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ASSOCIATION OF DIETARY MACRO AND MICRONUTRIENTS WITH BODY MASS INDEX OF MALE CHILDREN FROM A SELECT SCHOOL IN CHENNAI

Jenita Hepzhibha*[1] and Dr. Gowri Ramesh[2]

[1]Research Scholar, Department of Home Science, Women's Christian College, Chennai-600006.
[2]Associate Professor, Department of Home Science, Women's Christian College, Chennai-600006.

*Corresponding Author: Jenita Hepzhibha

Research Scholar, Department of Home Science, Women's Christian College, Chennai-600006.

ABSTRACT

Background: Proper intake of dietary macro and micronutrients will contribute to good nutritional status of an individual. Therefore, the objective of this study was to assess the dietary macro and micronutrient intake of male children from a select school in Chennai, and find its association with their Body Mass Index. **Methodology:** The design of the study was Ex-post facto. Convenience sampling was used to select two hundred male children aged 10 to 15 years from the selected school. Height, body weight and BMI were recorded for the subjects, and nutrient intake was estimated using a 24 dietary recall. **Results:** On comparison with the Recommended Dietary Allowances (RDA), among all subjects categorized as underweight, normal weight, overweight and obese, energy intakes were found to be lower, while fat intake was found to be higher. The two essential minerals calcium and iron in the subjects' diet were found to be lower than the RDA. Most of the other micronutrients were also found to be less than the RDA. However, no significant correlation was observed between subject's macro and micronutrient intake with their BMI. **Conclusion:** Intake of recommended nutrients in children's diet will help prevent under or over nutrition related health problems.

KEYWORDS: Macronutrients, Micronutrients, Body Mass Index, RDA.

INTRODUCTION

Proper nutrition is essential during childhood to obtain a healthy height and weight, to be able to concentrate in academic activities, and not indicate any signs of nutritional deficiencies (Sarah, 2014). Malnutrition is a condition that results from deficient or excess nutrients in the diet.

Under nutrition resulting from inadequate consumption usually affects the balance of all the nutrients in the body. Problems relating to a deficiency in carbohydrates, proteins and fats will manifest first and most acutely. Initially, the body starts using its glycogen reserves, stored water and body protein. Then, fatty acids and lean muscle are broken down for energy. These two effects of under nutrition result in a dramatic decrease in body weight (Parks, 2015). Micronutrient deficiencies of iron, vitamin A and zinc are ranked among the World Health Organization's top ten leading causes of death through disease in developing countries. These have led to increased prevalence of anemia, scurvy, pellagra, beriberi, xerophthalmia and ultimately death (World Food Program, 2016). Iron deficiency anemia impairs childhood development, work capacity, learning capacity and resistance to disease (Benoint et al., 2003). Iodine deficiency is the world's most common cause of preventable brain damage and one of the main causes of impaired cognitive development in children (WHO, 2012). Vitamin A deficiency often coexists with marginal Protein Energy Malnutrition (Tang et al., 2003). A lack of calcium can lead to poor mineralization of bones and low bone mineral density. This can lead to many problems including permanent bone deformities and diseases of the bone such as osteoporosis in later life (Mesias, 2011). Over-nutrition can develop into obesity, which increases the risk of serious health conditions, including cardiovascular diseases, hypertension, cancer, and type-2 diabetes (Louis et al., 2016).

Assessment of nutritional status of adolescents is important to understand their nutrient consumption and dietary pattern, growth and development. If the diet of an adolescent is lacking or is in excess of either micro or macronutrients, assessment of the dietary pattern will help identify the specific nutrient related disorder, and thereby help in overcoming it. Therefore, with this perspective, the study was planned to assess the macro and micronutrient composition in the diet of male children aged 10 to 15 years from a select school in Chennai, and to find its association with their Body mass Index.

MATERIALS AND METHODS

Objectives of the Study
The objective of this study was to assess the macro and micronutrient composition in the diet of male children aged 10 to 15 years from a select school, and to find its Association with their Body Mass Index.

Design of the Study
The design of the study was an Ex-post facto research design.

Selection of Sample
Selection of school
Asan Memorial Senior Secondary School located in Nungambakkam, was selected for the study, after obtaining permission from the school authorities.

Selection of subjects
Convenience sampling was used to select two hundred male children in the age group of 10 to 15 years from the school.

