Original Article

Validation study of a self-administered diet history questionnaire for estimating amino acid intake among Japanese adults

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Background and Objectives: Despite growing interest in the association between dietary amino acid intake and optimal health, validated dietary questionnaires that can estimate amino acid intake have been scarce. We examined the validity of amino acid intakes estimated using a self-administered diet history questionnaire (DHQ) comparing with 16-day semi-weighed dietary records (DR). **Methods and Study Design:** A total of 184 Japanese men and women completed a four-day DR and a DHQ four times, once in each season. Dietary amino acid intakes were estimated as crude, energy-adjusted, and percentage of total protein intake (% protein) using an amino acid database of Japanese foods. The validity of dietary amino acid intake estimated by the first-time DHQ was examined using the mean of 16 days' DRs as reference. **Results:** Mean intakes of almost all amino acids estimated by DHQ were significantly lower than those estimated by the DR for energy-adjusted values in both sexes. Although mean amino acid intakes estimated by DHQ were significantly higher than those estimated by the DR for % protein value, the differences between the DR and DHQ were slight (-0.04 to 0.39% protein for men, -0.05 to 0.37% protein for women). Pearson correlation coefficients between DHQ and the DR showed reasonable ranking ability in % protein values for men (interquartile range (Q1–Q3): 0.31-0.47) and energy-adjusted values for women (interquartile range (Q1–Q3): 0.40-0.45). **Conclusion:** DHQ showed acceptable ability to estimate mean amino acid intake and to rank individuals in a population according to their amino acid intake for using in large-scale epidemiological studies.

Key Words: diet history questionnaire, amino acid, dietary intake, validation study, Japanese

INTRODUCTION

Amino acids play important roles as the constituents of protein, co-enzymes, and hormones, and as the precursors of neurotransmitters in humans. Amino acids are classified as indispensable (essential) amino acids or dispensable (non-essential) amino acids in accordance with their availability for protein synthesis. Indispensable amino acids cannot be synthesized in the human body, and must be supplied from the diet.

Since indispensable amino acids must be supplied from the usual diet, inadequate dietary intake has been considered problematic to health. Previous epidemiological studies have attempted to examine the relationship be-

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tween habitual dietary amino acid intake and health outcomes;[1–9] however, these studies remain scarce. This is partly due to the lack of a comprehensive amino acid database and validated dietary questionnaires able to estimate amino acid intake. To conduct large-scale epidemiological studies with lower cost and respondent burden, dietary questionnaires are indispensable.

Sasaki et al developed a comprehensive self-administered diet history questionnaire (DHQ) to assess the Japanese diet which has already has been used in many epidemiological studies.[10-12] Although the DHQ can estimate the dietary intake of energy and 42 selected nutrients,[11] the intake of amino acids has not been evaluable due to the lack of amino acid composition data of Japanese foods. In a previous study, we developed a comprehensive amino acid composition table for Japanese foods,[13] which enabled the DHQ to estimate habitual amino acid intake.

The aim of this study was to examine the validity of the DHQ for estimating amino acid intake among healthy Japanese adults using a 16-day semi-weighed dietary record (DR) as a reference method.

MATERIALS AND METHODS

Participants

This study was based on a multicenter survey conducted in three areas of Japan, Osaka (urban), Nagano (rural inland), and Tottori (rural coastal) from November 2002 to September 2003.[11,12,14,15] These three areas were selected in consideration of potential regional differences in food availability and dietary habits, and availability of participants.[12] In each area, apparently healthy women aged 30 to 69 years who lived with their husbands were invited. In each 10-year age class (30–39, 40–49, 50–59, and 60–69 years), eight women were equally enrolled without consideration to the age of their husbands. Thus, a total of 96 women and 96 men were invited. Information sessions for the participants were held before the study at which the study purpose and protocol were explained. We excluded eight subjects (four women and four men) who did not complete the study protocol. Finally, 92 men (30 from Osaka, 31 from Nagano, and 31 from Tottori) aged 32 to 76 years and 92 women (30 from Osaka, 31 from Nagano, and 31 from Tottori) aged 31 to 69 years were included in the final analysis sample.

