Is dietary diversity a proxy measurement of nutrient adequacy in Iranian elderly women?

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A B S T R A C T

Objectives: To investigate whether consumption of more diverse diets would increase the probability of nutrients adequacy among elderly women in Tehran, Iran.

Methods: This cross-sectional study was conducted on 292 women aged ≥60 years who were randomly selected from 10 public health centers among 31 centers in south area of Tehran. Because of some limitations we randomly chose these 10 centers. The sample sizes provided 80% statistical power to meet the aim of study for test the relationship between Nutrient Adequacy Ratio (NAR), Mean Adequacy Ratio (MAR) as a dependent variable and total Dietary Diversity Score (DDS) as an independent variable. Dietary intakes were assessed by two 24-h recall questionnaires. The mean probability of adequacy across 12 nutrients and energy were calculated using the Dietary Reference Index (DRI). Dietary diversity Score was defined according to diet quality index revised (Haines et al. method). To investigate the relationship between MAR and DDS some demographic and socioeconomic variables were examined.

Results: Mean ± SD of total dietary diversity was 4.22 ± 1.28 (range 1.07–6.93). The Fruit and vegetable groups had the highest (1.27 ± 0.65, range 0–2.0) and the lowest (0.56 ± 0.36, range 0–1.71) diversity score, respectively. We observed that total DDS has significant positive correlation with MAR (r = 0.65, P < 0.001). Total DDS was significantly associated with NAR of all 12 studied nutrients (P < 0.01); probability adequacy of vitamin B2 revealed the strongest (r = 0.63, P < 0.001) and vitamin B12 revealed the weakest (r = 0.28, P < 0.01) relationship with total DDS. When maximizing sensitivity and specificity, the best cut-off point for achieving MAR ≥1 was 4.5 for DDS.

Conclusion: The results of our study showed that DDS is an appropriate indicator of the probability of nutrient adequacy in Tehranian elderly women.

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1. Introduction

Dietary diversity and nutrient adequacy are one of the most important nutrition concern in the world. Generally, there is an increasing trend of emphasizing on the overall dietary quality by nutritionists instead of the individual foods or nutrients (Clausen, Charlton, Gobotswang, & Holmoe-Ottesen, 2005; Ruel, 2003). It has been demonstrated that optimal nutritional adequacy is necessary for higher mental and physical health status for people of all ages including the older adults (Bernstein & Munoz, 2012; Oldewage-Theron & Kruger, 2008).

Dietary diversity and food variety are considered as a key predictable component of dietary adequacy (Murphy et al., 2006)

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Abbreviations: NAR, nutrient adequacy ratio; MAR, mean adequacy ratio; DDS, dietary diversity score; DRI, dietary reference intake; ROC, receiver-operating characteristic; AUC, area under curve; FVS, food variety score.

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which is recommended by both global dietary guidelines and national food-based dietary guidelines (Organization, 1998).

Dietary diversity is defined by the number of food groups containing bread/grains, meats, fruits, vegetables, and dairy products consumed over the given time period (Ruel, 2003). There are several ways to calculate the dietary diversity score (Collins et al., 2015; Haines, Siega-Riz, & Popkin, 1999; Kant & Thompson, 1997; Kennedy, Ballard, & Dop, 2011), that these indices determined based on the aim, region, ethnicity and specific age groups of study by researcher.

Older people in both developed and developing countries are subject to nutritional deficiencies (Organization, 2002; Rosenberg & Gallego, 2002; Shatenstein, Nadon, & Ferland, 2003). In older adults, dietary diversity and adequate nutritional intake have been highly influenced by the combination of several factors including, medical, socio-economical, environmental, functional status and other age-related complications.

The positive correlation of dietary diversity with biochemical measures of nutritional status (Campbell, Roe, & Eickwort, 1982; Savv, Martin-Prevet, Sawadogo, Kameli, & Delpeuch, 2005) as well as the increased intakes of fruits and vegetables (Daniels, Adair, Popkin, & Truong, 2009; Randall, Nichaman, & Contant Jr., 1985) have been previously reported.

In addition, researchers have indicated that dietary diversity is inversely associated with age-adjusted mortality rate (Kant, Sachtzkin, Harris, Ziegler, & Block, 1993) and certain non-communicable diseases including cancers (Kant, Sachtzkin, & Ziegler, 1995), metabolic syndrome (Azadbakht, Mirmiran, & Azizi, 2005a; Williams et al., 2000), hypertension (Miller, Crabtree, & Evans, 1992; Moon & Park, 2007), obesity (L. Azadbakht, Esmailzadeh, 2011) and cardiovascular diseases (Azadbakht, Mirmiran, Esmailzadeh, & Azizi, 2006; Kant et al., 1995), while is positively associated with prolonged longevity (Kant et al., 1993).

