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Original/*Valoración nutricional*

Validity of a food-frequency questionnaire for estimating calcium intake in adolescent swimmers

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Abstract

Introduction: **accurate estimates of the intake of specific nutrients such as calcium (Ca) are crucial to correctly rank or classify subjects in the distribution of intakes. Therefore, we aimed to estimate the relative validity of a food frequency questionnaire (FFQ) for measuring Ca intake in two different groups of healthy adolescents, a normoactive control group and a physically active group of swimmers with 2 non-consecutive 24h recalls (2 x 24HR) collected as the reference method.**

Methods: **Pearson correlations, agreement between the 24HR and the FFQ at an individual level and questionnaire's ability to assign individuals to the same quartile of intake as the 24HR were calculated.**

Results: **mean daily Ca intakes were 564.6 mg (SD 232.0) and 895.9 mg (SD 343.1) for the 2 x 24HR and FFQ respectively in controls ($P < 0.001$); and 731.9 mg (SD 299.8) and 979.8 mg (SD 408.5) for the 2 x 24HR and FFQ respectively in swimmers ($P < 0.001$). Pearson correlations were 0.52 for controls and 0.47 for swimmers after correcting for intra-variability. Cross-classification analysis indicated that 73.7% of controls and 63.1% of swimmers were classified correctly or in the adjacent category. Also, the 89% of the control group and 79% of swimmers were classified correctly with the FFQ according to the dietary reference intake (DRI) of 1300 mg/d.**

Conclusions: **for both groups, the FFQ tended to overestimate Ca intake, however it demonstrated fairly good ability to classify subjects into extremes of Ca intake and**

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VALIDACIÓN DE UN CUESTIONARIO DE FRECUENCIA DE CONSUMO DE ALIMENTOS PARA ESTIMAR LA INGESTA DE CALCIO EN ADOLESCENTES NADADORES

Resumen

Introducción: **estimar correctamente la ingesta de calcio es crucial para conocer cómo se distribuye nutricionalmente la ingesta calórica a lo largo del día. Por lo tanto, el objetivo del presente trabajo fue validar un cuestionario de frecuencia de consumo para calcular la ingesta de calcio, mediante dos recordatorios de 24 horas, usado como método de referencia en un grupo control de adolescentes normo-activos y un grupo de adolescentes nadadores de alta competición.**

Metodología: **la congruencia de los cuestionarios se estudio mediante correlación de Pearson y el estudio del acuerdo entre los dos métodos a nivel individual, así como la habilidad del cuestionario para clasificar a los sujetos en el mismo cuartil que los recordatorios de 24 horas.**

Resultados: **la ingesta media diaria de calcio del grupo control fue 564,6 mg (DE 232,0) y 895,9 mg (DE 343,1) calculada mediante el recordatorio de 24 horas y el cuestionario, respectivamente ($P < 0.001$); y 731,9 mg (DE 299,8) y 979,8 mg (DE 408,5) en los nadadores mediante el recordatorio de 24 horas y el cuestionario, respectivamente ($P < 0.001$). Las correlaciones de Pearson fueron 0,52 para el grupo control y 0,47 para los nadadores después de corregir por intravariablidad. Los análisis de clasificación indicaron que el 73,7% de los controles y el 63,1% de los nadadores fueron clasificados correctamente o en la categoría contigua. El 89% de los controles y el 79% de los nadadores fueron clasificados correctamente según estuvieran por encima o por debajo de las recomendaciones de ingesta de calcio diarias (1.300 mg).**

Conclusiones: **para ambos grupos, el cuestionario de frecuencia de consumo tiende a sobreestimar la ingesta de calcio, sin embargo demuestra ser un buen método para clasificar tanto a los sujetos de ingestas de calcio**

identified adolescents having Ca intakes lower than the dietary reference intake.

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extremas, como a los sujetos que no cumplen las recomendaciones de calcio.