This study did not undergo ethical approval because it was conducted before ethical guidelines for epidemiologic research were mandated in Japan. However, it was conducted according to the guidelines laid down in the Declaration of Helsinki, and use of data from the study was approved by the Research Ethics Committee of the University of Tokyo Faculty of Medicine (No. 3421). Written informed consent was obtained from all participants.

Structure of the DHQ

The DHQ is a 16-page structured self-administered questionnaire that asks about the consumption frequency and portion size of 150 selected food and beverage items to estimate the dietary food and nutrient intake during the preceding month.[11,12,14] It consists of seven sections: (1) general dietary behavior; (2) usual cooking methods; (3) consumption frequency and amount of alcoholic beverages; (4) consumption frequency and semi-quantitative portion size of selected food and non-alcoholic beverage items; (5) dietary supplements; (6) consumption frequency and semi-quantitative portion size of staple foods (rice, other grains, noodles, bread and other grain products), soup for noodles, and miso (fermented soybean paste) soup, with questions on the size of cups (bowls) usually used for rice and miso soup; and (7) open-ended items for foods consumed regularly (≥ once/week) but not appearing in the DHQ.[11] The food and beverage items were selected as foods commonly consumed in Japan. Standard portion sizes and sizes of bowls for rice and cups for miso soup were derived from several recipe books for Japanese dishes.

Dietary assessments

Participants completed a 4-nonconsecutive-day semi-weighed DR four times, once in each season, at intervals of approximately three months: DR1 in November or December 2002 (autumn), DR2 in February 2003 (winter), DR3 in May 2003 (spring), and DR4 in August or September 2003 (summer).[11,12] One weekend day and three weekdays were included in each set of four recording days. During the information session, registered dietitians provided the participants written and verbal instructions on how to record the DR, recording sheets, and a digital scale, and asked them to record and weigh all foods and beverages consumed on each recording day. The weight of foods and beverages consumed was documented as the weight of the edible portion. For standardization of the survey method, all collaborators (registered dietitians) were trained in how to check the collected DR before starting the survey. All collected records were checked by trained dietitians at the respective local center and then again at the study center. Intakes of energy and protein were estimated based on the Standard Tables of Food Composition in Japan 2010,[16] and those of 18 amino acids (isoleucine, leucine, lysine, methionine, cysteine, phenylalanine, tyrosine, threonine, tryptophan, valine, histidine, arginine, alanine, aspartic acid, glutamic acid, glycine, proline, and serine) were estimated based on an amino acid database developed by Suga et al.[13]

The participants were also asked to answer the DHQ four times, once in each season: DHQ1 in November or December 2002 (autumn), DHQ2 in February 2003 (winter), DHQ3 in May 2003 (spring), and DHQ4 in August or September 2003 (summer).[11,12] The DHQ was administered approximately two days before the start of each dietary recording period to avoid the influence of the memory of recording the DR. Intakes of energy, protein, and 18 amino acids were estimated based on the intake of food items obtained from the DHQ, the Standard Tables of Food Composition in Japan 2010,[16] and the amino acid database developed by Suga et al.[13] Information on dietary supplements and data from the open-ended questionnaire items in the DHQ were not used in the calculation of dietary intake because no reliable database of dietary supplements was available and few participants reported food intake using the open-ended questionnaire.

Statistical analysis

The validity of amino acid intake values derived from the DHQ were examined using the average value of the 16-day DR as a reference. In this validation study, we used mean amino acid intake values and Pearson correlation coefficients to examine the DHQ's ability to estimate a group's mean amino acid intake and to rank individuals according to their amino acid intake, respectively. In addition, agreement for amino acid intakes between the DR and the DHQ at the individual level was examined using intraclass correlation coefficients (ICC) and Bland-Altman plots.[17,18] We plotted the amino acid intake differences between the DR and the DHQ against mean values of the DR and DHQ. The limits of agreement were set as 1.96 times the standard deviation (SD) of the difference.