Criteria for selection of sample
Inclusion criteria
- After obtaining permission from the school authorities, subjects aged 10 to 15 years, from classes VI to IX standard were given the consent form.
- Subjects were selected based on the consent letter signed and returned by the parents.
  Exclusion criteria
- Children who were not interested and did not get the consent letter signed by their parents.

Ethics Committee Approval
Institutional ethics committee of the Home Science Department, Women's Christian college, Chennai, approved the protocol of the study. After obtaining the school's permission for conducting the study, the study protocol was explained in detail to the school authorities. Individual written informed consent was obtained from the parents of children for their willingness to be part of the study.

Duration of the Study
The period of study was from November 2015 to March 2016.

Tools used for the Study
1. Questionnaire
A standardized questionnaire was designed to elicit information such as demographic details and health related details of the subjects.

2. Interview Schedule
An interview schedule was used to elicit information on the dietary pattern of the subjects. Nutrient intake for the subjects was estimated using a 24 hour dietary recall for three days.

3. Anthropometric Measurements
a) *Height:* Standing height of the subjects was measured using a non-stretchable tape-measure fastened to a wall. The subjects were asked to remove their footwear and made to stand straight with heels together, arms to the side, legs straight, shoulder relaxed and head leaned against the wall. The height measurement was recorded to the nearest 0.1 cm.
b) *Body Weight:* Body weight of the subjects was measured using a portable weighing scale after adjusting for zero setting. The subjects were asked to remove their footwear and stand still in the middle of the scale's platform without touching anything and with the body weight equally distributed on both feet. The weight was recorded to the nearest 0.5kg.
c) *Body Mass Index:* BMI was estimated and subjects were categorized as underweight, normal weight, overweight and obese, based on the International Obesity Task force cut-off values for BMI for this age group.

Statistical Analysis
The data collected was subjected to descriptive and inferential analysis. Karl Pearson's correlation was used to find the association between the macronutrients and select micronutrient composition in the diet of subjects with their BMI.

RESULTS

General information about the Subjects
A majority of the subjects (73.5%) belonged to nuclear families. Most of the families belonged to the middle-income and high-income categories. Based on occupation, 77% of the fathers were found to be involved in moderate activity, whereas a majority of mothers were found to be sedentary in nature. 56 % of fathers and 47% of mothers were graduates, while 44 % of fathers and 53% of mothers were found to have completed school level education. Diabetes and hypertension was widely prevalent among the subject's family members.

Anthropometric Measurements
Measurements of height and body weight
Subjects were distributed in the age groups of 10 to 12 and 13 to 15 years to study the association of macro and micronutrients with their BMI, since the Recommended Dietary Allowances for adolescents is given for these age groups. Since there were no subjects at age 10 years, age groups were discussed as 11 to12 years and 13 to15 years.

Mean height and body weight of subjects in the age group of 11 to 12 years was found to be 149.59±6.909 cm and 43.64±11.587 kg respectively. In the age group of 13 to 15 years, the mean height and body weight of subjects was found to be 160.20±10.360 cm and 54.03±13.661 kg respectively. In the present study, body weight of the subjects in the respective age groups was

found to be higher than the recommended weight suggested for Indian adolescents (Gopalan et al., 2010).

Percentage distribution of subjects based on Body Mass Index
Based on the classification of BMI by the International Obesity Task Force for children aged 10 to 15 years (Cole et al., 2000)**,** BMI range was used to classify subjects as underweight, normal weight, over weight and obese. This is presented in the following table. (Table 1 near here).

From the above table, a majority of subjects in the age group of 11-12 years were found to be distributed in the underweight and overweight categories. For subjects aged 13-15 years, a similar trend was observed. A larger number of subjects were also found to be obese.

Dietary Pattern of the Subjects
- A majority of the subjects (77%) were non-vegetarians. 72.5% of the subjects consumed breakfast daily, which included mostly traditional items.
- Snack foods such as popcorn, fast foods, and baked items were found to be frequently consumed by the subjects. Most of the subjects (83.5%) snacked while watching television. Preference for fast foods and soft drinks was found to be more among the subjects. Taste was an important factor which influenced their choice of junk food, followed by the advertisements on televisions.
- A majority of subjects consumed one cup of vegetables on a daily basis. The commonly eaten vegetables were potatoes, tomatoes, carrots, beans and green leafy vegetables. 51.5% of the subjects consumed one fruit such as bananas, oranges and apples per day.
- Milk consumption of subjects was found to be less than the recommended allowances for that age group. About 30 % of the subjects consumed soft drinks frequently.
- Many subjects (49.5%) ate out at-least twice a week, at smaller hotels.

