Within-person variance of the energy and nutrient intake in adolescents: data adjustment in epidemiological studies

Variância intrapessoal da ingestão de energia e nutrientes em adolescentes: correção de dados em estudos epidemiológicos

Abstract

Objective: The aim of this paper is to calculate within-person variance component of the energy and nutrient intake that can be useful to adjust intake distribution from adolescents when is available only a single 24-hour recall for each participant. It will also give an example of its use in the intake distribution adjustment in adolescents from another sample. **Methods:** It was used 24 hour recall from 215 adolescents living in São Paulo, Brazil. The variance components were estimated using the Software for Intake Distribution Estimation (PC-SIDE). It was made a model for each nutrient and sex of which were included covariates for day and month of intake and weight variable as well. **Results:** The within-person variance component ranged from 0.55 for mono saturated fat (female) up to 0.96 for folate (male). I was found higher values regarding to macronutrient and energy for males. In the example of the use of the variance component, it was estimated the distribution of intake of vitamin B6 with less bias, when compared to the distribution with no adjustment. **Conclusion:** These results can be used to estimate habitual energy and nutrient intake for adolescent population when it is only a single dietary measurement.

Keywords: Nutrients. Adolescents. Diet surveys. Nutrition assessment. Energy consumption. Methods.

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Resumo

Objetivo: Este artigo objetiva fornecer valores de componentes de variância intrapessoal da ingestão de energia e nutrientes que possibilita estimar a ingestão habitual em adolescentes, em inquéritos dietéticos quando há disponível somente um recordatório de 24 horas para cada indivíduo. Também será fornecido um exemplo de sua aplicação na correção da distribuição da ingestão de nutrientes proveniente de adolescentes de outro estudo. **Métodos:** Foram utilizados recordatórios de 24 horas de 215 adolescentes do município de São Paulo. Os componentes de variância foram estimados utilizando o *Software for Intake Distribution Estimation* (PC-SIDE). Para cada nutriente foi construído um modelo, estratificado por sexo, que inclui o dia e o mês da coleta, e variáveis de ponderação. **Resultados:** Os componentes de variância intrapessoal variaram de 0,55 para gordura mono-saturada (sexo feminino) a 0,96 para o folato (sexo masculino). Entre os macronutrientes e energia foram observados valores mais elevados para o sexo masculino. No exemplo da aplicação do componente de variância, foi estimada a distribuição da ingestão de vitamina B6 com menos viés comparada à distribuição sem a correção. **Conclusão:** Estes dados podem ser utilizados na estimativa da ingestão habitual de energia e nutrientes e cálculo da prevalência de inadequação em adolescentes de populações semelhantes, quando há disponível somente um recordatório de 24 horas para cada indivíduo do estudo.

Palavras-chave: Nutrientes. Adolescente. Inquérito sobre dietas. Avaliação nutricional. Consumo de energia. Métodos.

Introduction

Studies on the prevalence of inadequate nutrient intake are informative for public health, providing useful data for nutrition diagnosis and for the establishment and monitoring of public policies in nutrition[1].

The use of dietary surveys such as the 24-hour dietary recalls (24hR) and food records are recommended to collect the data on nutrient intake required to calculate inadequate intake. This is because these surveys identify food consumption with more details about servings and forms of preparation of such foods[1]. However, when applied to one or few days, these instruments fail to identify the daily variations in consumption. Consequently, the intake distribution becomes flatter and wider, having a direct effect on the analysis and interpretation of results. One example is the under- or over-estimation of the proportion of individuals below or above a given criterion of adequacy[2]. The effect of daily variation is reduced with the increase in the number of 24hR applied to each individual in the study population[3]. However, in epidemiological studies, collecting multiple 24hR is not usually possible, because of the costs and individuals' availability to report their consumption in detail on several occasions.

One alternative is the use of statistical methods to correct data according to within-person variability in consumption[4]. Ideally, this adjustment is made when there is at least one repetition of the dietary survey in at least one representative sub-sample of the study population. When only one 24hR is applied to each participant, the adjustment of intake distribution is possible with the use of external within-person variance, provided that it is obtained from a similar population. This strategy is recommended[5,6] and it has been used in the adjustment of nutrient intake distribution among adolescents of the city of São Paulo[7].

Currently, within-person variance components for the adjustment of energy and nutrient intake distribution obtained from Brazilian studies are restricted to the adult

and elderly population exclusively[8]. The present study aimed: 1) to make available within-person variance components to correct the nutrient intake distribution among adolescents; and 2) to provide an example of its application in the adjustment of nutrient intake distribution in adolescents from another study.