Many epidemiological studies administer dietary assessment questionnaires only once. To assess the validity of the use of the DHQ, which asks dietary intake during the preceding month, we used the estimated dietary intake value from DHQ1 to examine whether a single (and the first time) DHQ can represent habitual dietary intake over a longer period (e.g. one year).

Since previous studies on the relationship between amino acid intake and health outcome used crude values,[4,19,20] energy-adjusted values by the residual method,[1,5-7] and a percentage of total protein intake (% protein) values,[2,3,8,9] amino acid intake values were estimated using these three expression in this study. Energy and protein intakes were also estimated based on the Standard Tables of Food Composition in Japan 2010 to calculate energy-adjusted and % protein values.[16] As nutrient intakes were not normally distributed, intake values were log-transformed before analysis.

Statistically significant differences in mean values between the DR and DHQ were determined by a paired t-test using two-sided values. p values less than 0.05 were considered to indicate a statistically significant difference. All statistical analyses were conducted using the SAS statistical software package version 9.2 (SAS Institute Inc., Cary, NC, USA) for women and men separately.

RESULTS

The mean ages of men and women were 52.8 (SD 12.1) and 49.6 (SD 11.4) years, respectively. The mean (interquartile range) energy and protein intakes estimated by the DR were 9804 (8709–10756) kJ/day and 83.1 (73.2–91.8) g/day for men and 7722 (7071–8589) kJ/day and 69.5 (62.8–79.5) g/day for women. Those estimated by DHQ were 9300 (7604–10879) kJ/day and 71.6 (55.9–89.1) g/day for men and 7854 (6925–9053) kJ/day and 65.8 (54.3–79.7) g/day for women.

Mean amino acid intakes calculated from the DR and DHQ are shown in Table 1. Regarding the energy-adjusted values, mean amino acid intakes estimated by DHQ were significantly lower than those estimated by the DR for men. Similar results were shown for women; however, significant differences were shown for only six amino acids: cysteine, histidine, alanine, aspartic acid, glutamic acid, and glycine. Regarding the % protein values, mean intake of amino acids estimated by DHQ was significantly higher than that estimated by the DR in both sexes, except for histidine and glycine for both sexes and proline for men.

Pearson correlation coefficients for amino acid intake estimated by the DR and DHQ are shown in Table 2. The medians (interquartile ranges (Q1–Q3)) of Pearson correlation coefficients between crude amino acid intakes estimated by the DR and those estimated by DHQ were 0.33 (0.31–0.35) for men and 0.27 (0.26–0.28) for women. Regarding energy-adjusted and % protein values, the medians (interquartile ranges (Q1–Q3)) were 0.32 (0.26–0.37) and 0.43 (0.31–0.47) for men and 0.42 (0.40–0.45) and 0.32 (0.25–0.44) for women, respectively. For men, the Pearson correlation coefficients of % protein values tended to be the highest among the three types of values. For women, those of energy-adjusted values tended to be the highest.

ICCs for amino acid intake estimated by the DR and DHQ are shown in Table 3. ICCs for crude values were close to the Pearson correlation coefficients in both sexes. However, for non-crude values, ICCs were very low, except for energy-adjusted values for women. This implied that non-crude amino acid intake estimated by DHQ showed poor agreement at the individual level.

