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Content validity and reliability of a food frequency questionnaire to measure eicosapentaenoic acid and docosahexaenoic acid intakes in young adults: A pilot study

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ABSTRACT:

Background: The food environment is rapidly changing with regard to omega-3 fatty acids. Research is hindered by the lack of a tool specifically designed to measure intakes of long-chain omega-3 fatty acids in US populations. The purpose of this pilot study was to assess the content validity and reliability of a novel 14-item food frequency questionnaire (FFQ) designed to measure contemporary sources of eicosapentaenoic aid (EPA) and docosahexaenoic acid (DHA).

Methods: During May of 2009, college students (n = 165) completed the FFQ and provided feedback. Forty-five completed the questionnaire a second time allowing for the evaluation of test-retest reliability**.**

Results: None of the students reported consuming a food naturally rich in EPA and DHA that was not included in the FFQ. Overall instrument reliability (n = 54) was strong ($\rho = 0.86$, $p < 0.001$) and the reliability for each of the non-functional food items ranged from moderate to strong ($\rho = 0.48$ to 0.86, $p < 0.001$). Correlation coefficients for each of the functional food items were low and/or non-significant. Uncertainty regarding omega-3 functional foods was listed as a reason by eight of the twelve who felt one or more of the questions were difficult to answer.

Conclusions: Overall instrument reliability was strong and content validity was good. Nonetheless, participant feedback, and the decreased test-retest coefficients for the omega-3 functional foods, suggests unfamiliarity may be problematic when measuring intakes from these food sources.

Keywords: Functional foods, n-3 fatty acids, dietary assessment, seafood, eicosapentaenoic acid, docosahexaenoic acid

FINDINGS:

Purpose

Seafood, particularly oily fish, is a rich source of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). However, consumers ingest EPA and DHA from a variety of supplements and foods including eggs, poultry, milk, juices, vegetable oil spreads, and sushi. In fact, fish oil and other long-chain omega-3 supplements are the most commonly used non-vitamin, non-mineral supplements in the US [1], and since 1988, roughly 2,200 foods containing EPA and DHA have been introduced worldwide [2]. Consumer research indicates almost one third of US adults have purchased a food, drink, or supplement containing omega-3 fatty acids [3].

Thus far, measurements of omega-3 fatty acid intake in US populations have not kept pace with consumer trends by taking into account all sources of long-chain omega-3 fatty acids. For example, one recently developed omega-3 food frequency questionnaire (FFQ) included sushi but did not include eggs, chicken, or functional foods [4]. Currently, a convenient and comprehensive instrument specifically designed to measure EPA and DHA intakes in US populations does not appear to exist. Therefore, a 14-item FFQ was developed to measure consumption of these fatty acids from contemporary food sources. This newly developed FFQ takes approximately five minutes to complete and was designed to prevent excessive participant burden while measuring the relationship between EPA and DHA intakes and variables related to cognition and mood among young adults.

The purpose of this pilot study was to evaluate the content validity and reliability of this newly developed FFQ prior to conducting a subsequent biomarker validation study.

MATERIALS AND METHODS

A self-administered survey containing the FFQ and a set of instrument evaluation questions was administered to a mixed-gender convenience sample of college students in May of 2009. To assess the test-retest reliability of the FFQ, a subset of participants willing to complete the survey a second time was identified. These students were given postage-paid return envelopes and instructed to complete and return the second survey in two weeks. All surveys returned between two and eight weeks were included in the test-retest reliability analysis.

This protocol was approved by the Kansas State University Institutional Review Board, and all participants were required to provide written informed consent prior to participation.

Questionnaire

Using expert feedback and the literature as a guide, a semi-quantitative FFQ was developed by modifying an existing FFQ that had been validated in an Australian population [5]. The newly developed FFQ included seven items related to seafood consumption. Five of the seafood items were based on the seafood items found on the Fred Hutchinson Cancer Research Center General FFQ [6]. Two seafood items were added to measure intake from sushi and sardines. Two items, one to measure intake from pork and the other to measure intake from beef, were initially included; however, responses from these items were not included in the intake analysis due to unavailability of long-chain fatty acid composition data for these items. In all, the newly developed FFQ included 14 items to capture intake of EPA and DHA from: 1) seafood, 2) poultry and eggs, 3) omega-3 functional foods, and 4) dietary supplements.