Methods

Study population

Data from the *Inquérito de Saúde de São Paulo* (ISA-Capital – City of São Paulo Health Survey) were used to estimate within-person variance in nutrient intake. This is a population-based cross-sectional study which is routinely conducted in the city of São Paulo. A complex, stratified, cluster sampling process was used and its details were obtained from another publication[9]. In the 2003 ISA-Capital, a total of 813 adolescents were interviewed. They were subsequently invited to participate in the present study, in 2007. Of all participants, 314 remained in the 14-to-18-year age group; of these, 3% (n = 9) refused to participate, 15% (n = 46) changed their address and could not be located, and 14% (n = 44) could not be found at home, even after three visits made at different times and on different weekdays. This age group is in agreement with what is proposed by the Institute of Medicine as one of the stages of adolescence for which nutrient intake recommendations have been established. The final sample was comprised of 215 adolescents, of which 112 were males and 103 were females.

A sample of male adolescents, who participated in the ISA collected between 2008 and 2009 and who responded to two 24hR (n = 102), was used in the adjustment of nutrient intake distribution to illustrate the effect of application of within-person variance components, obtained from the present study. The 2008 ISA complex sampling process was similar to that of the 2003 ISA and its details can be found in another publication[10].

Data collection

Interviews were conducted in the homes of the participants by previously trained interviewers, between 2007 and 2008. Food consumption was collected with the 24hR, using the multiple-pass method[11]. All adolescents (n = 215) were invited to respond to a new 24hR, after an interval of nearly two months, so that the within-person variance in consumption could be calculated. This collection was conducted by telephone and the response rate was 65% (n = 73) and 70% (n = 73) for males and females, respectively. Both collections (at home and by telephone) were performed in a way that covered all weekdays and months of the year. Before data on food consumption were input, the information contained in each of the collections was checked, aiming to monitor the quality of the interviews and to define a standard for the amounts of foods and recipes of preparations reported.

Data analysis

The reported consumption was converted into values of energy and nutrients using the Nutrition Data System for Research software (NDS, 2007 version, Nutrition Coordinating Center, University of Minnesota, Minneapolis, USA). Mandatory fortification of wheat and corn flours, effective in Brazil since 2004, was considered for iron and folic acid.

Within-person variance components of the distribution of intake of energy and macro- and micro-nutrients were calculated with the method developed by the Iowa State University (ISU)[3], using the Intake Distribution Estimation software (PC-SIDE, version 1.0, 2003; Department of Statistics, Iowa State University, Ames). This method is basically comprised of the following procedures: preliminary adjustments for weekday and season of the year and incorporation of sampling weights; transformation to normality using power transformation; and estimation of within- and between-person

variance using an error measurement model.

A model was developed for each nutrient, in which the collection day and month and weighting variables (primary sampling unit, stratum and sampling weight) were included. Data were analyzed separately by sex. Descriptive measures of consumption (mean, standard deviation, standard error and percentiles) and within- and between-person variance components were generated for each nutrient. Another parameter required in the adjustment of dietary data, the fourth moment, a measure that refers to the flatness of distribution (kurtosis), was also calculated.

Application of variance components

Using the ISU method, the distribution of B6 vitamin intake, exclusively based on the first 24hR responded by each adolescent, was corrected with the within-person variance component and the fourth moment of distribution obtained in the present study, regarding the male sex. Distributions were estimated in two different ways to verify the effect of adjustment: using only the first 24hR for each adolescent without any adjustments; and using the within-person variance component obtained by repeating the collection in the sample itself. A frequency density graph was constructed and the mean, standard deviation, percentiles of consumption and prevalence of inadequate intake, i.e. the proportion of individuals with an intake lower than the estimated mean requirements, were calculated for each distribution[1].

Results

A total of 16% of adolescents were overweight, 67% drank alcohol, 11% smoked and 87% belonged to households whose head had completed up to eight years of school. There were no differences between sexes for these variables. Table 1 shows the within-person variance components and the fourth moment of energy and nutrient intake distribution in males and females.

Table 2 shows the mean, standard deviation, percentiles of consumption and prevalence of inadequate vitamin B6 intake in the sample of male adolescents, calculated from the distribution without adjustment, adjusted by the within-person variance (calculated from the sample) and by the external variance. The effect of the adjustment with external variance is notable, when compared to the distribution corrected with the within-person variance itself. Standard deviations and percentiles of consumption were similar, as were the prevalences of inadequate intake estimated, 6% and 10% respectively; both substantially lower than the level of inadequacy found when only one 24hR was used (30%). The estimated distributions are shown in Figure 1.

Discussion

The present study revealed components of within-person variance in energy and nutrient intake obtained from a sample of adolescents in the city of São Paulo. These data can be used to estimate the usual energy and nutrient intake in a similar population, when there is only one 24hR available for each study participant.

