Variance sources and ratios to estimate energy and nutrient intakes in a sample of adolescents from public schools, *Natal*, Brazil[1]

Fontes e razões de variância para estimar a ingestão de energia e nutrientes de uma amostra de adolescentes de escolas públicas

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ABSTRACT

Objective

The aim of this study was to describe the sources of dietary variance, and determine the variance ratios and the number of days needed for estimating the habitual diet of adolescents.

Methods

Two 24 hour food recalls were used for estimating the energy, macronutrient, fatty acid, fiber and cholesterol intakes of 366 adolescents attending Public Schools in *Natal*, *Rio Grande do Norte*, Brazil. The variance ratio between the intrapersonal and interpersonal variances, determined by Analysis of Variance, was calculated. The number of days needed for estimating the habitual intake of each nutrient was given by the hypothetical correlation (r)≥0.9 between the actual and observed nutrient intakes.

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Results

Sources of interpersonal variation were higher for all nutrients and in both genders. Variance ratios were <1 for all nutrients and higher in women. Two 24 hour dietary recalls were enough to assess energy, carbohydrate, fiber and saturated and monounsaturated fatty acid intakes accurately. However, the accurate assessment of protein, lipid, polyunsaturated fatty acid and cholesterol intakes required three 24 hour recalls.

Conclusion

Interpersonal dietary variance in adolescents was greater than intrapersonal variance for all nutrients, resulting in a variance ratio of less than 1. Two to three 24 hour recalls, depending on gender and the study nutrient, are necessary for estimating the habitual diet of this population.

Indexing terms: Adolescent. Energy intake. Food consumption. Nutrients.

RESUMO

Objetivo

O objetivo deste estudo foi descrever as fontes de variância da dieta, determinar as razões de variâncias e o número de dias necessários para estimar a dieta habitual em adolescentes.

Métodos

A ingestão de energia, macronutrientes, ácidos graxos, fibra e colesterol foram estimadas por meio de dois recordatórios de 24 horas, aplicados em 366 adolescentes de escolas públicas de Natal, Rio Grande do Norte. A razão de variância foi calculada entre o componente da variância intrapessoal e interpessoal, determinada pela Análise de Variância. A definição do número de dias para a estimativa da ingestão habitual de cada nutriente foi obtida considerando a correlação hipotética de (r)≥0,9, entre a verdadeira ingestão de nutrientes e a observada.

Resultados

As fontes de variância interpessoal foram maiores para todos os nutrientes e em ambos os sexos. As razões de variâncias foram <1 para todos os nutrientes, e mais elevadas no sexo feminino. Dois dias de recordatórios de 24 horas seriam suficientes para avaliar com precisão o consumo de energia, carboidratos, fibra, ácidos graxos saturados e monoinsaturados, exceto para proteínas, lipídeos, ácidos graxos poliinsaturados e o colesterol, que necessitariam de três dias.

Conclusão

A variância interpessoal da dieta dos adolescentes foi maior do que a intrapessoal, para todos os nutrientes, repercutindo em uma razão de variância menor que 1. Para estimar a dieta habitual nesta população, uma variação de dois a três dias é necessária considerando o sexo e o nutriente avaliado.

Termos de indexação: *Adolescente. Ingestão de energia. Consumo de alimentos. Nutrientes.*

INTRODUCTION

Data on food consumption and habitual diet are important in epidemiological studies not only because they allow estimating the energy and nutrient intakes of a population, but also because they demonstrate whether the consumed foods are associated with disease-related outcomes. Assessing habitual food intake is complex because it involves factors related to daily intake variability, information reliability and identification of under- or overreporting[1-3].

Food intake and variance estimates differ among populations, genders, age groups and cultures[4]. The number of 24 hour food Recalls (24hR) necessary for assessing habitual energy and nutrient intakes accurately remains controversial[5-8].

At least two nonconsecutive observation days has generally been suggested. Observation days must be planned considering seasons of the year and different days of the week. With these criteria, it is possible to estimate which intra- and interpersonal variations should be used for defining the number of consumption measures.

These measures of variance can therefore be used to conduct studies in similar populations[5,6]. Variance ratios can also be used in population studies where food intake was measured for a single day. In this case, statistical adjustments are recommended to eliminate the effect of intrapersonal variance[9].

