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DIETARY DIVERSITY AS AN INDICATOR OF MICRONUTRIENT ADEQUACY AMONG ADOLESCENTS OF GURGAON, INDIA

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Dietary Diversity (DD) has been identified as a potentially useful indicator of micronutrient status. The aim of present study was to observe the DDS, FVS and PA of micronutrients among adolescents; to compare these on the basis of gender and urbanization; and to find out the correlation of PA of micronutrients and dietary diversity. This study was carried out in Gurgaon district of Haryana state. Rao Lal Sing Public School, Gurgaon (urban) and Laxmi Senior Secondary School, Gurgaon (rural) were selected randomly. Information on dietary intake of adolescents was collected using 24-h recall method. The DDS was calculated as sum of all food groups consumed by an individual. PA of five micronutrients was calculated based on Estimated Average Requirement. Bivariate (Pearson) correlations were computed to explore the relationship between DDS and FVS and probability of adequacy of micronutrients. Urban adolescents had significantly higher DDS, FVS and probability of adequacy of iron and zinc whereas probability of adequacy of vitamin C and β-carotene was significantly higher in rural adolescents. Boys had significantly higher DDS, FVS and probability of adequacy of iron, zinc, vitamin C whereas girls had significantly higher probability of adequacy of β-carotene.

Keywords: Adequacy, Probability, Micronutrients, Dietary diversity, Food variety

INTRODUCTION

Adolescence is defined as the period of transition between childhood and adulthood and is characterized by an exceptionally rapid rate of growth. This phase of life has been reported and proven as one of the most vulnerable in the path of human life cycle after infancy (Giuseppina, 2000; and Mulugeta *et al*., 2009). A rapid growth rate combined with a marginal nutrient intake increases the risk of nutritional deficiencies in this population (Spear, 2002; and Rogol *et al*., 2002). This situation is further complicated when adolescents are often exposed to infections and parasites that can compromise nutritional status

Micronutrient malnutrition is a serious threat to the health and productivity of more than 2 billion people worldwide (FAO/WHO, 2002). Globally around 60-80% adolescents are suffering from micronutrient deficiency. In India, around 50% of adolescent girls and 20% of adolescent boys are iron deficient; the prevalence is even high in few states. Information is scanty about other micronutrients status though the nationwide studies showed a low intake of micronutrients than their respective RDA's among adolescents. The consequences of micronutrient deficiencies, such as iron, zinc, vitamin A, folate, and iodine, are profound and include premature death, poor general health, blindness, growth stunting, mental retardation, learning disabilities, and low work capacity. The prevalence of some micronutrient deficiencies remains largely unknown because of lack of data, but also because of the absence of

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easily measurable, sensitive and specific indicators of micronutrient status. Adolescents are considered to be a nutritionally vulnerable segment of the population.

Dietary Diversity (DD), which is defined as the number of different food groups consumed over a given reference period, has been identified as a potentially useful indicator of micronutrient status. Despite the instinctive link between increasing diversity of the diet and increased nutrient intake, the relationship between dietary diversity and adequate micronutrient intake has not yet been sufficiently validated across different cultural settings and in different age groups. Information regarding dietary diversity scores and food variety scores is simple to collect, easily adapted to diet in various settings. These are helpful in identifying key components of diet (foods and food groups), which can be clearly linked to nutritional needs and translated into population-specific nutritional guidelines.