The effect of adjustment with within--person variability in consumption is notable, as shown in Figure 1 and well described in the literature[4]. Using external variance, a percentage of adolescents with a level of consumption lower than the recommendations could be obtained, comparable to that obtained when corrected with the within--person variability of the sample itself. Both totaled approximately 1/3 of this percentage when only one 24hR was used. A sample of adolescents similar to that used to calculate within-person variance components was used in the example. Theoretically, its use in a sample with distinct characteristics (for example, adolescents from other cities) could lead to bias in the results. This question was discussed in the study conducted by Jahns et al. (2005)[5], who compared the prevalence of inadequate vitamin C intake in a sample of North-American individuals

Table 1 – Within-person component variance and forth moment of the energy and nutrient intake distribution in adolescents. São Paulo, 2007-2008.
Tabela 1 *– Componentes de variância intrapessoal e quarto momento da distribuição da ingestão de energia e nutrientes entre adolescentes. São Paulo, 2007-2008.*

	Males		Females	
	Within-person variance component	Fourth moment	Within-person variance component	Fourth moment
Energy	0.7846	3.67	0.5533	3.61
Carbohydrates	0.7483	4.48	0.6061	3.19
Total fat	0.8294	2.59	0.6058	3.21
Saturated fat	0.8159	2.68	0.5841	3.35
Monounsaturated fat	0.8244	2.06	0.5427	4.19
Polyunsaturated fat	0.9145	3.00	0.7157	3.13
Trans fat	0.8701	3.39	0.7446	3.41
Protein	0.5581	2.78	0.7559	3.71
Vitamin A	0.7402	2.34	0.6045	5.70
Vitamin D	0.5583	2.86	0.5976	3.03
Vitamin E	0.8372	3.40	0.5360	3.60
Vitamin K	0.6654	2.46	0.6244	2.75
Vitamin C	0.8045	2.46	0.7101	2.82
Thiamin	0.7886	2.61	0.6224	3.04
Riboflavin	0.7325	3.24	0.6792	3.05
Vitamin B6	0.7338	2.89	0.5725	2.36
Vitamin B12	0.5921	3.17	0.7185	2.45
Calcium	0.6208	3.34	0.6545	4.24
Phosphorus	0.6479	2.84	0.7470	3.91
Magnesium	0.7052	2.81	0.5097	1.94
Iron	0.7412	2.76	0.6912	2.62
Zinc	0.6353	3.27	0.7023	2.65
Manganese	0.9168	3.15	0.7532	2.38
Copper	0.6549	3.75	0.6683	4.64
Selenium	0.8117	3.70	0.7283	3.23
Sodium	0.7046	4.22	0.6632	3.04
Potassium	0.8067	2.31	0.7428	4.21
Folic acid	0.9681	2.97	0.7736	3.77
Niacin	0.6482	3.03	0.7809	3.40
Cholesterol	0.7347	3.33	0.7762	2.83
Fiber	0.6190	2.97	0.6263	2.63
Pantothenic acid	0.6232	3.71	0.6954	3.23
Linoleic acid	0.9316	2.37	0.7324	3.24
Linolenic acid	0.9003	2.48	0.5588	3.87

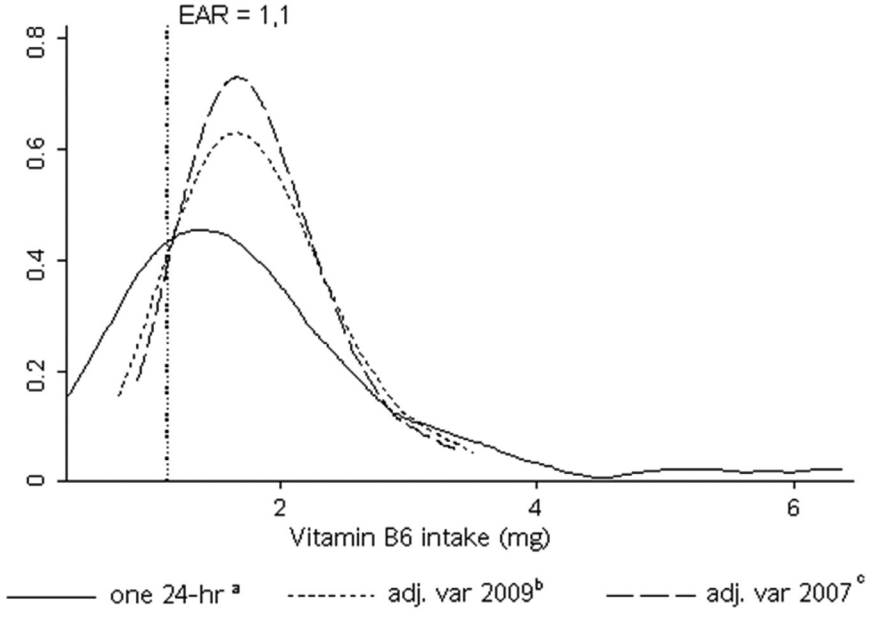
using variance components from two studies, one American and the other Russian. The authors concluded that the use of external variance should be recommended, even when it is not the same population, as the worst case scenario is the distribution being obtained from only one 24hR.