Azadbakht et al. reported that the variety of different food groups is a useful indicator of specific nutrient adequacy among 295 men aged ≥18 in the district 13 of Tehran, Iran (Azadbakht, Mirmiran, & Azizi, 2005b) and Mirmiran et al. showed this association among Tehranian women (Mirmiran, Azadbakht, & Azizi, 2006).

Although previous studies have supported the dietary diversity as an indicator of nutrient adequacy in children, adolescents and adults (Arimond & Ruel, 2004; Mirmiran, Azadbakht, Esmailzadeh, & Azizi, 2004a; Steyn, Nel, Nanthel, Kennedy, & Labadarios, 2006), few studies have been performed in this regard among elderly subjects in other population (Bernstein et al., 2002; Oldewage-Theron & Kruger, 2008; Rathnayake, Madushani, & Silva, 2012). To our knowledge, this is the first study to demonstrate the association between DDS according to Haines et al. scoring methods and nutrients adequacy in Iranian older women.

The aim of this study was to explore the relationship between dietary diversity and nutrient adequacy in a sample population of Iranian elderly women. Assuming that dietary diversity is correlated with nutrient adequacy, therefore, dietary diversity may become an easy and useful tool in evaluating dietary adequacy and nutritional risk among Iranian elderly women.

2. Materials and method

2.1. Study population

This cross-sectional study was conducted on a sample of 300 apparently healthy elderly women aged ≥60 years, in city of Tehran during September to December 2014. Elderly women were selected randomly from 10 public health centers among 31 public health centers in the south area of Tehran affiliated to Tehran University of Medical Sciences. We selected 10 public health centers randomly among those socioeconomic similarity. As we had some budget, facilities and time limitations, we could not include all 31 public health centers in our study. However we checked the socioeconomic status of the participants and the region, and these 10 centers were representative of all 31 public health centers. Inclusion criteria include the subjects who were not following specific diets (weight reduction diet, vegetarian diet or any major change in ordinal daily diet such as fasting) during last 6 months or had not any history of cardiovascular disease, diabetes and stroke which was based on self-reported information by the participants. Sample size was determined by pilot study in 2 public health centers in south area of Tehran. First 15 person were randomly selected from 2 these centers. After calculated DDS, MAR and adequacy across 12 nutrients and energy for them, maximum sample size obtained from correlation between B12 and DDS. For calculating sample size we used this formula:

\[
r(B12, DDS) = 0.17
\]

\[
power = 1 - \beta = 0.8
\]

\[
c = \frac{1}{2} \left( \frac{1 + r}{1 - r} \right)
\]

\[
n = \left( \frac{Z_{1-\alpha} + Z_{1-\beta}}{c} \right)^2 + 3
\]

\[
n = 270 + 10\% \text{ losse of samples} \approx 300
\]

After completed all participant information, we excluded the ones whose dietary energy intake was out of ±3SD energy intakes of total participants and/or who completed only one 24-h recall. Finally, after excluded these 8 subjects, the data of 292 women was included in the analysis.

The protocol of this study was approved by the Ethics Committee of Tehran University of Medical Science (TUMS). All of the participants were given the informed written consent.

2.2. Dietary measures

Dietary intake was measured using the 24-h recall for each participant on two non-consecutive weekdays which was completed by trained dietitians. These two days were selected randomly at maximum 7 days interval. Both recall were completed at the diet unit of each health center. Each diary consisted of six eating occasions: breakfast, morning snack, lunch, afternoon snack, dinner and evening snack.

We collected a detailed description of the foods eaten by each participant including cooking method, white or whole meal bread, peeled or unpeeled fruits, etc. The amount of consumed food was estimated using visual aids (photographs of servings) and food portion models (graduated cup, two bowls, a plate, spoons and a ruler), as well as common household utensils (Ghaforpour, Houshiarrad, & Kianfar, 2005). Standard reference tables were used to convert household portions to grams (Ghaforpour, Houshiarrad, & Kianfar, 1999).

These estimations were converted into weights by experienced dietitians on the basis of a standardized protocol, including a manual on household weights and measures (Bellemans & De Maeyer, 2002). Participants’ daily intake of energy was estimated using the average of two 24-h dietary recalls. Nutrient intakes were computed using nutrient database Nutritionist IV software (version 4.1; First Databank Division, The Hearst Corporation, San Bruno, CA, USA) (DataBank & Nutritionist, 1995) which was modified for the evaluation of Iranian foods.
2.3. Dietary diversity score

Using a method developed by Haines et al. (Haines et al., 1999), a DDS was calculated for 23 sub-categories derived from the five main food groups including, grain/bread, vegetables, fruits, meats, and dairy foods.