Based on the concept of generic memory [7], participants were instructed to indicate how often they ate each food item during the previous six months. Nine response options were possible, and the options ranged from "never" to "two or more per day." Participants were also instructed to indicate their usual serving size relative to a medium size (e.g., four ounces or 113 grams) serving. Size choices were "small," "medium," and "large." A small serving was one-half (0.5) the medium serving size, and a large serving was one-and-one-half (1.5) times the medium serving size. A photo of a plated four-ounce portion of fish was used to help participants increase the accuracy of their estimates. The omega-3 supplement usage was measured by asking participants to write in the type and normal daily amount of supplements taken.

For each item on the FFQ, an average daily intake of EPA + DHA was calculated based on the fatty acid content of the item and the frequency and potion size in which it was consumed. The EPA + DHA content for each item was determined using the US Department of Agriculture National Nutrient Database for Standard Reference, Release 22 [8]. For supplements and items not listed in the US Department of Agriculture database, fatty acid content data was obtained either from the product labels or from product representatives. To assess content validity, a set of questions was developed to evaluate the clarity and completeness of the FFQ. This set of questions was included with the FFQ and included questions with nominal response choices (i.e., "yes" or "no") as well as open-ended questions (i.e., "if yes, explain").

Statistical Analyses

Data analyses were performed using Predictive Analytics Software (version 18, 2009, SPSS, Inc, Chicago, IL). As the purpose of this study was to assess the performance of the FFQ, outlier values were not excluded from the analyses. Percentages were calculated based on the number of complete responses. Mean and median values for average daily DHA + EPA intakes were calculated for each item, for all four categories of items (i.e., seafood, chicken and eggs, functional foods, and supplements), and for the overall total. FFQs with missing responses were not included in the EPA + DHA calculations for the categories to which the missing response belonged, nor were they included in the calculation of total EPA + DHA. However, the responses to individual items from these surveys were retained during item analyses.

Because intake values for the fatty acids were not normally distributed, non-parametric statistical analyses were performed. Test-retest reliability was evaluated using Spearman rank order correlation coefficients to measure the correlation between the fatty acid intake values obtained from the initial FFQ with those obtained on the repeat FFQ. Cohen's kappa coefficient was used to measure test-retest agreement for omega-3 supplement use. Mann-Whitney U tests were conducted to determine whether EPA + DHA intakes differed between those who completed the survey a second time and those who did not.

RESULTS

The initial survey participation rate was 83.7% (n = 165). The EPA + DHA intakes were positively skewed with values clustering at the low end. Calculation of total EPA + DHA intakes was possible for 144 participants and ranged from zero to 2734 mg/day with a mean of 189 mg/day, a median of 89 mg/day, and a standard deviation of 346 mg/day. The contribution of each category to the mean was as follows: fish and seafood 65% (122 mg/day), dietary supplements 19% (36 mg/day), chicken and eggs 13% (24 mg/day), and omega-3 functional foods 3% (6 mg/day).

Twenty-nine percent of participants (n = 47) consumed at least one omega-3 functional food, 21.3% (n = 35) had eaten sushi, 12.2 % (n = 18) consumed seafood twice a week or more, and nine percent (n = 15) had taken an omega-3 supplement. Although sushi was consumed by a sizeable proportion of participants, the calculated EPA + DHA content for sushi (143 mg/serving) was relatively low compared to the average content of other seafood items (796 mg/serving). In addition, sushi was consumed less often than any of the other seafood items except sardines and accounted for less than one percent (1 mg/day; 0.76%) of the EPA + DHA intake. The most commonly listed types of sushi were California rolls, which were listed 13 times and accounted for 34% of all types listed, and salmon, which was listed seven times and accounted for 18.4% of all types listed.

With regard to evaluation of the FFQ's completeness, 3.0% (n = 5) said they consumed omega-3 foods not incorporated in the FFQ. The following four foods comprised the list of foods that were consumed but not incorporated into the FFQ: flaxseed, peanut butter, granola bars, and flatbread. None of the foods that were listed are naturally rich in EPA or DHA. With regard to clarity, 7.2% of the participants (n = 12) said they had trouble understanding or answering one or more questions. Of the 12 participants who identified clarity as a concern, eight cited issues related to the omega-3 functional foods. Select representative responses from those who experienced confusion regarding omega-3 functional foods are provided in Table 1.

