and Americans. The values were, however, higher than those obtained for female nursing students aged 20-25 years from the University College Hospital, Ibadan and Iyiana Hospital, Enugu, Nigeria Cole and Udekwe (1989).

Acknowledgement

The authors are grateful for the partial support from Senate Grant Fund of the University of Ibadan. The authors acknowledge with thanks the participation of adolescent girls (1991-92 session) of Saint Anne's School. Molete. Ibadan, Nigeria.

References

Association of Official Analytical Chemists (1980). Official methods of analysis 13th Ed. Wasgington DC. AOAC.

Atinmmo, T. Mbofung, G. M. F. Egun, E. and Osotimehin, B. (1988) Nitrogen balance study in young Nigerian adult male, using four levels of protein intalse Br. J. Nutr. 60: 451-458

Bleiberg, F. M.; Brun, T. A.; Goimans, S. A.; Liffman, D. (1981). Food intalse and energy expenditure of male and femals farmers from Upper-Colta. Br. J. Nutr. 45: 505-515

Binghan, S. A. (1987). The dietary assessment of individuals, methods, accuracy, new technique and recommendation Nutr. Abstr. Rev. 57: 705-742

Cole, A. H.; Taiwo, O. O.; Nwagbara, N. I.; Cole, C. E. (1997. Energy intalse, anthropometry and body composition of Nigerian adolescent girls; a case study of an institutionalized secondary school in Ibadan. Br. J. Nutr. 77: 496-509

Cole, A. H. and Ogungbe, R. F. (1987). Food intake and energy expenditure of Nigerian female students. Br. J. Nutr. 13: 309-318

Cole, A. H.; Ibeziako, P. A.; Bamgboye, E. A.; (1989). Basal metabolic rate and energy expenditure of pregnant Nigerian women Br. J. Nutr. 62: 631-637

Cole, A H and Udekwe, I. O. (1989). Body composition, energy, protein and iron intalse of Nigerian female nursing students Die Nahrung 33: 703-708

Cronk, C. E. Roche, A. F. (1982). Race and sex specific reference data for triceps and subscapular sbinfolds and weight/stature Am. J. Clin. Nutr. 35: 347-354

Drunin, J. V. G. A. (1990). Low energy expenditure in free living population Eur. J. Clin. Nutr. 44. suppl. 1: 95-120

Edwards, D. W. (1951). Differences in the distribution of subcutaneous fat with sex and maturity Clin. Sci. 10: 305-315

Empfehlunge fur die tagliche Energie and Nahrstoffeaufneheme in der Ernahrungsprazis der Bevolkerung der Deutschen Democratischen Republic (1977). Recommendations for the daily energy and nutrient intakes in the German Democratic Republic Zentralinstitut fur Ernahrung der Akademie der Wissenschaften der DDR and der Gesellschaft fur Ernahrung in der DDR, Potsdam – Rehbruebe.

Food and Agriculture Organization / World Health Organization / United Nations University (1985). Energy and Protein Requirements. Technical Reports Series No. 724 Geneva: WHO

Food and Agriculture Organization / World Health Organization (1973). Energy and Protein Requirements Technical Report Series No. 552 Geneva: WHO

Food and Nutrition Board, US (1980). Recommended Dietary Allowances Committee on Dietary Allowances, Division of Biological Sciences, Assembly of Life Science. NRC Washington DC.

Garn, S. M. (1985). Relative fat patterning on individual characteristics Hum. Biol. 27: 75-89.

German Society of Nutrition (1991). Recommendation on nutrient intake. Abstract and Tables of the 157 pages booklet. 5th revised edition.

Henry, C. J. K.; Piggot, S.; Emery, B. (1988). Basal metabolic rate and diet-induced thermogenesis in Asians living in Britain Hum. Nutr. Clin. Nutr. 41C: 317-402.

Hackett, A. F.; Rugg-Gunn, A. J; Applaton D. R. (1983). The use of dietary diary and interview to estimate the food intalse of children Hum. Nutr. Appl. Nutr. 57A: 293-300.

Johnson, D. and Scholz, C. (1989). Anthropometrische methoden Zur Ermittlung und Beuteilung des Ernahrungs – Zustandes des Menschen (Anthropometric methods for assessment and estimation of nutritional status of man) Wissenschaffliche Zeitschrift der Humboldt University zu Berlin R Medizin 38: 218-226

Jelliffe, D. B. (1966). The assessment of nutritional status of the community Geneva WHO.

Ketz, H. – A (1990). Bestimmung der Ernahrungszustandes (Assessment of Nutritional status) In Grundriss der Ernahrungslehre 3rd Ed. 388 – 401. Jena.

McNaughton, J. W. and Audrey, J. C. (1970). A study of food intake and activity of group of urban adolescents Br. J. Nutr. 24: 331-344

Mason, E. D. and Jacob, M. (1992). Variations in basal metabolic rate responses to changes between tropical and temperate climates Hum. Biol. 44: 141-172

Oguntona, C. R. B.; Oguntana, T. E. Williams, L. S. and Biu, K. A. (1987). The food and nutrient intake of adolescents in Bornu State. Nigeria Nutr. Rep. Int. 36L 981-987

Prentic, A. M.; Whitehead, R. G.; Robert, S. B. and paul, A. A. (1981). Long-term energy balance in children bearing Gambia women Am. J. Clin. Nutr. 24: 2790-2799

Schofield, E. N. (1985). Predicting basal metabolic rat; new standards and review of previous work Hum. Nutr. 39: suppl, 5-41.

Tan, S. P. (1988). Nutritional beliefs, attitudes, knowledge and practice of young adolescents and the impact on these of school health education programme. Ph.D thesis, University of Otago, NZ.

Tan, S. P.; Welb, J. E.; Beawon, D. W. and Hornblow, A. R. (1989). Energy and macronutrient intake at New Zealand adolescents Ecol. Food Nutr. 33: 225-236

Tanner, J. M. and Whitehouse, T. (1962). Standards for subcutaneous fat in British children Br. Med J. 1: 446-451

Woodword, D. R.; Lynch, P. P.; Waters, M. J.; Maclean A. R.; Ruddock W. E.; Rataj J. W.; Lemoh J. W. (1987) Dietary studies on Tasmanian high school student sintake of energy and nutrients Austr. Paediat 17: 196-201.

Whitehead, R. W. (1991). The new British Dietary Reference values Nestle Foundation Annual Report 37-48.