The ‘bread/grain’ group was divided into seven subgroups (non-whole grain breads, whole grain breads, rice, pasta, whole grain cereals, non-whole grain cereals and quick breads); ‘fruits’ into two subgroups (first group include citrus fruit, melons, berries and second group include all other fruits and juices) and seven subgroups including potato and potato products, tomato and tomato products, starchy vegetables, legumes, deep yellow and orange vegetable, dark green leafy vegetables and all other vegetables were considered as belonging to vegetables group. ‘Meats and meat substitutes’ were categorized into four subgroups (red and organ meat, poultry, fish, and egg), and ‘dairy’ into three subgroups (all type of milk, yogurt, and cheese).

To be counted as a “consumer” for any of the food groups, a respondent had to consume at least one-half serving of each food group as define by My Plate -Serving Equivalents Guide (Department of Agriculture, 2011), during the 2-day survey period.

The maximum of diversity score for each of the five main food group was equal to 2. Total score was the sum of the scores of this five main groups. The range of total DDS in this study was 0–10. For calculating the diversity score of each group, we divided the number of subgroups consumed by the total number of sub groups of each main group and then we multiplied it by two. For example if a respondent consumed at least one-half serving from 4 of 7 possible vegetables categories, she would receive a subgroup score is 4/7 × 2 = 1.14. At the time being, researchers use this method for calculating DDS in Iran (Azadbakht & Esmaillzadeh, 2011; Azadbakht, Haghighatdoost, & Esmaillzadeh, 2012; Azadbakht et al., 2005a; Azadbakht et al., 2006; Mirmiran et al., 2006; Mirmiran et al., 2004a).

2.4. Assessment of nutrient adequacy

Nutrient adequacy was measured through computing the NAR and MAR methods (Hatluy, Torheim, & Oshaug, 1998). NAR was calculated for the energy and 12 nutrients including vitamin A, vitamin C, vitamin B12, vitamin B2, niacin, folic acid, vitamin B12, calcium, iron, zinc, magnesium, and protein. The mean probability of adequacy across 12 nutrients was calculated using the DRIs. To estimate the nutrient adequacy of the diet, NAR was calculated for the energy intake and 12 nutrients. The NAR for a given nutrient is the ratio of a subject’s intake to the current recommended allowance (RDA) for each sex and age category (Hellwig, Otten, & Meyers, 2006). All of the values regarding recommended allowance were not AI or EAR.

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

\[
\text{MAR} = \sum \text{NAR (each truncated at 1)} \div \text{number of nutrients}
\]

2.5. Anthropometric measures

Weight, height and waist circumference were measured according to standard protocols, as reported earlier (Mirmiran, Esmaillzadeh, & Azizi, 2004b). A waist circumference ≥88 cm was considered as abdominal obesity (Panel, 2002). Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m²).

2.6. Assessment of other variables

The following socio-demographic variables were asked by interview from the participants: family status, education, chewing problems, supplement intake and economic status. Socio-economic status information of participants was obtained by self-reported which included home ownership, monthly income and the number of essential item for living.

2.7. Statistical analysis

The Statistical Package for Social Science (SPSS) statistical software package, version 16 (version16; SPSS Inc., Chicago, IL) was used for all statistical analysis. Data are expressed as mean ± standard deviation for continuous variables and as frequency (percentage) for categorical variables. The normality of continuous variables for comparison sakes at groups was tested using the Shapiro-Wilk test. Pearson correlation coefficients were used for determining the association of DDS with NAR for 12 selected nutrients. We used linear regression model to determine the role of DDS for food groups in MAR. Only variables with value 0.20 or less from the univariate analysis were entered into the final model. The model was controlled for energy intake (kcal/day) (Model 2) in addition to the consumption of dietary supplement, economic status and chewing problem (Model 3). Finally, ROC curve analysis was conducted to test the performance of classification schemes of MAR adequacy (MAR<1 or MAR>1) via total DDS. The accuracy of separation into two groups of MAR via DDS was calculated by AUC analysis (area under curve), and the appropriate cutoff value of DDS for achieving good sensitivity/specificity value of classification was explored.

All assumptions made for comparisons and regression models were checked. The residual normality, consistency of error variance and collinearity problem at regression models were checked by normality test, scatter plot of residuals, predicted values, and variance inflation factor (VIF), respectively.

3. Results

The baseline characteristics of the participants are presented in Table 1. The average age of participants was 67.1 ± 4.8 year and more than half of them were illiterate (55.1%). Mean BMI and waist circumference were 31.2 ± 4.8 kg/m² and 97.9 ± 10.4 cm, respectively. More than half of the participants were obese (55.1%) and 84.2% of subjects had abdominal obesity. Less than one tenth of them had chewing problems (7.2%). Regarding the socioeconomic status, older women in this study were categorized in three groups including subjects with low (36.6%), middle (53.1%) and high (10.3%) economic status, respectively. Most of elderly women in this study lived in household with more than one people (80.9%). The mean ± SD total Dietary Diversity Score was 4.22 ± 1.28 (ranged from 1.07 to 6.93). Fruits group had the highest (1.27 ± 0.65, range from 0 to 2.0) and vegetables and had the lowest (0.56 ± 0.36, range from 0 to 1.71) diversity score between food groups (Table 2).

