Original Article

Dietary diversity score in adolescents - a good indicator of the nutritional adequacy of diets: Tehran lipid and glucose study

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The purpose of this study was to determine dietary diversity and its relation to dietary adequacy in 10-18 year-old adolescents of district 13 of Tehran during the period 1999-2001. After excluding for over and under reporters, dietary intake assessment was conducted on 304 , 10-18 year old individuals, participants of Tehran Lipid and Glucose Study. A dietary diversity score was calculated as part of the pyramid serving database that is categorized into 23 broad food groups. Each of the 5 broad food categories received a maximum diversity score of 2 of the 10 possible score points. To be counted as a "consumer" for any of the food groups categories, a respondent needed to consume one-half serving, as defined by Food Guide Pyramid quantity criteria, at any time during a 2-day survey period. The nutrient adequacy ratio for a given nutrient is the ratio of a subject's intake to the current recommended allowance for the subject's sex and age category. Weight and height were measured and BMI was calculated. Student's t-test was used to compare the means. Those variables which had normal distribution were tested by Pearson correlation coefficient and the others were tested by the Spearman correlation coefficient. Mean ± SD of dietary diversity score (DDS) was 6.25 ± 1.08 (range 0-10). The maximum and minimum scores of dietary diversity were related to the fruit (1.46 ± 0.61) and bread-grain (0.95 ± 0.27) groups, respectively. Significant positive correlation was observed between DDS and the mean adequacy ratio (MAR) ($r = 0.42$, $P < 0.001$). Fifty percent of people had DDS ≥ 6. In people with a DDS of six or over, BMI was higher (19.81 ± 4.08 vs 18.95 ± 3.30 Kg/m^2, $P < 0.01$) than others. There was a significant and positive correlation between DDS and most of the nutrient adequacy ratios (NARs). It is concluded that DDS is an appropriate method to evaluate nutrient intake adequacy in this group of adolescents.

Key Words: dietary diversity, food variety, nutritional adequacy, adolescent, Tehran lipid and glucose study, Iran

Introduction

Epidemiological studies related to diet and chronic diseases tend to have focused on the relation between single-nutrient consumption and disease risk, despite the presence of many other nutrients in food. The intake of one nutrient is correlated with intakes of another, it would perhaps be better to estimate the relation between diet structure and selected health outcomes. Healthy diets are said to be those that are the most varied.[1,2] Food diversity is emphasized by the Food Guide Pyramid and the USDA (The United States Department of Agriculture).[3] Food variety is expressed as the number of biologically distinct foods eaten over a designated period of time. In other words, variety means that we choose to eat a mixture of foods across the range of food types (cereal, fruit, dairy) and a mixture from within food types (rye, barley, wheat). Food variety provides for several dimensions to human health. The first is that it encourages biodiversity and sustainability, the second, it allows for nutritional adequacy, the third is that it minimizes the adverse consequences of food on health, and the fourth is that it provides interest in food and the likelihood that it will be eaten. The fifth is that it reduces the prevalence of cancer, cardiovascular and other chronic diseases.[4-10]

Krebs-Smith *et al.*, suggested that consumption of a varied diet reduces the risk of developing a deficiency or excess of any one nutrient.[11] Kant described the use of foods or food groups as one of the major methods for assessing overall quality of a diet.[12] Inspite of much research about food variety, its relation to dietary adequacy has been less emphasized.[8] The purpose of our study was to determine dietary diversity and its relation to dietary adequacy in 10-18 year old adolescents of district no.13 of Tehran between 1999-2001.