Mean Nutrient Intake of Subjects
Mean macro and micronutrient intake of subjects
Percentage distribution of subjects according to their nutrient intake is presented in the following table: (Table 2 here)

For subjects in the age group of 11 to 12 years and 13 to 15 years, mean energy intake was found to be less than the RDA values. Mean protein and fat intake was found to higher than the RDA. Mean intake of thiamine, niacin and magnesium was found to be high among subjects in 11-15 age groups, while the intake of calcium, iron, vitamin A, carotene, riboflavin, vitamin B6, vitamin C, folic acid, vitamin B12 and zinc was found to be lesser than the RDA. With respect to micronutrients, mean intake of thiamine, niacin and magnesium was found to be higher than the RDA among subjects in both the age groups. Intake of calcium, iron, vitamin A, carotene, riboflavin, vitamin B6, vitamin C, folic acid, vitamin B12 and zinc was found to be less than the RDA for subjects aged 11 to 12 years. For subjects in the 13 to 15 year age group, except for vitamin C, all other micronutrients were lower than the RDA. (Table 3 here)

Energy intake was less than the RDA in all categories except the obese category. Protein and fat intake among subjects in all categories was higher compared to the RDA.

Among the micronutrients, calcium, vitamin A and riboflavin intake was high among subjects in obese category and less in all other categories compared to RDA. Iron and folic acid intake was high in underweight and obese subjects whereas in normal and overweight subjects, the intake was less compared to RDA. Thiamin and magnesium intake among subjects in all the categories was high compared to RDA. Niacin intake was higher than the RDA in all categories except in the obese category. Among all subjects in all the categories, carotene, pyridoxine, ascorbic acid and vitamin B12 intakes were less compared to the RDA. (Table 4 here)

For subjects aged 13 to 15 years, a similar trend was observed with respect to the macronutrients. Among the micronutrients, calcium and vitamin A intake was less than the RDA in all categories except in overweight category. Thiamin, niacin, ascorbic acid and magnesium intake among subjects in all categories was high compared to RDA. Iron, carotene, riboflavin, pyridoxine, folic acid, vitamin B12 and zinc intake is low among all the subjects compared to RDA.

Correlation Analysis
- Among subjects aged 11 to 15 years and 13 to 15 years, no significant correlation was found between macro and micronutrient intake with their BMI.

Table 1: Percentage distribution of subjects based on BMI.

Age group	Classification of BMI	BMI Range (kg/m^2)	Mean BMI (kg/m$^{2)}$) Mean ± S.D	Number of subjects	Per cent (%)
11 to 12 years (n=56)	Underweight	<18	15.738±1.783	26	46.4
	Normal	18.1-19.9	19.000±0.866	3	5.4
	Overweight	20-23.9	21.530±1.256	20	35.7
	Obese	>24	27.900±4.034	7	12.5
13 to 15 years (n = 144)	Underweight	<18	16.916±1.479	48	33.3
	Normal	18.1-19.9	19.136±0.707	11	7.6
	Overweight	20-23.9	21.804±1.579	43	29.9
	Obese	>24	26.635±3.224	42	29.2

Table 2: Percentage distribution of subjects based on their mean macro and micronutrient intake.

Nutrient intake	RDA		Subjects Mean ± S.D	
Macro nutrients	**10-12 years**	**13-15 years**	**11 to 12 years (n=56)**	**13 to 15 years (n=144)**
Energy (kcal)	2190	2750	2124.04±967.499	2078.26±811.128
Protein (g)	39.9	54.3	54.18±17.037	56.16±17.744
Fat (g)	35	45	70.52±25.992	69.58±24.404
Carbohydrate (g)			283.323±147.571	301.308±142.092
Micronutrients				
Calcium (mg)	800		620.59±391.989	766.08±516.455
Iron (mg)	21	32	18.30±7.299	18.41±7.179
Vitamin A *(µg/d)* Retinol (µg) β-carotene (µg)	600 4800		552.73±245.943 3198.539±1820.233	582.40±220.671 3180.863±1724.964
Thiamin (mg)	1.1	1.4	3.733±2.525	3.123±2.312
Riboflavin (mg)	1.3	1.6	1.005±0.540	1.102±0.519
Niacin (mg)	15	16	18.697±10.946	18.355±9.425
Vitamin B6 (mg)	1.6	2.0	0.340±0.294	0.323±0.274
Vitamin C (mg)	40		33.34±22.952	50.53±44.179
Folic acid *(µg)*	140	150	133.56±26.340	136.18±30.164
Vitamin B12 *(µg)*	0.2-1.0		0.032±0.080	0.018±0,061
Magnesium (mg)	120	165	435.433±216.066	485.888±340.614
Zinc (mg)	9	11	4.532±1.895	4.973±1.775