In a summary of seven studies reviewed by Ruel (2003) five found a positive association between dietary diversity score and nutrient adequacy. Of the studies focusing on young children, a positive correlation was found between dietary diversity score and nutrient adequacy in Mali (Hatloy *et al*., 1998), Kenya (Onyango *et al*., 1998) and Niger (Tarini *et al*., 1999), while inconsistent results or no correlation were found in Guatemala (Brown *et al*., 2002), Ghana and Malawi (Ferguson *et al*., 1993). Greater dietary diversity was associated with improved nutrient adequacy in children 4-8 years of age in Kenya (Ruel *et al*., 2004). Analysis of children aged 6-13.9 months from four developing countries concluded that there was promising evidence for the utility of dietary diversity as an indicator of inadequate nutrient intake (Dewey *et al*., 2004). Dietary Diversity is strongly associated with household economic status. As income increases, the possibility that people diversify their diets also increases. This is due to the fact that varied diets generally are more palatable and more pleasant. A few studies have specifically addressed the association between dietary diversity and household socio-economic status and food security. Hoddinott and Yohannes (2002) tested whether household dietary diversity was associated with household per capita consumption (a proxy for household income) and energy availability (a proxy for food security), and found that as households diversify their diet, they tend to increase their consumption of prestigious, non-staple foods rather than increasing variety within the category of staple foods.

Probability of Adequacy (PA) is the probability that an individual's intake of one particular nutrient is adequate given the requirement distribution. The Estimated Average Requirements (EAR) and the Standard Deviation (SD) are used to calculate PA. PA takes the distribution of the nutrient intake of the population into account and the proportion of individuals at risk for inadequate intakes can be estimated. DD and PA are strongly associated with socio economic status. As income increases, the possibility that people diversify their diets also increases.

MATERIALS AND METHODS

Selection of Respondents

The present study was carried out in Gurgaon district of Haryana state in 2014-15. Multistage sampling technique was used where in at first stage state zone, followed by district and schools were selected for the study. Rao Lal Sing Public School, *Sidhrawali*, Gurgaon (urban) and Laxmi Senior Secondary School, *Rathiwas*, Gurgaon (rural) were selected randomly for this study. The present study was conducted on school going adolescents (13-17 y). Total 220 school going adolescents were selected for the study. Out of them 110 adolescents were selected randomly from the *Laxmi* senior secondary school, *Rathiwas* Gurgaon and another 110 students were selected from the Rao Lal Singh Public School, *Sidhrawali*, Gurgaon randomly. The proportion of male and female students was not assigned equal while selecting the respondents as the selection was random.

Dietary Diversity and Probability of Adequacy of Micronutrients

The information on micronutrients intakes of adolescents was collected using 24-h recall method. The total amount of the cooked food and the amount consumed by the respondent were measured in household units, and were used to determine the proportion of the total cooked dish consumed by the respondent (Slimani, 2000). Cooked food was converted into their raw equivalent. Mean micronutrients intake was calculated by taking mean of the two non-consecutive days intake using values given in nutritive value of Indian foods (Gopalan *et al*., 2001). To reflect dietary diversity, two variables were calculated for each individual: Dietary Diversity Score (DDS) and Food Variety Score (FVS). For calculating dietary diversity score foods were categorised under 13 food groups, i.e., 1. All starchy staples; 2. All legumes and nuts; 3. All Dairy; 4. Organ meat; 5. Eggs; 6. Small fish eaten whole with bones; 7. All other flesh foods and miscellaneous, small animal protein; 8. Vitamin A-rich dark green leafy vegetables; 9. Vitamin A-rich deep yellow, orange and red vegetables; 10. Vitamin A-rich fruits; 11. Vitamin C-rich vegetables; 12. Vitamin C-rich fruits; and 13. All other fruits and vegetables. The DDS was then calculated as the sum of all food groups consumed by an individual. The total score could range from 0 to 13. To calculate FVS, all food items consumed by the subjects during the two recall days were counted and summed. The food items that were categorized in the 13 food groups were taken into account for this calculation. The total score of FVS was ranged from 0 to 96 in present study. Probabilities of Adequacy (PA) of five micronutrients, i.e., vitamin A, vitamin C, calcium, iron and zinc was calculated based on the Estimated Average Requirement (EAR). PA was calculated by the equation PA = [(observed individual intake - EAR)/Standard Deviation] using function CDFNORM, where CDFNORM is the statistical function from SPSS that calculates the probability. Mean Probability of Adequacy (MPA) was calculated as the sum of probabilities of 5 micronutrients.