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Subjects and methods

This study, conducted within the framework of Tehran Lipid & Glucose Study (TLGS), was a part of a dietary intake assessment, carried out according to the Food Guide Pyramid, of individuals residing in district 13 of Tehran between 1997-2001. Sample size was determined by considering a confidence interval of 95%, study power of 80%, predicted prevalence rate of 13% for dyslipidaemia in people under 30 years old, attrition rate estimation of 20%. Cases were 1287 randomly chosen persons, 10 years and older.[11] All cases, whose energy intake/basal metabolic rate were lower than 1.35, or equal to and more than 2.4, were excluded as over- and under-reporters, respectively.[14] After excluding the under- and over-reporters, 304 cases (162 girls and 142 boys), aged 10-18 years, remained in this study for evaluation of dietary diversity. Dietary intake assessment was undertaken with 2-day**,** 24-hour recalls by expert interviewers. The reliability and validity of 24-hour recalls has been proven in several studies.[15,16] The 24-hour dietary recall describes reported intakes from midnight to midnight, meal after meal. The first recall was performed at subjects' homes and the second during a clinic visit at the diet unit of TLGS. These two days were among usual days for subjects. Mothers were asked about the type and quantity of meals when subjects were unable to recall. Standard reference tables were used to convert household portions to grams for computerization. After coding the diaries, the dietary recall form was linked to a nutrient database (Nutritionist III) and nutrient intakes calculated using the Mosby Nutritract software for conversion of quantity to servings of food consumed. For mixed dishes, food groups were calculated according to their ingredients. To score dietary diversity, we used five groups of bread-grains, vegetables, fruits, meats and their substitution and dairy foods, according to the Food Guide Pyramid.[17] The main groups mentioned were divided into 23 subgroups. Seven of the groups reflected bread and grain-based products and seven categories of vegetables were included. There were also two primary categories of fruits and juices, four groups of meat products (meat, fish, poultry, eggs) and three groups of dairy products - these groups constituted the remaining 23 categories. These categories show the dietary diversity across the groups of the Food Guide Pyramid. We expanded the number of bread-grain food group categories into seven to reflect the diversity and importance of plant-based foods and to better reflect the number of servings of grain products recommended in the Food Guide Pyramid. To be counted as a “consumer” for any of the food group categories, a respondent needed to consume one-half serving as defined by the Food Guide Pyramid quantity criteria, at any time during the 2-day survey period. Each of the 5 broad food categories receive a maximum diversity score of 2 out of the 10 possible score points. Within each of the food groups, the score reflects the percentage of the possible maximum score. For example a person consuming at least one half serving in only 3 of 7 possible grain categories would receive a group score of (3:7) ×2 or 0.85 of 2 points. The scores of the other main groups were calculated by the same method and the total score was the sum of the scores of the five main groups. An unweighted score across the 23 food categories would skew diversity, because groups with more possible categories of food would receive more weight than would those with fewer categories. The higher the dietary diversity score, the greater the variety shown. The dietary diversity score (DDS) was divided to three subgroups: six and over, 3, 4 and 5, and less than three.[18]

Since the dietary diversity within food groups reflects different aspects of diet, we compared DDS with other standards of dietary quality. One role of dietary diversity is to guarantee dietary adequacy. DDS was therefore compared to mean adequacy ratio (MAR). To estimate the nutrient adequacy of the diet, a nutrient adequacy ratio (NAR) was calculated for energy intake and 12 nutrients (vitamin A, riboflavin, thiamin, vitamin C, calcium, iron, zinc, phosphorus, magnesium, protein, potassium, fat). NAR was calculated for each nutrient as the ratio of daily individual intakes to standard recommended amounts for subject’s sex and age category. MAR was calculated as described according to the formula below.[11]

$$\text{NAR}= \frac{\text{daily nutrient intake}}{\text{recommended amount of nutrient}}$$

$$\text{MAR}= \frac{\Sigma\ \text{NAR (each truncated at1)}}{\text{number of nutrients}}$$

NAR was truncated at 1 so that a nutrient with a high NAR could not compensate for a nutrient with a low NAR.[2] The NAR of selected vitamins, minerals, and energy are based on RDA[19] (Recommended Dietary Allowances) and DRI[20] (Dietary Reference intake). The NAR of potassium was based on estimated safe and adequate daily dietary intakes.[21] The NAR of the percentage contribution of energy from fat is based on recommended energy intake (30%).[2,18]

Anthropometric study

Weight and height were measured, without shoes, using a digital electronic weighing scale (seca 707; range 0.1-150 kg) and tape meter stadiometer, respectively. From the anthropometric data the body mass index was calculated (BMI, weight/height^2, kg/m^2). Overweight and obesity were defined according to recommended BMI cut-off values for adolescents.[22] Subjects were divided into four groups: overweight, obese, underweight and normal weight.

Analysis

Data was analyzed by SPSS (ver.9.05) statistical software program. Data was reported as mean ± SD. Student’s t-test was used to compare the means. Distribution of DDS between men and women was shown and analyzed by t-test. To determine whether variables had normal distributions or not, the Kolmogrov-Smirnov test was used. Correlation coefficients help us to compare DDS with MAR and NARs. Those variables which had normal distribution were tested by the Pearson correlation coefficient and the others were tested by Spearman correlation coefficient - P<0.05 was considered as significant.