The Bland-Altman plots showed that the mean differences for men were larger than those for women. Also, the mean differences for energy-adjusted amino acid intakes were larger than those for crude intake, whereas the mean differences for % protein values were slight. The limits of agreement of crude and energy-adjusted values were relatively large compared to those of % protein values. These results indicated that % protein value may be preferable for estimating amino acid intake at the individual level. As an example, Bland-Altman plots for agreement between the crude, energy-adjusted, and % protein intake of tryptophan estimated by the 16-day DR and by DHQ are shown in Figure 1 for men and Figure 2 for women. The plots of crude values in both sexes showed a significant relationship between the difference and the average of DHQ1 and the DR (slope 0.569, $p<0.001$ for men and slope 0.633, $p<0.001$ for women). In addition, % protein values in women also showed a significant relationship (slope 0.261, $p=0.046$). Thus, proportional biases were likely to exist in crude values in both sexes and in the % protein values in women. Similar results were observed for other amino acids (data not shown).

DISCUSSION

In this study, we examined the validity of amino acid intake estimated by the DHQ, using DR collected over a total of 16 days as reference. Mean amino acid intakes estimated by DHQ tended to be lower than those estimated by the DR for crude and energy-adjusted values in both sexes. On the contrary, for % protein values, mean amino acid intakes estimated by DHQ tended to be higher than those estimated by the DR in both sexes. Regarding correlation coefficients between amino acid intakes estimated by the DR and DHQ, % protein values showed higher correlation coefficients than crude and energy-adjusted values for men while energy-adjusted values showed higher correlation coefficients than crude and % protein values for women.

The mean amino acid intakes estimated by DHQ were

Table 1. Mean intakes of amino acids estimated by the 16-day DR and DHQ among 92 men and 92 women

	Men (n=92)									Women (n=92)								
	Crude (mg/day)			Energy-adjusted (mg/day)			% protein (% protein)			Crude (mg/day)			Energy-adjusted (mg/day)			% protein (% protein)		
	DR	DHQ		DR	DHQ		DR	DHQ		DR	DHQ		DR	DHQ		DR	DHQ	
Isoleucine	3374	2990	**	3374	2990	***	4.06	4.18	***	2857	2792		2857	2792		4.11	4.25	***
Leucine	6030	5384	**	6030	5384	***	7.26	7.53	***	5094	5015		5094	5015		7.33	7.63	***
Lysine	5063	4438	**	5063	4438	***	6.10	6.21	*	4251	4158		4251	4158		6.12	6.33	***
Methionine	1839	1634	**	1839	1634	***	2.22	2.29	***	1521	1486		1521	1486		2.19	2.26	***
Cysteine	1205	1089	**	1205	1089	***	1.45	1.52	***	1010	977		1010	977	**	1.45	1.49	***
Phenylalanine	3498	3121	**	3498	3121	***	4.21	4.36	***	2966	2897		2966	2897		4.27	4.41	***
Tyrosine	2716	2440	**	2716	2440	***	3.27	3.41	***	2288	2263		2288	2263		3.29	3.44	***
Threonine	3101	2748	**	3101	2748	***	3.73	3.84	***	2601	2542		2601	2542		3.75	3.87	***
Tryptophan	933	835	**	933	835	***	1.12	1.17	***	786	773		786	773		1.13	1.18	***
Valine	3981	3554	**	3981	3554	***	4.79	4.97	***	3365	3310		3365	3310		4.84	5.04	***
Histidine	2634	2289	**	2634	2289	***	3.17	3.20		2165	2086		2165	2086	*	3.12	3.18	
Arginine	4634	4119	**	4634	4119	***	5.58	5.76	***	3803	3695		3803	3695		5.48	5.63	***
Alanine	3962	3501	**	3962	3501	***	4.77	4.90	***	3257	3149		3257	3149	*	4.69	4.79	***
Aspartic acid	7242	6368	***	7242	6368	***	8.72	8.90	***	6104	5887		6104	5887	*	8.79	8.96	***
Glutamic acid	14137	12451	***	14137	12451	***	17.0	17.4	*	12103	11694		12103	11694	**	17.4	17.8	***
Glycine	3614	3081	***	3614	3081	***	4.35	4.31		2943	2752	*	2943	2752	***	4.24	4.19	
Proline	4382	3843	***	4382	3843	***	5.28	5.38		3825	3729		3825	3729		5.51	5.68	***
Serine	3654	3262	**	3654	3262	***	4.40	4.56	***	3096	3013		3096	3013		4.46	4.59	***