The average of nutrients intake and the percentage of participants with adequate intakes are presented in Table 3. The majority of participants had adequate intakes of Vitamin B12 and Iron (70.2% and 68.5%, respectively), whereas the intakes of Calcium and Magnesium were reported as inadequate in 100 and 98.3% of women, respectively.

Fig. 1 shows the percentage of women consuming at least 1/2 serving of food items during the 2 days. Among the 23 food items,
rice, whole and non-whole grain bread, all other vegetables, all other fruits and juices, red meat and cheese were the top five. Total DDSs had no significant association with BMI and waist circumference, whereas, there was an inverse significant relationship between diversity score of vegetables group and waist circumference \( (r = -0.14, p < 0.05) \).

The correlation between the diversity score of food groups and NAR are shown in Table 4. The diversity score of grain/bread group was correlated with vitamin \( B_2 \), vitamin \( B_6 \), protein and energy adequacy \( (P < 0.05) \). Diversity score of vegetables group was significantly correlated with vitamin \( A \), vitamin \( C \), folate, and magnesium \( (P < 0.01) \). In addition, there was a significant correlation between diversity score of fruits group with the probability of dietary intake of vitamin \( C \), vitamin \( A \), folate, magnesium and energy adequacy \( (p < 0.01) \).

The diversity score of meat group was associated with NAR of all nutrients \( (P < 0.01) \), with the exception of folate acid, calcium, vitamin \( C \) and vitamin \( B_1 \). The intake adequacy of vitamin \( B_2 \), vitamin \( B_{12} \), calcium, magnesium, protein and energy were significantly correlated with the diversity score of milk and dairy group \( (P < 0.01) \). Besides, the total DDS was significantly associated with NAR of all 12 studied nutrients \( (P < 0.01) \). The probability of adequacy of vitamin \( B_2 \) revealed the strongest \( (r = 0.63, P < 0.01) \) and vitamin \( B_{12} \) revealed the weakest \( (r = 0.28, P < 0.01) \) relationship with total DDS.

Dietary intake of energy was significantly correlated with diversity scores of all food groups \( (P < 0.05) \), expected vegetables.

As showed in Table 4, the MAR, proxy of nutritional adequacy associated positively and significantly with DDS \( (r = 0.65, P < 0.01) \).

The diversity scores of all food groups, except grain/bread group had shown a significant association with MAR \( (P < 0.001) \) that remained significant after adjustment in model 2 (adjusted for energy intake) and in model 3 (adjusted for energy and supplement intakes, economic status and chewing problem) for vegetables, fruits and dairy products groups (Table 5).

ROC analyses were performed to assess the value of the diversity score in each food group in predicting dietary intake adequacy (MAR \( \geq 1 \)). The area under the ROC curve was calculated for diversity score of each dietary group for predicting the (MAR \( \geq 1 \)).

As shown in Table 6, dairy and cereals had the highest and the lowest area under the curve among dietary groups \((0.76 \text{ and } 0.48\text{, respectively})\).

The areas under the curve for all dietary groups, except for grain/bread group was also positively display significant prediction of nutrient adequacy (Table 6).

In addition, The ROC curves of total diet diversity score for predicting dietary intake adequacy (MAR \( \geq 1 \)) are shown in Fig. 3. The value of AUC was 0.82 (95%CI: 0.76–0.87, \( P < 0.05 \)). The cut-off point, sensitivity, and specificity of DDS to classify subjects as MAR \( \geq 1 \) were 4.5, 79%, and 69%, respectively.