Statistical Analysis

Data were statistically analyzed using SPSS statistical package (version 14.0) for windows. Bivariate (Pearson) correlations were computed to explore the relationship between DDS and FVS and probability of adequacy of micronutrients (adjusted for protein intake, energy intake, age, gender and income).

The study was approved by the Technical Committee of Research and Dean, Post Graduate Studies, Chaudhary Charan Singh Haryana Agricultural University, Hisar. A written consent from each student was obtained prior to start the study.

RESULTS AND DISCUSSION

Dietary Diversity Score and Food Variety Score

Scores for DDS and FVS did not range to the highest possible score. Mean value of DDS was 6.7 (± 0.87). The theoretical range was 1 to 13, while in the sample it varied from 4 to 8. Ninety six different food items were reported to be eaten by the adolescents during the survey period. Mean FVS was 25.3 (± 3.5), with a minimum intake of 8 and a maximum of 34. Area-wise comparison showed that urban adolescents had significantly ($p<0.01$; $p<0.05$) higher scores of dietary diversity and food variety than rural adolescents (Table 1). The dietary diversity score and food variety score of urban adolescents was 7.7 and 26.21, respectively while the diversity score and food variety score of rural adolescents was 5.6 and 24.4, respectively. Gender-wise comparison showed that boys had more scores of dietary diversity and food variety than girls however a non significant difference for dietary diversity score but significant difference for food variety score was observed. The dietary diversity score and food variety score of boys was 7.01 and 26.5, respectively while the diversity score and food variety score of girls was 6.3 and 24.0, respectively. Indicators based on food groups (dietary diversity scores) have been shown to be more valuable in predicting nutrient adequacy than those based on individual foods (Hatloy *et al.*, 1998). Dietary diversity scores are a promising method for identifying populations at increased risk of malnutrition and related advances are valuable (Kennedy *et al.*, 2007). Rani *et al.* (2010) conducted a cross-sectional survey among 232 children (5-8 years) of Hisar, Haryana using a 24 h recall. Food Variety Score (FVS) and Dietary Diversity Score (DDS) were calculated. Scores for DDS and FVS did not range to the highest possible score. Mean value of DDS was 6.5. Seventy-eight different food items were reported to be eaten by the children during the registration period. Mean FVS was 12.2. A cross-tabulation of DDS against the individual food groups was done to provide a picture of how diets diversify. Diets continue to diversify as scores increase.

Table 1: Area-Wise and Gender-Wise Comparison of DDS[1] and FVS[2]

		DDS[1] (13 Dub Food Groups)	FVS[2] (96 Sub Food Items)
Total (n=200)		6.7±0.9	25.3±3.5
Area-wise	Rural (n=110)	5.6±0.9	24.4±3.5
	Urban (n=110)	7.7±0.9	26.2±3.2
	t-value	7.3**	1.0*
Gender-wise	Boys (n=122)	7.0±0.9	26.5±3.4
	Girls (n=98)	6.3±0.9	24.0±3.5
	t-value	0.2NS	1.1*

Note: Values are mean±SD; [1] Dietary diversity score: min: 4, max: 8; [2] Food variety score: min: 8, max: 34. ** Significant at 1% level; * Significant at 5% level.

Probability of Adequacy of Micronutrients

In general, all the estimates of probability of adequacy for micronutrients ranged low. Intakes of iron had the lowest (35%) while intakes of calcium had the highest (75%) probability of adequacy followed by the zinc (65%), β-carotene (55%) and vitamin C (38%). The mean probability of adequacy across 5 micronutrients was 54% (Table 2).

The mean probability of adequacy across five micronutrients among rural adolescents was 56%. The probability of adequacy of calcium, iron, zinc, vitamin C and β-carotene in the diets of rural adolescents was 76, 32, 61, 46 and 65%, respectively whereas the probability of adequacy of calcium, iron, zinc, vitamin C and β-carotene in the diets of urban adolescents was 74, 38, 69, 30 and 45%, respectively. Area-wise comparison of probability of adequacy among adolescents indicated that rural adolescents had the significantly (p<0.01) higher probability of adequacy of vitamin C and β-carotene whereas the probability of adequacy of iron and zinc was significantly (p<0.01) higher in urban adolescents (Table 2).