Observed nutrient intakes vary significantly depending on age group[10,11], gender[12] and culture, as seen in Russian and American adolescents[7]. Adult period-to-period and day-to-day interpersonal variations contribute significantly to energy and macronutrient intake variations[2]. Brazilian studies that assess the number of 24hR needed for estimating the habitual intake of adolescents are scarce and have been done only in the country's southeast, in the cities of *Piracicaba* (*São Paulo*)[13] and *São Paulo* (*São Paulo*)[14]. The present study is different because it was done in the Northeast region where the sociocultural and socioeconomic indicators are differences. The aim of this investigation was to describe sources of data variance, and to calculate variance ratios and the number of days needed for estimating the habitual dietary intake of adolescents from the city of *Natal, Rio Grande do Norte*, Brazil.

METHODS

A cross-sectional study was conducted with 432 adolescents aged 10 to 19 years, attending municipal schools between April 2007 and November 2008, in *Natal*, Northeast Brazil. The investigation was approved by the Research Ethics Committee of the *Universidade Federal do Rio Grande do Norte* (URFN), under protocol n° 112/06. All participants provided written Informed Consent prior their inclusion in the study.

Study design, calculation of sample size, sampling and field logistics for data collection have been described elsewhere[15]. A pilot study was done to estimate the prevalence of dyslipidemia and determine sample size. The statistical parameters included an estimated limit of error of 4% and a sample loss of 30%.

The sample size (483) was defined by stratified sampling with Neyman allocation as follows: n_{North}=285 n_{South}=63 n_{East}=34 n_{West}=101, and the number of schools (21) was given by the mean number of students per school by proportional allocation: n_{North}=9 n_{South}=3 n_{East}=3 n_{West}=6.

Food intake

Each participant answered two specific 24 hour dietary recalls[16] at an interval of 30 to 45 days, according to the following criteria: (1) on different days excluding Mondays to avoid recording atypical data; (2) at different times of the month, considering the purchasing power of the families; and (3) at different times of the year due to seasonal foods.

Food intake data were collected by a team trained as recommended by Thompson & Byers[17]. Interviews were done at the schools.

Food intakes were recorded in cooking units aided by photographs of common foods and two manuals created by the researchers, namely the Household Utensil Measures Manual and the Food Portions Manual.

Despite the limitations associated with administering the 24hR to 10-year-olds, the information collected by each 24hR was double checked to assess interview quality and standardize food portions and recipes. Cooking units and food units were converted to grams, as recommended by the literature[18,19]. Regional and other unusual preparations were made at the Food Technique Laboratory, Department of Nutrition, UFRN.

The energy, macronutrient, Monounsaturated Fatty Acid (MUFA), Polyunsaturated Fatty Acid (PUFA), Saturated Fatty Acid (SFA), fiber and cholesterol contents of the diets were determined by the software Virtual Nutri 2.0 plus[20]. Databanks of food preparations were updated with the inclusion of preparations and the nutritional composition of certain foods. The Food

Composition Table[21] and United States Department of Agriculture (USDA)[22] databases were selected because of their more comprehensive and updated nutrition information, including that of regional foods. Nutrition information taken from processed food labels was also used. Participants with an energy intake greater than 5,000kcal or smaller than 500kcal were excluded[4].

Data analysis

The study databank included the energy, carbohydrate, protein, lipid, MUFA, PUFA, SFA, fiber and cholesterol intake information stored in the Virtual Nutri 2.0 plus software[20]. The software Statistical Package for the Social Sciences (SPSS) 17.0 was used for the statistical analyses. Descriptive analysis (mean and standard deviation) and the skewness-kurtosis test for normality were also used.

Variance components were given by one-way Analysis of Variance (Anova). The Variance Ratio (VR) as calculated by the following formula: $VR=s_w2/s_b2$, where s_w2 is the intrapersonal variance (day-to-day food intake variation of the same individual) and s_b2 is the interpersonal variance (day-to-day food intake variation between two individuals). The equation proposed by Nelson *et al*.[23] was used for estimating correlation coefficient accuracy.

Table 1. Mean and standard deviation of energy and nutrient intakes determined by two 24-hour recalls of adolescents from public schools, according to gender. *Natal* (RN), Brazil, 2007-2008.