### Table 1
General characteristics of participants (n = 292).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housemate</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>54 (18.5)</td>
</tr>
<tr>
<td>With husband</td>
<td>82 (28.1)</td>
</tr>
<tr>
<td>With husband and children</td>
<td>86 (29.5)</td>
</tr>
<tr>
<td>Only with children</td>
<td>68 (23.3)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Illiterate</td>
<td>31 (10.7)</td>
</tr>
<tr>
<td>Primary</td>
<td>98 (33.5)</td>
</tr>
<tr>
<td>High school and higher</td>
<td>126 (43.2)</td>
</tr>
<tr>
<td>Economic status</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>107 (36.3)</td>
</tr>
<tr>
<td>Middle</td>
<td>155 (51.1)</td>
</tr>
<tr>
<td>High</td>
<td>30 (10.3)</td>
</tr>
<tr>
<td>BMI category</td>
<td></td>
</tr>
<tr>
<td>Underweight (20 kg/m²)</td>
<td>3 (1.0)</td>
</tr>
<tr>
<td>Normal (20–25 kg/m²)</td>
<td>127 (43.4)</td>
</tr>
<tr>
<td>Overweight (25–29.9 kg/m²)</td>
<td>133 (45.5)</td>
</tr>
<tr>
<td>Obese (≥30 kg/m²)</td>
<td>20 (6.8)</td>
</tr>
<tr>
<td>Abdominal obesity</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>294 (94.0)</td>
</tr>
<tr>
<td>No</td>
<td>21 (7.2)</td>
</tr>
<tr>
<td>Chewing problems</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>10 (3.4)</td>
</tr>
<tr>
<td>No</td>
<td>271 (92.8)</td>
</tr>
<tr>
<td>Supplement intake</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>118 (38.3)</td>
</tr>
<tr>
<td>No</td>
<td>174 (59.6)</td>
</tr>
</tbody>
</table>

* Abdominal obesity is defined as having ≥88 cm for Asian women on the basis of the IDF.
* Intake food supplements in ≥3 times per week during past 3 months.

### Table 2
Mean, Minimum and Maximum range* of total DDS, Diversity Score in each food group in elderly women in Tehran (n = 292).

<table>
<thead>
<tr>
<th>Dietary diversity scores</th>
<th>Mean ± SD</th>
<th>Min and max range*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains &amp; bread group</td>
<td>0.84 ± 0.24</td>
<td>0.29–1.43</td>
</tr>
<tr>
<td>Vegetables group</td>
<td>0.56 ± 0.36</td>
<td>0.0–1.71</td>
</tr>
<tr>
<td>Fruit group</td>
<td>1.27 ± 0.65</td>
<td>0.0–2.0</td>
</tr>
<tr>
<td>Meat group</td>
<td>0.76 ± 0.44</td>
<td>0.0–1.5</td>
</tr>
<tr>
<td>Dairy group</td>
<td>0.79 ± 0.56</td>
<td>0.0–2.0</td>
</tr>
<tr>
<td>Total</td>
<td>4.22 ± 1.28</td>
<td>1.07–6.93</td>
</tr>
</tbody>
</table>

* Minimum and maximum range.

### 4. Discussion

The result of this study conducted on a sample population of Tehranian elderly women. The results of the present study showed that 55% of this older women were obese \( (BMI≥30 \text{ kg/m²}) \), but previous studies showed that less than 20% women had \( BMI≥30 \text{ kg/m²} \) \( (Bakhshi, Seifi, Biglarian, & Mohammad, 2012; Mirmiran et al., 2006) \). Differences between the result of our study and other studies may be due to difference in the population age groups. Also more than 80% women in the present study had abdominal obesity. The previous studies were reported higher prevalence of central obesity in women \( (Azadbakht, Mirmiran, Shiva, & Azizi, 2005c; Veghari et al., 2010) \), therefore it may be taken in concern. The results of the present study showed over half of the participant were illiterate. The previous studies showed higher prevalence of illiteracy \( (Noroozian, 2012; Shirazi Khah, 2012) \). The results of economic status and housemate of the present study are similar to the study by Tajvar et al. in elderly population \( (Tajvar, Arab, & Montazeri, 2008) \).

The result of current study showed a positive association between the overall DDS and the probability of nutritional adequacy. In this study, MAR and NAR indicators were used to determining the probability of nutritional adequacy according to the Foote et al. study \( (Foote, Murphy, Wilkens, Basiotis, & Carlson, 2004) \). The findings of the current study are consistent with the previous studies reporting a significant and positive association between DDS and nutritional adequacy in children \( (Steyn et al., 2006; Steyn, Nel, Labadarios, Mauder, & Kruger, 2014) \), adolescents \( (Mirmiran et al., 2004a) \), as well as adults \( (Kim, Kim, Ryu, & Sohn, 2007; Mirmiran et al., 2006) \). This is the first study reporting the relationship between DDS and nutrient adequacy in Tehranian elderly women. The consumption of a diverse diet within and between food groups is considered as an indicator of healthy dietary pattern, which is recommended widely in global and national dietary guidelines \( (Organization, 1998) \).
As mentioned previously, increased dietary diversity is related to the reduced risk of mortality (Kant et al., 1993) and some chronic diseases including cancer (Fernandez, Negri, La Vecchia, & Franceschi, 2000), cardiovascular disease (Azadbakht et al., 2006), metabolic syndrome (Azadbakht et al., 2005a), abdominal obesity (Azadbakht & Esmaillzadeh, 2011), as well as hypertension (Miller et al., 1992) and macrovacular disease in diabetic patients (Wahlqvist, Lo, & Myers, 1989).