The mean probability of adequacy across five micronutrients of boys was 55% which was 51% in girls. The probability of adequacy of calcium, iron, zinc, vitamin C and β-carotene in the diets of boys was 74, 40, 72, 42 and 49%, respectively whereas the probability of adequacy of calcium, iron, zinc, vitamin C and β-carotene in the diets of girls was 76, 30, 58, 34 and 61%, respectively. Gender-wise comparison of probability of adequacy among adolescents indicated that boys had the significantly (p<0.01) higher probability of adequacy of iron, zinc, vitamin C and mean probability of adequacy across 5 micronutrients (Table 3) whereas the girls had significantly (p<0.01) higher probability of adequacy of β-carotene.

Results presented in Table 4 highlighted the correlations between the dietary diversity scores and adequacy of micronutrients. Pearson's correlations coefficients of dietary diversity scores and adequacy of micronutrient were significant for probability of adequacy of iron, zinc, β-carotene and mean probability of adequacy (r = 0.40, r = 0.42, r = 0.38 and r = 0.35 respectively; p<0.01). The association of iron, zinc and mean probability of adequacy were increased after adjusting for income and association of iron and were decreased after adjusting for protein intake, energy intake, gender and age. The rest associations remained unchanged but significant after adjusting for protein intake, energy intake, age, gender and income.

Results presented in Table 5 highlighted the correlations between the food variety scores and adequacy of micronutrient. Pearson's correlations coefficients of food variety scores and adequacy of micronutrient were significant for probability of adequacy of iron, β-carotene and mean probability of adequacy (r = 0.34, r = 0.40 and r = 0.23 respectively; p<0.01). The association calcium, iron, β-carotene and mean probability of adequacy were increased and remained significant after adjusting for income. The rest associations remained unchanged but the effect was not significant after adjusting for energy intake, age, gender and income.

Dietary diversity scores have been positively correlated with increased mean micronutrient adequacy of complementary foods, micronutrient adequacy of the diet

Table 2: Area-Wise Comparison of Probability of Adequacy of Micronutrients Among Adolescents

Micronutrients	Total (n=220)	Urban (n=110)	Rural (n=110)	t-value
Calcium	0.75±0.6	0.74±0.7	0.76±0.5	0.4 NS
Iron	0.35±0.3	0.38±0.3	0.32±0.3	6.9*
Zinc	0.65±0.2	0.69±0.2	0.61±0.1	5.3**
Vitamin C	0.38±0.3	0.30±0.4	0.46±0.2	2.1*
β-carotene	0.55±0.3	0.45±0.3	0.65±0.3	4.6**
Mean	0.53±0.2	0.51±0.1	0.56±0.2	1.4 NS

Note: Values are mean±SD. ** Significant at 1% level; * Significant at 5% level. NS Non-significant.

Table 3: Gender-Wise Comparison of Probability of Adequacy of Micronutrients Among Adolescents

Micronutrients	Total (n=220)	Boys (n=122)	Girls (n=98)	t-value
Calcium	0.75±0.6	0.74±0.6	0.76±0.7	0.1 NS
Iron	0.35±0.3	0.40±0.3	0.30±0.3	2.23*
Zinc	0.65±0.2	0.72±0.1	0.58±0.2	9.4**
Vitamin C	0.38±0.3	0.42±0.3	0.34±0.3	2.0*
β-carotene	0.55±0.3	0.49±0.1	0.61±0.3	2.3*
Mean	0.53±0.2	0.55±0.1	0.51±0.2	1.2*

Note: Values are mean±SD. ** Significant at 1% level; * Significant at 5% level. NS Non-significant.