Data adjustment with external variance components includes a series of statistical procedures, rendering it impractical without the support of the PC-SIDE software. This software is not free of charge. However, the World Health Organization (WHO) is developing a public domain software based on

Table 2 – Mean, standard deviation, percentiles of intake and prevalence of inadequate intake of vitamin B6 among male adolescents. São Paulo, 2008-2009.
Tabela 2 – *Média, desvio padrão (dp), percentis de consumo e prevalência de inadequação da ingestão de vitamina B6 entre adolescentes do sexo masculino. São Paulo, 2008-2009.*

	Mean (sd)	Percentiles of intake					inad (%)[d]
		10	25	50	75	90	
Without adjustment[a]	1.80 (1.09)	0.76	1.06	1.56	2.13	2.96	30
2009 Var. corr.[b]	1.79 (0.59)	1.10	1.37	1.73	2.15	2.59	10
2007 Var. corr.[c]	1.80 (0.52)	1.19	1.42	1.73	2.10	2.50	[6]

[a] based on only a single 24-hour recall for each participant;
[b] distribution adjusted for the within-person variance from the replicate of the 24-hour recall in the same sample;
[c] distribution based on only a single 24-hour recall but adjusted for the external within-person variance;
[d] prevalence of inadequate nutrient intake.
[a] utilizando-se apenas o primeiro recordatório de 24 horas para cada participante;
[b] distribuição corrigida pela variância intrapessoal obtida da repetição do inquérito na própria amostra;
[c] distribuição utilizando primeiro recordatório de 24 horas para cada participante, corrigida pela variância externa;
[d] prevalência de inadequação da ingestão.



[a] utilizando-se apenas o primeiro recordatório de 24 horas para cada participante;
[b] distribuição corrigida pela variância intrapessoal obtida da repetição do inquérito na própria amostra;
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[a] based on only a single 24-hour recall for each participant;
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Figure 1 – Distribution of intake of vitamin B6 among male adolescents. São Paulo, 2008-2009.
Figura 1 – *Distribuição da ingestão de vitamina B6 entre adolescentes do sexo masculino. São Paulo, 2008-2009.*

the same methodology. Among other purposes, it enables the adjustment of nutrient intake distribution using external variance components. The development of this software is part of the WHO Intake, Monitoring, Assessment and Planning Program (IMAPP),

Available at: http://www.who.int/entity/nutrition/publications/micronutrients/9789241599603.pdf

whose detailed document is available on the Internet*.

The within-person variance component represents the percentage of total variance explained by the daily variation in all individuals of a certain population. The higher the value, the greater the variation in the amount of a nutrient consumed between one day and the next. This component has been described as the main source of variation in nutrient intake[9] and it varies according to the population, age group and sex studied.

The difference between sexes is clearer with regard to energy and macronutrients. Among males, high within-person variance components were observed for energy, carbohydrates and lipids, whereas those for proteins were low. Among females, the opposite was found: lower values for energy, carbohydrates and lipids and higher values for protein. This suggests that the energy intake is more stable among girls, while it shows greater variation between one day and the next among boys.

The ISU method and other methods available generate percentiles of habitual intake distribution for groups of individuals, rather than habitual intake values for each individual in the sample. This restricts the forms of analyses that associate the habitual intake estimated with multiple covariables. Tests of mean differences and proportion can be calculated by estimating a distribution for each category of the group expected to be compared. As an example, one could test whether men and women differ statistically in terms of their intake of a certain nutrient. First of all, the habitual intake for each sex is estimated. The t-test is then calculated using mean values and standard deviation estimated for each group.

The sample used in the present study was based on a representative sample of the population of adolescents of the city of São Paulo. However, due to the great number of individuals who became adults between the time of the random selection of the initial sample in 2003 and the return to their homes for a new data collection in 2007, this sample may have lost its representativeness. Nonetheless, of all 59 census tracts used in the initial sample, 53 remained in it, thus representing the several regions of the city of São Paulo in the same way. Additionally, there were no statistical differences between the strata (according to the percentage of heads of household with higher education) obtained from the 2003 and 2007 samples.

In conclusion, within-person variance components can be used in populations similar to the study sample to estimate habitual nutrient and energy intake, when only one 24hR is available for each study participant.

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