Table 1. Mean and standard deviation of total dietary diversity score (DDS) and DDS in food groups in men and men

Food groups	Boys (*N* = 142)	Girls (*N* =162)	Total (*N* =304)
Grain	0.92 ± 0.24	0.98 ± 0.29**	0.95 ± 0.27
Vegetable	1.34 ± 0.31	1.37 ± 0.33	1.36 ± 0.32
Fruit	1.42 ± 0.64	1.50 ± 0.59	1.46 ± 0.61
Meat	1.13 ± 0.32	1.12 ± 0.32	1.12 ± 0.32
Dairy	1.29 ± 0.57	1.38 ± 0.48*	1.34 ± 0.53
All	6.13 ± 1.06	6.37 ± 1.08	6.26 ± 1.08

* P<0.05, **P <0.01, as compared to boys

Table 2. Correlation coefficient between some nutrient intakes, dietary diversity score (DDS) and mean adequacy ratio (MAR) (*N* = 304)

Variables	Energy	Carbohydrate	Protein	Fat	Saturated fatty acids	Oleic acid	Linoleic acid	Fibre	MAR
Energy (Kcal)	-								
Carbohydrate(%)	-0.1	-							
Protein (%)	-0.15**	0.06	-						
Fat (%)	0.12*	-0.91**	-0.35**	-					
Saturated fatty acids (g)	0.52**	-0.44**	-0.15**	0.46**	-				
Oleic Acid (g)	0.25**	-0.12*	-0.44	0.21**	0.41*	-			
Linoleic Acid (g)	0.17**	-0.13*	-0.04	0.19**	0.16*	0.78*	-		
Fibre (g)	0.53**	0.16**	0.04	-0.19**	0.15*	0.01	-0.01	-	
MAR	0.41**§	-0.29**§	0.19**	0.23***	0.45**§	0.20**	0.12*	0.35**	-
DDS	0.09§	-0.05§	0.06	0.05	0.14*§	0.13*	0.18*	0.15*	0.42**

*P<0.05, **P <0.01, ***P<0.001, § pearson correlation coefficient

Table 3. Distribution of DDS of food groups in individuals with total dietary diversity score (DDS) ≥ 6 and DDS <6

Food groups	Total DDS ≥ 6	Total DDS <6
Grain	1.01 ± 0.27*	0.84 ± 0.24
Vegetable	1.42 ± 0.32	1.24 ± 0.29
Fruit	1.73 ± 0.44	0.95 ± 0.58
Dairy	1.53 ± 0.44	0.98 ± 0.50
Meat	1.18 ± 0.32	1.02 ± 0.29

*P<0.05, as compared to <6

This study was approved by the Ethics Committee of the Research Council of Shaheed Beheshti University of Medical Sciences. Informed written consent was obtained from each subject.

Results

Mean dietary diversity score was 6.25 ± 1.08 in this study (range 0-10). The maximum and minimum score of diversity was related to the fruit (1.46 ± 0.61) and bread-grain (0.95 ± 0.27) groups, respectively. Mean and standard deviation of DDS of food groups according to dietary guidelines of the Food Pyramid are shown in Table 1. A significant difference was seen in bread-grain and dairy group diversity scores (P<0.05). In both groups DDS was higher in girls than boys. Table 2 shows correlation coefficients between nutrient intakes and DDS as well as nutrient intakes and MAR. After dividing DDS into three groups, 61.4, 38.3 and 3% of individuals had DDS ≥ 6, 3-5 and <3, respectively. When distribution of DDS (according to the Food Guide Pyramid) was divided into two groups - less than six and six and over (Table 3) - those who had DDS ≥6 also had greater fibre intakes (2.71 ± 0.19 vs 2.10 ± 0.20, P<0.01).

In people with a DDS of six or over, BMI was greater than in individuals with scores below six (19.81 ± 4.07 vs 18.95 ± 3.30 kg/m^2, P<0.01). Table 4 shows correlation coefficients between NAR and DDS. There was a positive and significant correlation between DDS and most of the NARs.