Table 4: Correlation Between Probability of Adequacy of Micronutrients and DDS[1] (Controlled for Protein, Energy Intake, Sex, Age and Income)

	DDS[1]					
Micronutrients	Uncontrolled	Controlled for Protein Intake	Controlled for Energy Intake	Controlled for Gender	Controlled for Age	Controlled for Income
Calcium	0.15	0.15	0.15	0.15	0.15	0.15
Iron	0.40**	0.28	0.18	0.16	0.14	0.45**
Zinc	0.42**	0.42**	0.42**	0.35**	0.38**	0.48**
Vitamin-C	0.22	0.15	0.23	0.21	0.22	0.22
β-carotene	0.38*	0.38**	0.38**	0.36**	0.37**	0.38**
Mean	0.25*	0.25	0.26	0.26	0.25	0.28**

Note: * Significant at 5% level; ** Significant at 1% level. [1] Dietary diversity score.

Table 5: Correlation Between Probability of Adequacy of Micronutrients and FVS[1] (Controlled for Protein, Energy Intake, Sex, Age and Income)

	FVS[1]					
Micronutrients	Uncontrolled	Controlled for Protein Intake	Controlled for Energy Intake	Controlled for Gender	Controlled for Age	Controlled for Income
Calcium	0.19	0.19	0.2	0.19	0.19	0.23*
Iron	0.34**	0.34	0.34	0.35	0.34	0.39**
Zinc	0.38	0.38	0.37	0.38	0.38	0.38
Vitamin-C	0.25	0.25	0.25	0.26	0.25	0.27
β-carotene	0.40**	0.4	0.41	0.4	0.4	0.48**
Mean	0.23*	0.23	0.23	0.24	0.23	0.31*

Note: * Significant at 5% level; ** Significant at 1% level. [1] Food variety score.

in adolescents (Mirmiran *et al*., 2004) and adults (Foote *et al*., 2004). Calcium intake was positively associated with individual food groups, but not with total number of foods consumed. Iron intake on the other hand was positively associated with intake of flesh, dairy, cereal, fruits, and fat. Zinc intake was only seen to be positively associated with the total number of foods consumed and intake of fats and oils. Vitamin A, thiamin, riboflavin, Niacin, vitamin B_{12} intake and MAR were positively correlated with flesh, dairy, vegetable, cereal, fruit and fat intake. However, vitamin B_6 and folate intake were only positively correlated with the total varieties consumed (FVS), flesh and fat consumption. Among the nutrients, calcium had the lowest r^2 value followed by vitamin C (Acham *et al*., 2012).

Average micronutrient intakes by girls were 50 to 70% lower than the respective Indian recommended dietary intakes, which is in agreement with other studies. Correlations of the Adolescents Micronutrients Quality Index (AMQI) with micronutrient intakes and total bioavailable intakes of iron and zinc were positive and statistically significant ($P<0.01$). Correlations of calcium and iron intakes with the AMQI were higher than the correlations reported with other diet quality indexes. After adjusting for energy intake and socio demographic factors, partial correlations of the micronutrient intakes with the AMQI were reduced yet remained positive and statistically significant ($P<0.01$) (Chiplonkar and Tupe, 2010).

CONCLUSION

It may be concluded that adolescents (13-17 y) of Gurgaon, India were found to be at the risk of having micronutrient deficiencies as the mean probability of adequacy across 5 micronutrients (calcium, iron, zinc, β-carotene and vitamin C) was found very low (54%). Further, results of dietary diversity showed that diet of the majority of the adolescents was limited up to the consumption of cereals (wheat flour), roots and tubers (potato and onion), sugars, oils, other vegetables and milk and milk products (use of milk in tea preparation; buttermilk). This indicated the poor intake of micronutrients in adolescents and therefore, confirms the risk for them being micronutrient deficient. The boys had more food variety score in their diets as compared to girls; on the other hand urban adolescents had higher dietary diversity score and food variety score than their rural counter parts.

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