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Palabras clave: *Ingesta dietética. Recordatorio de 24 horas. Cuestionario.*

Introduction

In epidemiological studies of diet-health relationships in children and adolescents, accurate estimates of the intake of specific nutrients is crucial to correctly rank or classify subjects in the distribution of the dietary reference intake (DRI). Swimming is a non-weight bearing sport and its practice has been associated with changes in bone mass[1]. Therefore, young swimmers represent an important population to be monitored for dietary factors related to bone growth and development. Calcium (Ca) intake during adolescence is considered to play an important role in bone health[2-5] and its DRI is established in 1300mg of Ca per day in Spanish and USA adolescents[6,7]. Consequently, there is need for a method of estimating dietary Ca intake that is practical for epidemiological studies in this specific population.

Several instruments can be used for assessing the eating habits but the most appropriate one will depend on the aim of the study, the sample size, the target population and the available resources. Food frequency questionnaires (FFQ) are shown to be a practical and easy approach to assess a subject's recalled intake over a longer period, and may reveal nutrition habits not evident from a food record[8]. Because of the lack of a gold standard for dietary assessment, the validity of a dietary assessment technique is based on a comparison with a supposedly superior technique[9]. To assess the usual intake of an individual person, multiple days of collection are required. The limited findings suggest that the 24-hour recall (24HR) conducted over at least a 2-day period that includes week days and weekend days could be one of the most accurate methods[10].

Therefore, the present study aimed to estimate the relative validity of a FFQ for measuring Ca intake in two different groups of healthy adolescents, a normoactive control group and a physically active group of swimmers with 2 non-consecutive 24HR (2x24HR) collected as the reference method.

Methods

Participants in the validation study were part of a randomized controlled trial investigating bone health and nutrition habits of Caucasian adolescent swimmers from Aragón, Spain (14.4 y ± 2.4)[11]. The RENACIMIENTO project involves a follow-up period of 3 years where swimmers and controls are measured in four occasions. The study has been approved by the appropriate ethics committee and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Measures for this specific validation study of Ca intake were taken in September/October 2012.

Age-matched control adolescents were excluded from the study when:

(a) practiced swimming.
(b) performed no more than 3 hours per week of any sport, as they were considered as being normoactive.

Swimmers were excluded from the study when:

(a) trained less than 6 hours per week, as they were not considered high performance swimmers.
(b) had swum for less than 3 years, as it was required for the inclusion criteria in the study design[11].

The FFQ developed to estimate Ca intake contained questions on the average consumption of nineteen food items during the past year. Adolescents were asked to indicate the number of times per day, week or month that they consumed these food items. Food items were selected based on another FFQ for Ca intake assessment which included Ca-rich foods[12]; items identified for inclusion were as follows: any kind of milk, yogurt, frozen yogurt, ice cream, milk shakes, cheese, calcium-fortified orange juice, bread, breakfast cereals, pizza, pasta dishes like macaroni, broccoli, cauliflower, soft drinks, sardines, anchovies and salmon. Some of the food groups included in the original FFQ were not included in the new version, because they are products that are not consumed by the Spanish population (i.e. Chinese broccoli). The questionnaire intentionally contained a limited number of food items to enable their quick completion. Portion sizes quantified by household measures (i.e. one cup) were explained item by item in the FFQ. A trained person helped the adolescents to complete the FFQ when necessary.

Ca intakes were computed by multiplying the frequency of consumption of each food item by the mean Ca content (calculated for the food item concerned) per 100g of product.

The 24HR was chosen as the reference method in the present study. The 24HR were collected by use of a computer-based self-administered tool, the

HELENA-Dietary Intake Assessment Tool (HELENA-DIAT)[13], including one week day and one weekend day. This tool was adapted from a previous version developed and validated for Flemish adolescents[14]. This assessment tool is based on six meal occasions (breakfast - morning snacks - lunch - afternoon snacks - evening meal - evening snacks) referring to the previous day. A trained dietitian performed the 24HR interview with the adolescents. All the consumed foods and beverages were selected from a food list in the HELENA-DIAT. Items not available in the list could be added at any moment.