DR: dietary records; DHQ: self-administered diet history questionnaire.
Mean values obtained by the crude and the energy-adjust by residual method were the same.
All variables were log-transformed before analysis.
Significant difference from the DR: *$p<0.05$, **$p<0.01$, ***$p<0.001$ (paired t-test).
Mean values obtained by the crude and the energy-adjust by residual method were the same.

Table 2. Pearson correlation coefficients of amino acid intakes between the DR and DHQ among 92 men and 92 women

	Men (n=92)			Women (n=92)		
	Crude	Energy-adjusted	% protein	Crude	Energy-adjusted	% protein
Energy	0.41	-	-	0.30	-	-
Protein	0.33	0.28	-	0.27	0.47	-
Isoleucine	0.32	0.32	0.36	0.25	0.40	0.13
Leucine	0.33	0.33	0.41	0.26	0.42	0.29
Lysine	0.29	0.26	0.25	0.26	0.36	0.15
Methionine	0.31	0.25	0.26	0.26	0.35	0.20
Cysteine	0.37	0.37	0.45	0.27	0.42	0.30
Phenylalanine	0.35	0.38	0.52	0.27	0.46	0.44
Tyrosine	0.34	0.35	0.48	0.27	0.42	0.25
Threonine	0.31	0.28	0.26	0.27	0.40	0.09
Tryptophan	0.34	0.37	0.56	0.27	0.46	0.44
Valine	0.33	0.35	0.52	0.26	0.41	0.34
Histidine	0.27	0.26	0.19	0.24	0.35	0.27
Arginine	0.35	0.30	0.41	0.32	0.45	0.45
Alanine	0.31	0.23	0.31	0.29	0.40	0.42
Aspartic acid	0.31	0.31	0.47	0.28	0.44	0.42
Glutamic acid	0.37	0.44	0.45	0.28	0.56	0.54
Glycine	0.33	0.21	0.31	0.31	0.43	0.46
Proline	0.40	0.50	0.47	0.31	0.58	0.61
Serine	0.34	0.37	0.44	0.27	0.44	0.27

DR: dietary records; DHQ: self-administered diet history questionnaire.
All variables were log-transformed before analysis.

Table 3. Intraclass correlation coefficients of amino acid intakes between the DR and DHQ among 92 men and 92 women

	Men (n=92)			Women (n=92)		
	Crude	Energy-adjusted	% protein	Crude	Energy-adjusted	% protein
Isoleucine	0.27	0.16	0.11	0.27	0.38	-0.15
Leucine	0.28	0.17	0.004	0.27	0.40	-0.17
Lysine	0.26	0.15	0.21	0.29	0.36	0.07
Methionine	0.27	0.12	0.11	0.28	0.34	0.05
Cysteine	0.31	0.16	0.21	0.24	0.38	0.23
Phenylalanine	0.29	0.19	0.15	0.27	0.44	0.08
Tyrosine	0.30	0.19	0.03	0.27	0.42	-0.19
Threonine	0.27	0.13	0.06	0.29	0.39	-0.15
Tryptophan	0.29	0.20	0.19	0.28	0.45	0.06
Valine	0.28	0.19	0.16	0.27	0.40	-0.06
Histidine	0.25	0.15	0.19	0.27	0.33	0.25
Arginine	0.30	0.12	0.26	0.31	0.44	0.36
Alanine	0.27	0.06	0.18	0.30	0.39	0.34
Aspartic acid	0.25	0.14	0.40	0.30	0.43	0.36
Glutamic acid	0.30	0.18	0.39	0.25	0.49	0.48
Glycine	0.28	-0.04	0.30	0.29	0.36	0.44
Proline	0.32	0.27	0.42	0.28	0.53	0.55
Serine	0.29	0.18	0.13	0.27	0.42	0.06