Nutrients		Mean	SD	Minimum	Maximum
Energy (Kcal)	Total	1911.4	745.6	505.6	5000.0
	M	1969.7	755.0	523.6	5000.0
	F	1852.4	732.3	505.7	4888.6
Carbohydrates (g)	Total	264.4	111.4	55.3	753.9
	M	272.1	112.1	55.3	753.9
	F	256.7	110.2	57.8	699.4
Lipids (g)	Total	62.9	30.9	9.4	249.6
	M	64.7	32.9	9.4	217.0
	F	61.2	28.8	10.5	249.6
Proteins (g)	Total	72.0	35.0	12.7	315.2
	M	75.9	36.8	20.0	315.1
	F	68.1	32.8	12.7	200.5
PUFA (g)	Total	14.2	7.9	1.1	74.4
	M	14.7	8.1	1.1	53.5
	F	13.7	7.6	1.2	74.4
MUFA(g)	Total	18.7	10.0	1.9	89.6
	M	19.5	10.5	1.9	76.0
	F	17.9	9.5	3.2	89.6
SFA (g)	Total	20.5	11.0	2.5	74.1
	M	21.0	11.6	3.6	74.1
	F	20.0	10.4	2.5	68.8
Fiber (g)	Total	20.6	12.9	1.9	90.5
	M	21.9	13.8	2.0	90.5
	F	19.2	12.0	2.8	77.6
Cholesterol (g)	Total	262.5	204.6	1.0	1355.1
	M	279.3	220.9	1.0	1355.1
	F	245.6	185.4	9.8	1131.9

Note: SD: Standard Deviation of the mean; M: Male; F: Female; PUFA: Polyunsaturated Fatty Acids; MUFA: Monounsaturated Fatty Acids; SFA: Saturated Fatty Acids.

The number of days needed for estimating habitual nutrient intake was based on the hypothetical correlation (r)≥0.9 between the actual and observed nutrient intake, given by the formula proposed by Black *et al*.[9]:

$$D = \frac{r^2}{1 - r^2} \times \frac{S^2_w}{S^2_b}$$

D is influenced by intrapersonal and interpersonal variance ratios. If the intrapersonal variance observed during the day is smaller than its interpersonal counterpart, a smaller number of repeated measures will be needed. *D* also depends on the selected *r*. Thus, depending on *r*, the number of study days will be higher or lower.

RESULTS

Of the sample of adolescents (n=432), 83% (n=184) of the boys and 87% (n=182) of the girls answered the second 24hR. Boys presented higher mean energy and nutrient intakes but the difference was not significant (Table 1).

Considering all the nutrients, interpersonal sources of variance were greater than intrapersonal sources for both genders. Variance Ratios (VR) were less than one for all the nutrients and higher in the girls (Table 2).

The findings show an "r" close to the hypothetical correlation (r)≥0.9 for actual and

Table 2. Intrapersonal and interpersonal variations and variance ratio of adolescents from public schools, according to gender, *Natal* (RN), Brazil, 2007-2008.

Nutrients		Sources of variance		VR
		Intrapersonal	Interpersonal	
Energy (Kcal)	Total	383593.8	728799.3	0.53
	M	376053.3	763097.3	0.49
	F	391313.9	682009.9	0.57
Carbohydrates (g)	Total	8410.9	16419.0	0.51
	M	7951.4	17175.1	0.46
	F	8882.9	15447.2	0.58
Lipids (g)	Total	757.9	1159.9	0.65
	M	820.0	1340.7	0.61
	F	697.5	965.9	0.72
Proteins (g)	Total	949.8	1504.8	0.63
	M	989.1	1712.5	0.58
	F	912.6	1233.6	0.74
PUFA (g)	Total	54.1	69.3	0.78
	M	56.6	74.9	0.76
	F	51.8	62.4	0.83
MUFA (g)	Total	78.7	122.3	0.64
	M	78.4	141.3	0.55
	F	79.1	100.7	0.79
SFA (g)	Total	90.7	151.7	0.60
	M	94.8	172.5	0.55
	F	86.7	130.0	0.67
Fiber (g)	Total	115.7	221.7	0.52
	M	124.5	254.7	0.49
	F	107.3	180.9	0.59
Cholesterol (g)	Total	35637.1	48080.9	0.74
	M	41495.0	56054.1	0.74
	F	29921.2	38849.5	0.77

Note: VR: Variance Ratio; M: Male; F: Female; PUFA: Polyunsaturated Fatty Acids; MUFA: Monounsaturated Fatty Acids; SFA: Saturated Fatty Acids.

Table 3. Correlation coefficients and number of days necessary for estimating the habitual energy and nutrient intakes of adolescents from public schools, according to gender, *Natal* (RN), Brazil, 2007-2008.