Only 24HR including two completed days from a week day and a weekend day were included in the analyses. One dietitian carried out the exclusion procedure of the 24HR. As a cross-check, average energy intake and nutrient intakes were calculated as the mean of the two days. 24HR that produced very high (>6000 kcal/day) or very low (<300 kcal/day) estimates of energy intake were rechecked by the dietitian.

Consumed foods were translated to nutrients by linking the consumption data obtained with the Center for Superior Studies in Nutrition and Dietetics (CESNID) food composition table[15], using standardized procedures. For complex and mixed foods, recipes were created as ingredients using the German Food Code and Nutrient Data Base (BLS)[16] to calculate the total composition of each recipe.

The Statistical Package for the Social Sciences for Windows version 20 (SPSS Inc, Chicago, IL, USA) was used to carry out all statistical analyses. P value of 0.05 was used as the threshold for significance. Two-sided significance levels were quoted. To identify possible differences in validity, all analyses were stratified by type of study sample (swimmers vs. controls).

Tests for normality were performed using the Shapiro-Wilk test. Log transformation was performed to reduce positive skewness in Ca variables. Differences in Ca intake were analysed using the paired t test.

Furthermore, Pearson correlations were used to investigate relationships between both nutrient values. In addition, the correlation coefficient, comparing the FFQ with the 24HR for Ca intake, was corrected for within-individual variation. Agreement between the 24HR and the FFQ at an individual level was assessed using mean difference and standard deviation of the difference, which was visually shown in a Bland-Altman plot. Heteroscedasticity was examined by linear regression to determine whether the absolute inter-methods difference was associated with the magnitude of the measurement.

Individual results for Ca intake estimated via the 24HR and the FFQ were classified into quartiles to assess the questionnaire's ability to assign individuals to the same quartile of intake as the 24HR[9,17]. The percentage classified into the correct or adjacent quartile and the percentage grossly misclassified (lowest quartile for one method and highest quartile for the other) were calculated. Chi-square test was done to determine whether the classification into quartiles is different in controls and swimmers. Specificity was defined as the proportion of those with a daily Ca intake below 1300 mg on the basis of the 24HR who also fell below 1300 mg on the FFQ. Sensitivity was the proportion of those with a daily Ca intake above 1300 mg on the 24HR who also fell above 1300 mg on the FFQ. The predictive value was the proportion of those who fell below 1300 on the FFQ whose actual recorded intake was less than 1300 mg Ca/day.

Results

General characteristics of the study sample including the Ca intake recorded via FFQ and 24HR are shown in table I. In total, the 24HR of three adolescents needed to be excluded due to very high estimates of energy intake. Therefore, the total number of 24HR being of use for the validation study was reduced from 288 to 282 (as 3 (2x24HR) were excluded). The FFQ was fully completed by 161 adolescents. Combining the FFQ with the 2x24HR, 141 adolescents remained of use for the validity analysis, 84 swimmers and 57 controls (Table I).

Table I
General characteristics of the study sample

	Controls (n= 57; F=20)		*Swimmers (n= 84; F= 38)*		*P*
	Mean	*SD*	*Mean*	*SD*	
Age (yr)	14.21	2.66	14.45	2.17	0,841
Weight (kg)	53.38	14.53	55.31	12.96	0,329
Height (cm)	159.97	13.62	163.89	12.58	0,038
BMI (kg/m^2)	20.47	3.47	20.30	2.64	0,641
FFQ Ca intake (mg)	895.90	343.12	979.83	408.52	0,087
24HR Ca intake (mg)	564.55	232.02	731.97	299.78	<0.005
Physical activity (h/wk)	1.82	1.67	9.74	2.22	<0.005

BMI; body mass index; FFQ, food frequency questionnaire; 24HR, 24 hour recall; Ca, calcium