Using ROC curves, we identified the best cut-off point to be 4.5 for DDS in predicting MAR > 1. The results of our study were similar to previous studies by Kennedy, Pedro, Seghieri, Nantel, & Bourouer, 2007 (Kennedy et al., 2007) and Rathnayake et al. 2012 (Rathnayake et al., 2012) that found the best cut-off points for predicting a DDS of 4.5. These results support the evidence that dietary diversity is an important element of nutrition adequacy.

Earlier investigations among Iranian population also reported that DDS had an inverse association with cardiovascular risk factors (Azadbakht et al., 2006) and metabolic syndrome (Azadbakht et al., 2005a) in healthy subjects aged ≥ 18 years, as well as with abdominal obesity in healthy females students (Azadbakht & Esmaillzadeh, 2011).

As a natural process of life is characterized by a progressive decline of functions of many organs which is associated with increased risk of chronic disease and high prevalence of nutrients deficiency (Motta et al., 2005). Good nutrition is considered as an essential part of human’s overall health and well-being with protective effects against diseases. Therefore, adherence to healthy dietary pattern by focusing on increasing dietary diversity is recommended in aging people.

In addition our study has focused on how DDS for individual food groups contribute to the probability of nutritional adequacy in elderly women. Among this sample population of Tehranian elderly women, DDS of the grains/bread group was correlated with the probability of adequacy across vitamin B9, vitamin B12, protein, and energy intakes. In the present study, the consumption of rice was reported as being higher than other members of grains and breads family.

Traditionally, rice, as a main source of energy intake, is integrated into the dietary culture of Iranian people similar to East Asia countries (Wahlqvist, 2002). Moreover, the percentage of subjects who consumed at least 1/2 serving for whole grain breads was higher than non-whole grains breads (70.2% vs. 68.2%) but it was reported lower than white rice consumption (93.2%).

Other studies reported that the higher intake of whole grains is associated with lower concentration of insulin (Pereira et al., 2002) and better glycemic control (Fung et al., 2001). In addition, the higher consumption of whole grains has favorably influenced abdominal obesity, insulin sensitivity, and dyslipidemia all standing as risk factors of metabolic syndrome (Cho, Qi, Fahey, & Klurfeld, 2013; Slavin, 2004).

Our data showed that the diversity score of fruits was correlated with the chance of adequacy of folic acid, vitamin A, vitamin C, magnesium and energy intakes.

The results of Azadbakht et al. indicated that increasing the variety of fruits and vegetables was correlated with the adequacy of vitamin C intake among Iranian men (L. Azadbakht et al., 2005b). It has been demonstrated that vitamin A and vitamin C act as antioxidants vitamins, which play important roles in promotion well-being, improving cardiovascular health status, and preventing cancers and other chronic diseases (Devasagayam et al., 2004; Padayatty et al., 2003).

It is proved in the literature that natural antioxidants function as free-radical scavengers have protective effects in progressive deterioration of aging and physiological changes in aging (Ames, Shigenaga, & Hagen, 1993; Ashok & Ali, 1999; Junqueira et al., 2004).

In this study, 80.5% and 63.7% of elderly women were observed as having extents of vitamin A and vitamin C deficiency, respectively. A positive correlation between diversity score of vegetables and the adequacy of folic acid, vitamin C, vitamin A and magnesium was observed among this sample population of Tehranian older women. Within the vegetables group, based on the consumption of at least 1/2 serving during 2 days, all other vegetables including cucumber, eggplant, onion and etc. had the highest consumption (57.9%) that decreased according to the following order; dark green leafy vegetables, (38.4%) tomato and tomato products (37.3%), potato and potato products (32.2%), legumes (25.3%), deep yellow and orange vegetables (9.5%) and all other starchy vegetables such as corn and green peas (0.7%) were ranked as the last ones. On the other hand, only 11.0% and 1.7% of our participants met their needs for folic acid and magnesium. Noticeably, the present study showed that among 5 main dietary groups, fruits and vegetables had the highest and the lowest DDS, respectively. However, two previous studies reported fruit and grain/bread groups as dietary groups with the highest and the lowest DDS among a sample population including 10–18 year old adolescents and adult women of district 13 of Tehran during 1999–2001 (Mirmiran, Azadbakht, & Azizi, 2005; Mirmiran & Azizi, 2003).

Generally, the consumption rate of vegetables is lower among older persons compared to adults. This may be tracked in the differences, which exist in terms of culture, dietary habits, and the
effects of other factors such as seasonal variation in food availability, vegetables avoidance due to chewing problems and gastrointestinal disorders, and difficulty in preparing vegetables.

Otherwise, using alternative scoring methods of DDS may explain the inconsistency of results between various studies. The scoring method of this study was the same as what used in the Haines et al. study (Haines, Siega-Riz, & Popkin, 1999).