Nutrients		*r**	Days**
Energy (Kcal)	Total	0.89	2.26
	M	0.89	2.10
	F	0.88	2.43
Carbohydrates (g)	Total	0.89	2.17
	M	0.90	1.96
	F	0.88	2.47
Lipids (g)	Total	0.87	2.77
	M	0.88	2.60
	F	0.86	3.07
Protein (g)	Total	0.87	2.69
	M	0.88	2.47
	F	0.85	3.15
PUFA (g)	Total	0.85	3.33
	M	0.85	3.24
	F	0.84	3.54
MUFA(g)	Total	0.87	2.73
	M	0.89	2.34
	F	0.85	3.37
SFA (g)	Total	0.88	2.56
	M	0.89	2.34
	F	0.87	2.86
Fiber (g)	Total	0.89	2.22
	M	0.90	2.09
	F	0.88	2.51
Cholesterol (g)	Total	0.85	3.15
	M	0.85	3.15
	F	0.85	3.28

Note: *Considering days=2; **considering *r*=0.9.
M: Male; F: Female; PUFA: Polyunsaturated Fatty Acids; MUFA: Monounsaturated Fatty Acids; SFA: Saturated Fatty Acids.

observed nutrient intakes. The number of 24hR necessary for determining habitual diet and assessing energy and nutrient intakes varied from two to three. Gender affected this finding significantly (Table 3).

DISCUSSION

The interpersonal variance found by the present study was the greatest source of nutrient intake variance, resulting in a VR of less than 1 and corroborating the findings of Laningan *et al*.[1] in children and Herbert *et al*.[24] in adults. The lack of variation in habitual dietary intake can be attributed to the low purchasing power and low education levels of the study population. Studies on food intake and dietary patterns done in other regions of Brazil found a VR greater than 1, stemming from higher intrapersonal variance[13,14]. This demonstrates that the daily food intake of an individual is a random event, even though a particular group displays a stable food intake pattern[24].

The variance ratios of the study sample were lower than those observed in Brazilian adolescents from the cities of *São Paulo*[14] and *Piracicaba*[13]. VR was higher in women, whose pattern was identical to that observed in female adolescents in Russia[7], but different from the VR found by other studies[7,14]. The best correlations between food consumption and outcome are observed in studies where VR is less than 1. These results are important for creating study designs that use dietary variable correlations as indicators of health and disease[7,23]. Moreover, the findings of the present study, obtained by appropriate statistical methods[25-27], may be useful for using VR to correct nutrient intake distribution based only on one 24hR per individual. The use of VR given by population studies with similar characteristics is an alternative to administering several individual 24hR to estimate habitual diet.

The number of days required for estimating the habitual diet of adolescents as a function of VR varied from two to three, being higher for females, except for energy intake. In both genders, carbohydrates and fibers require fewer study days. Among fatty acids, PUFA requires the highest number of study days and SFA the fewest. Hoffmann *et al.*[5] suggested that only two repeated measures of consumption would be necessary for estimating habitual intake, provided that data collection encompasses all seasons and days of the week.

This study did not assess the effect of month or day of the week. However, these variables have little influence on the estimation of the number of days required for determining

habitual diet. This suggests that day-to-day nutrient intake is random. Therefore, no specific month or day of the week can be recommended[14]. Furthermore, the contribution of macronutrient and total energy intakes during different seasons does not provide additional information[28].

Accurate assessment of food consumption poses a challenge, mainly due to dietary complexity, whose matrix has widely varying components and external factors. For these reasons, it is difficult to assess food intake without incurring into random and systematic errors, since they are inherent to individuals and the method used[4,21,29].

In this study, the rigorous methodological approach used for data collection, food intake analysis and databank updating confirms the reliability of the results. When food consumption protocols are monitored more closely, especially during data collection, greater accuracy is achieved and fewer days are necessary for estimating the habitual intake of individuals and populations[2].

In conclusion, interpersonal variation was greater than intrapersonal variation for all nutrients, resulting in a variance ratio of less than 1. The number of 24hR needed for determining the habitual diet of adolescents varied from 2 to 3, depending on nutrient and gender. Estimates of variance ratios found by the present study may be of use in other investigations with adolescents with similar socioeconomic and cultural characteristics.

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COLLABORATORS

LFC PEDROSA and SCVC LIMA were responsible for conceiving the study, collecting, analyzing and interpreting data and reviewing the manuscript. CO LYRA, LGB PINHEIRO and CMM MORAIS participated in data collection, analysis and interpretation, and in the review of the final manuscript. KCM SENA-EVANGELISTA and B SLATER participated in data analysis and manuscript review.

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