DR: dietary records; DHQ: self-administered diet history questionnaire.
All variables were log-transformed before analysis.

lower than those estimated by the DR for crude and energy-adjusted values and were higher than those estimated by the DR for % protein values. Considering the differences in mean intakes between the DR and DHQ, the differences of % protein values were slight in both sexes (-0.04 to 0.39% protein for men, and -0.05 to 0.37% protein for women). This result indicates that is likely preferable to use % protein values to estimate a group's mean dietary intake.

Regarding the correlation coefficients between the DR and DHQ, crude intake values tended to be lower than non-crude (energy-adjusted and % protein) values. Though some previous epidemiological studies have used crude amino acid intake values to examine the relationship between amino acid intake and health outcome,[19,20] this result suggested that the use of crude values to estimate amino acid intake in epidemiological studies may be problematic. Most of the correlation coefficients of % protein values were higher than those of energy-adjusted values for men, although the opposite result was seen for women. Although this result was unexpected, it implied that an appropriate method of estimating amino acid intake by dietary assessment questionnaires may differ depending on the subjects' sex. One possible reason is that DHQ's significant underestimation of energy intake for men may affect the correlation of energy-adjusted amino

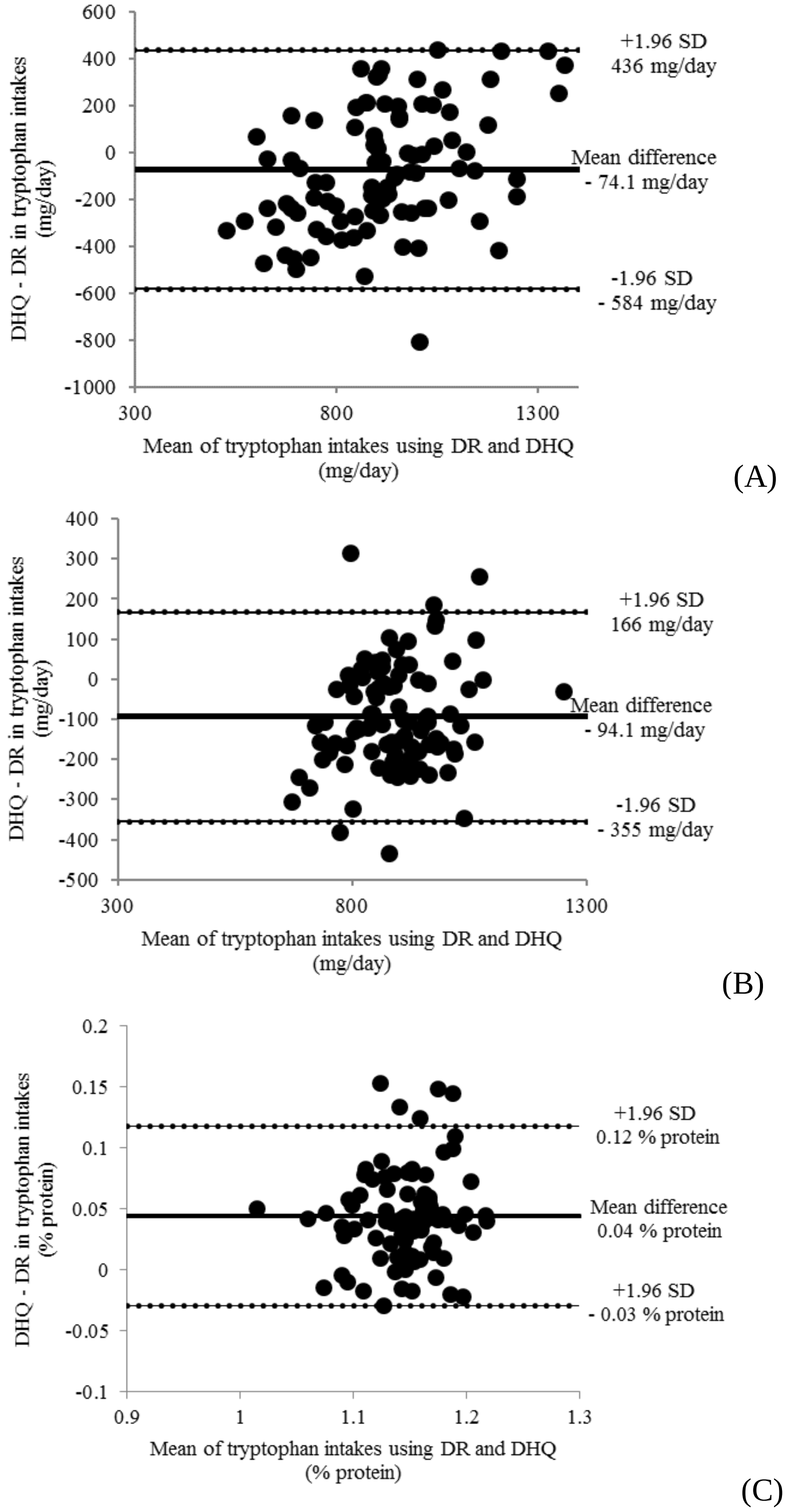

Figure 1. Bland-Altman plots of tryptophan intake between the DR and DHQ among 92 men estimated by (A) crude values, (B) energy-adjusted values, and (C) % protein values. DHQ: self-administered diet history questionnaire; DR: dietary records; SD: standard deviations.

acid intake. To our knowledge, this is the first study to examine the validity of amino acid intake estimated by a dietary questionnaire using % protein value, and to compare the difference between crude, energy-adjusted, and % protein values.

We used ICC and Brand-Altman plots to examine agreement for amino acid intakes between the DHQ and the DR at the individual level. ICC calculated using DHQ were relatively low compared to Pearson correlation coefficients. According to this result, although the DHQ had a reasonable ability to rank subjects in a group according to their amino acid intake, it had difficulty in estimating absolute values of amino acid intake at the individual level. Bland-Altman plots also showed poor agreement at the individual level. Because the DHQ's primary objective is to rank individuals according to their nutrient intake, rather than providing a measure of absolute intake, the results of this study imply that the DHQ is likely to have sufficient ability for its purpose.

Several limitations of this study should be mentioned.