Since the recommendations are identical for both sexes and there were no significant sex differences in Ca intake, results for boys and girls were analysed together. Mean daily Ca intakes were 564.6 mg (SD 232.0) and 895.9 mg (SD 343.1) for the 2x24HR and FFQ respectively in controls (P<0.001); and 731.9 mg (SD 299.8) and 979.8 mg (SD 408.5) for the 2x24HR and FFQ respectively in swimmers (P<0.001; Table I). The mean difference in Ca intake between the two methods was 331.3 mg (SD 353.5; 95% CI 253.6, 425.1) in controls and 247.9 mg (SD 432.8; 95% CI 153.9, 341.8) in swimmers, demonstrating that the FFQ overestimated Ca intake in comparison with the 24HR. This is graphically shown in Bland-Altman plots (Fig. 1). A visual inspection of this graph shows higher differences for higher mean Ca intakes (divergence), being confirmed by heteroscedasticity analysis (Fig. 1) for controls (r=0.291, p=0.001) and swimmers (r=0.228, p=0.030).

The Pearson correlation coefficient between the 2x24HR and the FFQ for daily Ca intake was 0.52 for controls and 0.47 for swimmers after correcting for intra-variability.

Cross-classification analysis performed in controls indicated that three subjects (5.3%) were grossly misclassified while 22 subjects (38.6%) were classified correctly and 42 participants (73.7%) were classified correctly or in the adjacent category. Cross-classification analysis performed in swimmers indicated that six subjects (7.1%) were grossly misclassified while 26 subjects (31.0%) were classified correctly and 53 participants (63.1%) were classified correctly or in the adjacent category (Table II). Chi square showed that the agreement between methods to classify individuals