Table 3: Mean macro and micronutrient intake of subjects aged 11 to 12 years based on BMI categories.

Nutrient intake	Subjects aged 11 to 12 years Mean ± S.D			
Mean macro nutrients	**Underweight (n = 26)**	**Normal (n = 3)**	**Overweight (n = 20)**	**Obese (n = 7)**
Energy (kcal)	1943.23±905.134	1497±354.017	1497±354.017	2288.86±1055.138
Protein (g)	51.92±16.840	47.33±14.434	47.33±14.434	70.71±9.196
Fat (g)	72±27.664	78.33±16.623	78.33±16.623	66.14±20.244
Mean micronutrients				
Calcium (mg)	525.77±261.007	513±359.776	513±359.776	983.14±499.684
Iron (mg)	17.50±7.601	22±11.790	22±11.790	17.71±5.736
Magnesium (mg)	465.540±253.323	386.243±346.992	386.243±346.992	438.948±153.358
Zinc (mg)	5.144±2.017	4.236±2.168	4.236±2.168	4.427±1.056
Retinol (µg)	510.38±241.726	513±359.776	513±359.776	783.14±124.435
β-carotene (µg)	3037.361±1799.424	3544.633±2627.221	3544.633±2627.221	3104.771±1955.588
Thiamin (mg)	4.533±2.680	2.343±1.942	2.343±1.942	4.521±2.859
Riboflavin (mg)	0.871±0.504	0.786±0.482	0.786±0.482	1.472±0.676
Niacin (mg)	20.800±14.612	16.223±3.492	16.223±3.492	11.050±3.167
Vitamin B6 (mg)	0.424±0.289	0.456±0.392	0.456±0.392	0.356±0.252
Vitamin C (mg)	28±18.542	25.33±15.144	25.33±15.144	33.29±16.235
Folic acid *(µg)*	128.16±29.248	150±29.614	150±29.614	132.29±24.137
Vitamin B12 *(µg)*	0.039±0.087	0.082±0.140	0.082±0.140	0.036±0.089

Table 4: Mean macro and micronutrient intake of subjects aged 13 to 15 years based on BMI categories.

Nutrient intake	Subjects aged 13 to 15 years Mean ± S.D			
Mean macro nutrients	Underweight (n = 48)	Normal (n = 11)	Overweight (n = 43)	Obese (n = 42)
Energy (kcal)	2044.37±675.947	1944.82±627.496	2165.14±973.098	2063±831.040
Protein (g)	55.67±19.039	56.27±18.948	57.28±17.440	55.55±16.779
Fat (g)	72.15±27.785	61.82±19.482	71.81±23.569	66.38±22.157
Mean micronutrients				
Calcium (mg)	779.08±588.854	585±270.501	885.81±507.238	676.07±468.032
Iron (mg)	19.25±7.595	17.64±7.159	18.58±7.159	17.48±6.837
Magnesium (mg)	508.515±351.841	418.302±135.922	488.680±343.920	473.262±364.422
Zinc (mg)	5.205±1.891	4.619±1.505	4.925±1.688	4.841±1.813
Retinol (μg)	532.21±208.346	585±270.501	671.86±208.418	547.50±212.471
β-carotene (μg)	3281.277±1776.240	3363.561±1647.676	3207.613±1731.613	2990.869±1723.068
Thiamin (mg)	3.212±2.403	3.221±1.871	3.233±2.486	2.882±2.183
Riboflavin (mg)	1.166±0.584	1.268±0.555	1.094±0.501	0.994±0.437
Niacin (mg)	19.209±9.820	17.094±5.860	19.388±12.156	16.653±5.847
Vitamin B6 (mg)	0.351±0.295	0.335±0.292	0.308±0.260	0.302±0.265
Vitamin C (mg)	57.15±62.035	52.82±31.093	45.47±28.889	47.55±34.880
Folic acid *(μg)*	141.77±29.308	147.27±25.350	130.51±30.569	132.69±30.969
Vitamin B12 *(μg)*	0.022±0.067	0.001±0.001	0.013±0.051	0.025±0.070