Based on the linear regression analysis, diversity score of vegetables, fruits, meats and dairy products were the strongest predictors of MAR which remained statistically significant for vegetables, fruits and dairy products following adjustment for confounders including energy and supplement intake, economic status and chewing problems. In another study among a sample population of men aged ≥18 year in Tehran, meats and dairy products were reported to have the strongest correlation with MAR, which was an indicator of nutritional adequacy (Azadbakht et al., 2005b). According to the results of the present study, all of the elderly women participating in this study failed to meet calcium requirements. Among the dietary groups, the diversity score of milk and dairy products had a significant association with calcium adequacy. Consistent to the results of Aazadbakht et al. study among Tehranian men (Azadbakht et al., 2005b), we showed in our study that dairy products varieties had a strong correlation with probability of adequacy of vitamin B_{12}, vitamin B_{12}, calcium, magnesium, protein and energy intakes. However, in the above-mentioned study, 71% of men experienced certain degrees of calcium deficiency.

It is needless to say that calcium is one of the most important minerals for all age groups particularly in older adults. Calcium plays essential roles in various metabolic and physiological pathways. It has been demonstrated that high dietary calcium intake could decrease the risk of chronic diseases namely, hypertension, fat absorption, obesity, diabetes, CVD, and metabolic syndrome (Meng, Li, & Yang, 2010; Teegarden, 2006, pp. 401–409; Xiao et al., 2013; Zemel, 2002). A hundred percent calcium deficiency recorded among participants in the current study could be an indicator of the high prevalence of calcium deficiency in Tehranian elderly women population. Therefore, based on the importance of calcium in health promotion and preventing of chronic disease, which are common in elderly, the implementation of educational programs and nutritional strategies for increasing the consumption of various low-fat dairy products among older adults is necessary. Furthermore, increasing the price of milk and dairy products during recent years may contribute to reducing the consumption of dairy products and bring out calcium deficiency among Iranian population. Otherwise, our study indicated that dietary energy intake correlated significantly with the diversity score of all main food groups, except for vegetables, which is partly due to the notion that this group had the lowest DDS across all dietary groups.

DDS is based on the Food Guide Pyramid so, it has not any specific control on the energy intake. As mentioned in previous studies, dietary intake with higher DDS is accompanied by higher energy intake. The association between DDS and energy use to be contradictory in the literature, which may be explained through different scoring methods of DDS and the distribution of the DDS for individual main food groups.

For example, in the studies by Kant et al., (Kant, Block, Schatzkin, Ziegler, & Nestle, 1991), Marshall et al (Marshall, Stumbo, Warren, & Xie, 2001), and Mirmiran et al (Mirmiran et al., 2004a), there was no association between DDS and dietary energy intake. However, all of these studies were conducted on the healthy adults. It has been shown that in addition to age, BMI, education and employment status, having a share of 48% the dietary energy intake also contributed to the variation of nutritional adequacy (Azadbakht et al., 2005b). However, we did not evaluate the correlation of DDS with energy intake and obesity, but energy intake was enrolled for adjustment in the regression model. It is remarkable that the association between higher DDS and increased energy intake, and the risk of obesity could be influenced by the quality of DDS, as a distribution of total DDS between the 5 main food groups. Therefore, higher total DDS is recommended by increasing the diversity score of fruits, vegetables and whole grains instead of fats and sugars.

In contrast, it had been suggested that the direct association
between higher DDS and increasing energy intake is useful in older people, because of its protective effect against low BMI rather than obesity in aging population (Rössner, 2001).

Our study had several limitations. The cross-sectional design of this study was one of the limitations, which do not reveal the causal relationship. Thus, longitudinal studies are suggested as a further attempt. Another limitation is the small sample size of the present study. In addition, considering that all of the participants in the current study were females, more studies are needed in this field in both genders to compare between them. In addition to DDS, FVS, dietary serving score (DSS) (Kant et al., 1995) and Australian recommended food score (ARFS) (Collins et al., 2015) are other indicators of dietary diversity which are not evaluated in this study. Moreover, we used DRI as a reference index for estimating nutrient adequacy that is established for health subjects. In our study, we had no complete knowledge regarding the health status of participants in the present study. Obviously, the use of medicines and presence of unknown or subclinical disease, which are common in elderly, could influence the dietary needs of this group.

Table 4
The correlation between DDS totally and diversity score in each food group with NAR of specific nutrients among elderly women (n = 292).