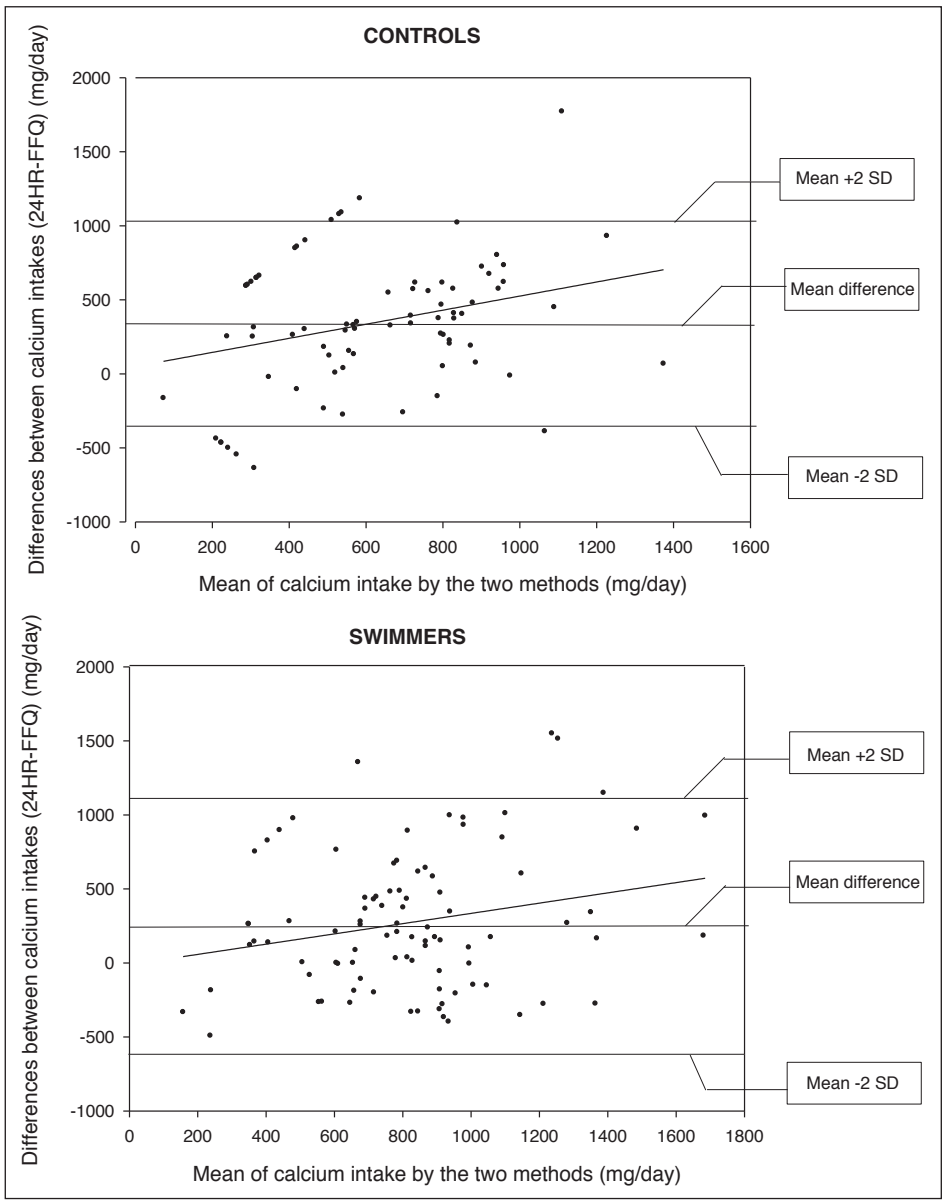

Fig. 1.—Differences between the mean Ca intake for the 24HR and the FFQ.

into quartiles was more accurate in controls than in swimmers ($P<0.05$).

Actual values for FFQ quartile showed a progressive increase in Ca intake between the first and fourth quartile (Table III) with statistically significant differences in mean Ca intakes between the different quartiles ($P<0.001$).

The sensitivity and specificity of the Ca FFQ, for indicating controls with lower and higher Ca intakes than the recommended daily intake of 1300 mg, were 89 and 100% respectively. In swimmers, the sensitivity was 83% and the specificity 25%.

The proportion of controls and swimmers with a FFQ intake below 1300 mg who also had a recorded intake below 1300 mg according to the 2x24HR was 100 and 95.7% respectively (Table IV).

Discussion

The present study showed that Ca intake estimated from the FFQ was higher than that from the 2x24HR, which is in line with other studies carried out in adolescents of similar age[18,19]. In particular, the FFQ tended to overestimate dietary Ca intake compared to the 2x24HR when intakes exceeded approximately 1000 mg/day.

The Bland-Altman plot showed large standard deviations of the differences between intakes assessed by the two methods, which indicated limited use of the FFQ to estimate Ca intakes for individuals. However, for epidemiologic purposes, the potential of a questionnaire to categorize and rank individual subjects by level of nutrient intake is more important than the capacity to measure absolute intakes of individuals.

According to Brunner *et al*.[10], correlations of about 0.5 between methods for most nutrients are good evidence that the FFQ has the ability to rank individuals. Since the correlation coefficient obtained in the present study was 0.52 for controls and 0.47 for swimmers, we conclude that this reported FFQ showed good ranking ability according to Ca intakes in adolescent and adolescent swimmers.

Cross-classification according to quartiles of intake showed reasonable agreement between the two me-

Table II
Cross-classification analysis for calcium intake from the 2 d estimated diet record (EDR) and the calcium food frequency questionnaire (FFQ) (Number of subjects in each category)

Quartiles of daily Ca intake (FFQ)		*Quartiles of daily Ca intake (EDR)*				*Total*	*Agreement of quartile categorisation (%)*
		Q1	*Q2*	*Q3*	*Q4*		
Controls	Q1	10	4	1	1	16	62,5
	Q2	5	3	2	3	13	23,1
	Q3	4	4	7	1	16	43,8
	Q4	2	4	4	2	12	16,7
	Total					57	
Swimmers	Q1	7	3	7	2	19	36,8
	Q2	1	4	8	9	22	18,2
	Q3	2	6	5	7	20	25.0
	Q4	4	7	2	10	23	43,5
	Total					84	