DISCUSSION

Height is an adequate measure of long-term nutritional status, and is reflects low height-for-age indicating stunting. Body weight is an important screening tool for identifying conditions such as protein-calorie malnutrition. Although BMI does not directly reflect body fatness and cannot be used to assess obesity, it is found to be highly correlated with body fatness and is one of the most recommended screening methods for weight status among youth (Barlow and Dietz, 2008). Underweight children are at increased risk of mortality from infectious illnesses such as diarrhoea and pneumonia. The effects of under-nutrition on the immune system are wide-ranging, and infectious illnesses also tend to be more frequent and severe in underweight children (Maurice et al., 2006). Healthy dietary pattern and normal body weight are positive contributors to academic performance. Maintaining a healthy diet often results in healthy weight, good physical, psychological and cognitive development and a better academic performance of learners (Konttinen et al., 2012).

Inadequate caloric intake can lead to malnutrition over time. A diet with extremely low calories does not allow for adequate consumption of the vitamins, minerals and antioxidants. Carbohydrate deficiency can cause ketosis and is reported in those who are on a low carbohydrate diet. In the absence of carbohydrates, the body starts using the proteins and convert it to sugars. This may lead to tiredness and lethargy. When protein intakes are consistently inadequate, reductions in linear growth, delays in sexual maturation and reduced accumulation of lean body mass may be seen (Neumark et al., 2005). However, in this study, protein intake among the subjects was found to be higher than the RDA. Diets high in saturated fatty acids and trans fatty acids have shown to increase LDL-cholesterol levels, and in turn, the risk of heart disease. Cardio vascular risk factors also tend to cluster, resulting in metabolic syndrome in some individuals (Aaron et al., 2010).

Micronutrient deficiencies of iron, vitamin A and zinc are ranked among the World Health Organization's top ten leading causes of death through disease in developing countries. These have led to increased prevalence of anemia, scurvy, pellagra, beriberi, xerophthalmia and ultimately death (World Food Program, 2016). Iron deficiency anemia impairs childhood development, work capacity, learning capacity and resistance to disease (Benoint et al., 2013). Low dietary intake of calcium among children and adolescents has deleterious effects on their skeletal health and bone metabolism (Albertson et al, 2012). Individuals following vegetarian diets are at risk for developing vitamin B12 deficiency owing to suboptimal intake. Thus, it is important to inculcate the concept of a balanced meal from a young age.

CONCLUSION

Estimation of the macro and micronutrient content in the diet of these children revealed a similar pattern in all categories. Compared to subjects in all categories, obese subjects were found to have higher intakes of most nutrients. Underweight subjects also showed an intake of nutrients similar to overweight or obese children. However their underweight status could be attributed to excessive energy expenditure, or decreased absorption of nutrients due to worm infestations. Intake of select nutrients in the diet of subjects did not show any significant association with their Body Mass Index. However, a higher intake of fat and protein, and decreased intake of the two essential minerals calcium

and iron was observed among a majority of subjects. Most of the other micronutrients were also found to be less than the RDA. When the macronutrient intake in the diet is high, it can lead to an increase in the overall caloric intake. Higher intake of fat can result in weight gain, and therefore increase the risk of chronic disorders such as type 2 diabetes mellitus. Decreased amounts of calcium can lead to poor mineralization of bones and low bone mineral density. Iron deficiency can cause anemia, which may impair growth and development, work capacity, learning capacity and resistance to diseases. Thus, while a deficiency can lead to under nutrition, an excessive intake can lead to over nutrition. Healthy dietary pattern and normal body weight have been found to be positive contributors to academic performance.

Therefore, it is of paramount importance to inculcate good food habits among adolescents and enhance their ability to make healthy food choices. Adolescents can be educated on the importance of good nutrition and the concept of a balanced diet during the growing years. This will equip them with making right food choices at home and outside places such as restaurants. Favorable changes in the dietary pattern can thus prevent or delay under and over nutrition related disorders, and help adolescents lead a healthier and productive life.

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