<table>
<thead>
<tr>
<th>Variable(s)</th>
<th>Diversity of grain &amp; bread</th>
<th>Diversity of vegetable group</th>
<th>Diversity of fruit group</th>
<th>Diversity of meat group</th>
<th>Diversity of dairy group</th>
<th>Total DDSa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B1</td>
<td>0.10</td>
<td>0.09</td>
<td>0.11</td>
<td>0.09</td>
<td>0.08</td>
<td>0.48**</td>
</tr>
<tr>
<td>Vitamin B2</td>
<td>0.16**</td>
<td>0.11</td>
<td>0.11</td>
<td>0.27**</td>
<td>0.66**</td>
<td>0.63**</td>
</tr>
<tr>
<td>Vitamin B3</td>
<td>0.12*</td>
<td>0.08</td>
<td>0.08</td>
<td>0.15**</td>
<td>0.09</td>
<td>0.46**</td>
</tr>
<tr>
<td>Folic acid</td>
<td>0.04</td>
<td>0.54**</td>
<td>0.19**</td>
<td>0.11</td>
<td>0.06</td>
<td>0.40**</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>0.08</td>
<td>0.05</td>
<td>0.09</td>
<td>0.24**</td>
<td>0.22**</td>
<td>0.28**</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0.09</td>
<td>0.36**</td>
<td>0.22**</td>
<td>0.18**</td>
<td>0.11</td>
<td>0.33**</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>-0.02</td>
<td>0.39**</td>
<td>0.49**</td>
<td>0.09</td>
<td>0.07</td>
<td>0.50**</td>
</tr>
<tr>
<td>Iron</td>
<td>0.08</td>
<td>0.11</td>
<td>0.10</td>
<td>0.20**</td>
<td>0.10</td>
<td>0.42**</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.09</td>
<td>0.11</td>
<td>0.11</td>
<td>0.39**</td>
<td>0.08</td>
<td>0.49**</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.08</td>
<td>0.09</td>
<td>0.06</td>
<td>0.09</td>
<td>0.73**</td>
<td>0.53**</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.10</td>
<td>0.44**</td>
<td>0.26**</td>
<td>0.16**</td>
<td>0.44**</td>
<td>0.52**</td>
</tr>
<tr>
<td>Protein</td>
<td>0.16**</td>
<td>0.08</td>
<td>0.10</td>
<td>0.38**</td>
<td>0.49**</td>
<td>0.60**</td>
</tr>
<tr>
<td>Energy</td>
<td>0.17**</td>
<td>0.11</td>
<td>0.12</td>
<td>0.32**</td>
<td>0.38**</td>
<td>0.55**</td>
</tr>
</tbody>
</table>

p < 0.05, **p < 0.01.

a Dietary diversity score.

Table 5
Unadjusted and adjusted correlation between diversity score of food groups and MAR among elderly women (n = 292).

<table>
<thead>
<tr>
<th>Model 1*</th>
<th>Model 2**</th>
<th>Model 3***</th>
</tr>
</thead>
<tbody>
<tr>
<td>R² = 0.47</td>
<td>R² = 0.79</td>
<td>R² = 0.001</td>
</tr>
<tr>
<td>β</td>
<td>P value</td>
<td>β</td>
</tr>
<tr>
<td>Diversity score of Grain &amp; bread</td>
<td>0.08(0.05)</td>
<td>0.078</td>
</tr>
<tr>
<td>Diversity score of vegetables</td>
<td>0.27(0.03)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diversity score of fruit</td>
<td>0.07(0.02)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diversity score of meat</td>
<td>0.09(0.03)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diversity score of dairy</td>
<td>0.17(0.02)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Unadjusted, **Adjusted for energy intake, ***Adjusted for energy and supplement intakes, economic status and chewing problem.

a Linear regression model.

b Standard coefficient.

Table 6
Area under the curve for diversity score of food groups among elderly women (n = 292).

<table>
<thead>
<tr>
<th>Variable(s)</th>
<th>Area</th>
<th>SEa</th>
<th>P value</th>
<th>95% CIb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals group score</td>
<td>0.48</td>
<td>0.04</td>
<td>0.66</td>
<td>0.40</td>
</tr>
<tr>
<td>Vegetables group score</td>
<td>0.72</td>
<td>0.03</td>
<td>0.000</td>
<td>0.65</td>
</tr>
<tr>
<td>Diary group score</td>
<td>0.76</td>
<td>0.03</td>
<td>0.000</td>
<td>0.69</td>
</tr>
<tr>
<td>Meats group score</td>
<td>0.64</td>
<td>0.04</td>
<td>0.001</td>
<td>0.56</td>
</tr>
<tr>
<td>Fruits group score</td>
<td>0.64</td>
<td>0.04</td>
<td>0.001</td>
<td>0.56</td>
</tr>
</tbody>
</table>

a Standard error.

b Confidence interval.
5. Conclusion

The findings of this study confirmed that Dietary Diversity Score is an appropriate indicator of the probability of nutrient adequacy in this group of elderly women.

Ethics statement

The protocol of this study was approved by the Ethics Committee of Tehran University of Medical Science (TUMS). All of the participants were given the informed written consent.

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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References