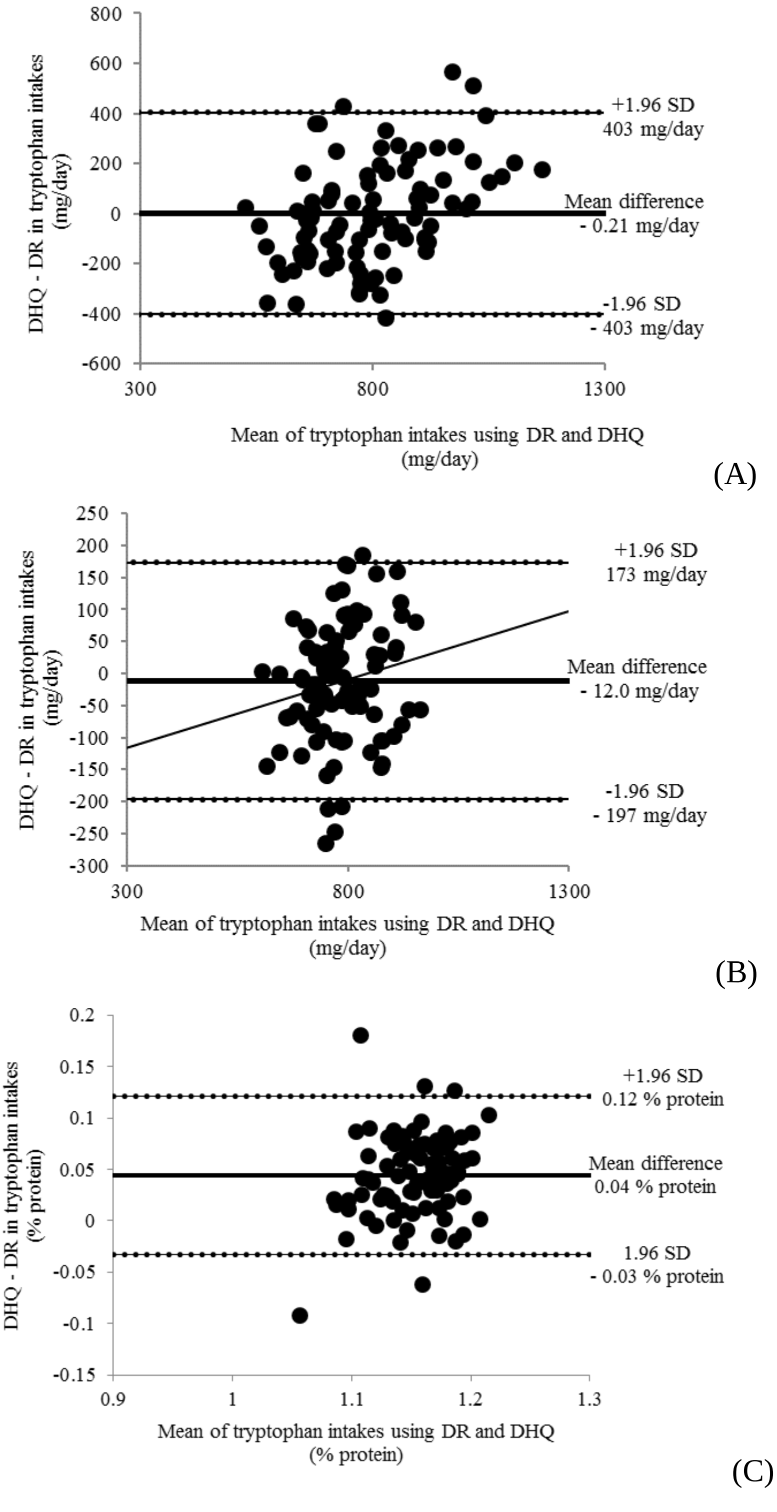

Figure 2. Bland-Altman plots of tryptophan intake between the DR and DHQ among 92 women estimated by (A) crude values, (B) energy-adjusted values, and (C) % protein values. DHQ: self-administered diet history questionnaire; DR: dietary records; SD: standard deviations.

First, since the amino acid database used in this study has missing values for some food and beverages, amino acid intake values estimated by the DHQ and 16-day DR were underestimated for participants who ate these food items. Nevertheless, the mean contribution of these food items to the estimation of amino acid intake in this study population was only 4.0%,[13] and we therefore considered that the effect of underestimation was not so large. Second, although we used mean values of amino acid intake derived from the 16-day DR as a reference, DR is susceptible to day-to-day variability in nutrient intake. The DR collection period of 16 days and our sample size (92 men and 92 women) may have therefore been too short and small for consideration of usual individual intake. On the other hand, considering the burden on participants, conducting a DR for more than 16 days appears to be unfeasible. Finally, our participants were volunteers, and may therefore have been more nutritionally conscious than others who did not participate in the study. Accordingly, the generalization of our results may be limited.

We examined the validity of amino acid intake estimated by the DHQ. The DHQ showed acceptable ability to estimate mean amino acid intake and to rank individuals in a population according to their amino acid intake. Although the DHQ is a dietary questionnaire which assesses individual dietary intake during the previous month, amino acid intakes estimated by a single DHQ showed acceptable validity for use in large-scale epidemiological studies.

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AUTHOR DISCLOSURES
The authors declare that there was no conflict of interest.

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