Table III
Use of actual values for surrogate categories to compare the calcium intake (mg/d) of the food frequency questionnaire (FFQ) with the 2 d estimated diet record (EDR)

		Calcium intake								*P*
		Q1		*Q2*		*Q3*		*Q4*		
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	
Controls	2d EDR	354,4	109,1	544.1	37,7	685,5	52,5	997.0	213.7	NA
	FFQ	496.0	103.0	807.0	89.0	1004,7	59,6	1380,4	237,1	P<0.01
Swimmers	2d EDR	346,9	91,7	537,4	38,1	714	65,5	1077,7	196,7	NA
	FFQ	512,3	120,8	818,4	74.5	997,8	55,1	1504,9	326,3	P<0.01

Table IV
*Sensitivity and specificity anlaysis for daily calcium intake estimated from the food-frequency questionnaire (FFQ) * (Number of subjects in each category)*

	Daily Calcium intake (FFQ)	*Daily Calcium intake (EDR)*		*Total*
		< 1300mg	*≥ 1300mg*	
Controls	< 1300 mg	50	0	50
	≥ 1300 mg	6	1	7
	Total	56	1	57
Swimmers	< 1300 mg	66	3	69
	≥ 1300 mg	14	1	15
	Total	80	4	84

EDR, estimated diet record
Sensitivity is the proportion of those with a daily calcium intake ≥ 800mg on the basis of the 2 d EDR who also fell ≥ 800mg on the FFQ; specificity is the proportion of those with a daily calcium intake < 800mg on the basis of the 2 d EDR who also fell <800mg on the FFQ

thods, especially in the control group. 73.7% of the controls were classified into one quartile of the 24HR, whereas only 5.3% of controls were misclassified at the extreme quartiles. In the case of adolescent swimmers, 63.1% were classified within one quartile of the 24HR and 7.1% in the extreme quartiles, suggesting that the newly developed FFQ is more accurate to rank controls than swimmers according to the Ca intake. Ca intake measured with FFQ and 24HR was higher in swimmers than in controls. This could be one of the reasons why FFQ is less accurate ranking swimmers in quartiles of intakes compared to controls as Bland-Altman graph showed that the higher the Ca intake the higher the difference between methods.

Since the actual values for surrogate FFQ categories showed the expected significant stepwise increase of Ca intake between the first and fourth quartile for both study groups, we provide evidence that the FFQ could reliably distinguish extreme Ca intakes.

Reporting the identification of actual daily intakes more than the RDI of 1300 mg, the sensitivity error is quite low showing that none of the controls and 4% of all the swimmers would be assigned to report over 1300 mg of Ca when they should not. Also, reporting the identification of actual daily intakes less than the DRI of 1300 mg, 88% and 79% of controls and swimmers respectively would be correctly identified.

The small sample in our study can be considered as a limitation because there were only a couple of cases above the DRI of 1300 mg/day of Ca intake which makes difficult to conclude that the FFQ is a good tool to identify individuals above the DRI. In addition, it should be considered that also the repeated 24-h recall method cannot be considered as a golden standard as it is not free of errors neither. However, an important strength is that the 24-h dietary recall method used in this validation study has already been validated before[14] and that two independent recalls have been administered per subject what allowed adjustment for within-person variability.

Another important strength is that the study also included a control sample what allowed a better interpretation of the validation results for swimmers by comparison with a reference group. In addition, the FFQ is a simple and convenient dietary intake assessment method and could therefore serve future studies interested in adolescent's calcium intakes. It consists of only 19 questions and it takes about 5 minutes to complete.

In conclusion, the food frequency questionnaire presented in this study has shown a good ability to classify subjects into extremes of calcium intake and to identify adolescents having calcium intakes lower than the dietary reference intake. While the 2 non-consecutive 24 hour recalls are found to be superior to the food frequency questionnaire, especially when aiming at assessing the individual mean calcium intake, the evidence suggests that the food frequency questionnaire could be a good method to rank individuals into calcium categories when time is lacking, independently of the grade of physical activity.

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