Discussion

This study showed that DDS had a positive correlation with MAR in adolescents. Other studies have reported the same results in children as well as adults.[2,11,12] Hence it is practical to use DDS as a tool to predict dietary quality. Dietary diversity score is considered to be a simple method and can be used to estimate nutrient adequacy in future studies. In this study, as well as in other studies, there was a significant and positive correlation between NAR of most nutrients and DDS.[2,11,23,24,26]

Today variety is so important that recent studies have demonstrated its significance in reducing the risk of total mortality. Although there are few studies about the effect of dietary diversity on chronic disease,[25,26] the present study has shown that fruit and bread-grain groups have the highest and the lowest scores respectively among adolescents living in district 13 of Tehran. In contrast, Magarey *et al.*,[27] showed that one quarter of adolescents did not consume the fruit group and the fruit variety score was the lowest. Less than 25% of all adolescents had an adequate fruit intake. Studies on adults over 18 years (families of these adolescents) also showed the same

Table 4. Correlation coefficient between nutrient adequacy ratio and total dietary diversity score

Nutrient Adequacy Ratio	Correlation coefficient (r) with dietary diversity score
Total energy	0.17**§
Carbohydrate	0.06§
Protein	0.16*
Fat	0.06
Vitamin C	0.14
Vitamin A	0.26***
Thiamin	0.05
Riboflavin	0.16*
Iron	0.03
Zinc	0.32***
Calcium	0.35***
Potassium	0.33***
Phosphorus	0.29***
Magnesium	0.29***
Mean adequacy ratio	0.42***§

* P<0.05, ** P<0.01, *** P<0.001, § pearson correlation coefficient

result.[28] The higher score of fruit diversity in adolescents was probably due to their culture and dietary habits or due to more availability of fruits in certain seasons. In the study of dietary variety in the urban and rural people of Tehran, vegetables had the highest score. These contrasts might be due to different methods used for scoring. Bread-grain had the lowest score in this study - probably due to culture, dietary habits and the limited number of bread-grain products (e.g whole grain cereals, fortified macaroni, and whole grain biscuits) in Iran compared with developed countries.[29] DDS of bread-grain and dairy groups in girls were higher than boys. In an Australian study,[27] scores of fruit and vegetables were higher in girls. The variety scores for the meat group was higher in adolescents compared to the adults. This is probably due to higher consumption of fast foods like hamburgers, pizza, eggs and foods prepared with eggs, fish and tuna.

There was no correlation between energy and macronutrient intakes with DDS. This finding is similar to the result of adults in this district[28] and the results of other studies.[23,24] Others have reported positive correlation between energy intake and DDS, but no correlation between macronutrients and DDS.[31] The positive correlation between energy and DDS may have been due to different scoring methods. In this study the scoring method was the same as that used by Haines *et al.*[16] Because of the larger number of participants who consumed different kinds of vegetables, fruits and dairy products, DDS was higher in the present study. There was no correlation between energy and fat consumption with DDS in the studies by Kant *et al.*,[24] and Marshall *et al.*[23] Of course, all the studies mentioned have been conducted on adults and there is no report available about correlation between macronutrient intakes and DDS. These results are logical because the Food Guide Pyramid is not a pattern for calorie control, but shows nutritional adequacy and balance.[32] Of course it is important to mention that the 10-18 year old individuals in this study had no specific food choice, eating whatever selection the family provided.

As DDS increased, the group score diversity increased. This result was seen in all food groups. In individuals whose score was more than six, the highest variety score was in fruits; this was also reported in the Bernstein *et al.*,[33] study. The higher intake of fibre in adolescents with DDS higher than 6 may be because of higher scores in the fruit and grain groups. However, this may result in higher intakes of vitamin C, carotenoids, antioxidants and phytochemicals. Ogle *et al.*,[34] also mentioned the importance of high variety scores in these food groups. In the studies by Tucker,[26] Togo,[35] and Tarini,[36] as well as in this study, high body mass index was seen in people who had high DDS. It could therefore be concluded that DDS is an appropriate tool for anthropometric assessment of 16-18 year old adolescents. Increased body fatness and energy intakes among individuals with high DDS scores is related to studies in which diversity in the sweet and fat group have been taken into account.[37]

Furthermore the action of many nutrients is dependent on the presence of others and the balance of nutrients in foods is important. The observation that multiple foods together provide the greatest protection from disease supports the importance of greater dietary variety for health outcomes. As evidence on diet and health accumulates, it becomes clearer that although individual nutrients are important, they work most effectively in the context of a complex dietary pattern that includes a balance of nutrients from a variety of healthful foods. Continued research that examines the complexity of dietary patterns may have much to offer in understanding associations between diet and health.

As DDS calculation is an appropriate method to evaluate nutrient intake adequacy, use of other indices like the Healthy Eating Index[38] and Diet Quality Index[39] are necessary to assess dietary adequacy.

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