Table 1. Selected responses from participants who experienced confusion regarding n-3 functional foods
"How do I know what is omega-3 enriched?"
"I'm not aware of my omega 3 intake."
"Not sure whether or not I have eaten omega-3 enriched foods."
"Explain omega 3 enriched foods."
"I don't know if the stuff I eat is omega-3 enriched."
"I don't know if foods are enriched."

Fifty-four students agreed to complete the FFQ a second time. Forty-five of those who agreed to complete the survey a second time did so, yielding a return rate of 83.3% for the repeat survey. Total EPA + DHA intake did not differ significantly between those who completed the survey a second time and those who did not ($U = 1848.5$; $p = 0.517$) with median intakes of 77mg/day and 90 mg/day for the two groups respectively. Results of the test-retest reliability assessment of food items are presented in Table 2. Test-retest reliability correlation coefficients for each of the non-functional food items and the overall scale were significant and ranged from $\rho = 0.48$ to 0.86; $p < 0.001$. Correlation coefficients for each of the functional food items were low and/or non-significant. Test-retest agreement for omega-3 supplement use was high with 97.6% ($n = 41$) of participants providing the same answer on both FFQs ($K = 0.844$; $p < 0.001$).

Table 2. Test-retest correlation coefficients for EPA + DHA intakes measured using 14-item food frequency questionnaire

FFQ Items	n	Spearman's rho	p
Seafood			
Canned Tuna	44	.80	< 0.001
Fried Fish	43	.64	< 0.001
Fried Shellfish	44	.70	< 0.001
Sardines	41	.83	< 0.001
Baked White Fish	44	.76	< 0.001
Baked Dark/Oily Fish	43	.48	< 0.001
Sushi	43	.58	< 0.001
All Seafood	38	.84	< 0.001
Other Food			
Dark Chicken	43	.79	< 0.001
Eggs	45	.67	< 0.001
Dark Chicken & Eggs	43	.68	< 0.001
Functional Food			
Omega-3 eggs	44	.52	< 0.001
Omega-3 margarine	42	.42	0.005
Omega-3 milk	44	.17	0.267
Omega-3 juice	44	.14	0.360
All Functional Foods	42	.24	0.127
Supplements	42	.86	< 0.001
Total All Sources	31	.86	< 0.001

DISCUSSION

With a correlation coefficient of $\rho = 0.86$, overall test-retest reliability was good. Participant responses indicate the overall content validity was good. In addition, the reporting of omega-3 supplement appears to be reliable, and to the best of our knowledge, this is the first time that the reliability of omega-3 supplement reporting has been measured.

Nonetheless, participant feedback and the decreased test-retest coefficients for the omega-3 functional foods, suggest unfamiliarity may be problematic when measuring intakes from these food sources. This finding substantiates earlier consumer research in which 26% of respondents said that they were uncertain whether or not they had purchased a food, drink, or supplement that contained omega-3 fatty acids [3]. While the contribution from reported intake of functional foods was only three percent of the total EPA + DHA intake, their actual contribution may be considerably higher, and additional work is needed to improve the reliability of the FFQ items related to these foods.

Limitations

Although reproducibility evaluations are useful, and high test-retest correlations are desirable, reproducibility evaluations alone do not constitute a sufficient instrument evaluation (Willet, 1998). Modifications to improve the clarity of the omega-3 functional food items and subsequent criterion-related validation (e.g. a biomarker study) are still needed. Since FFQs have a tendency to overestimate absolute intake, this instrument would be best suited for studies designed to rank participants based on their relative intake of EPA + DHA. In addition, because this pilot study was conducted among college students in Kansas, the results are not necessarily generalizable to populations from different geographic location or age group, or those with lower literacy levels.

CONCLUSIONS

The overall preliminary performance of this self-administered FFQ has been favorable. However, omega-3 functional food measurement appears to be problematic. The results suggest that modifications to improve the clarity of the omega-3 functional food items are needed. Consistent with what has been reported in consumer research studies, this finding prompted us to modify the questionnaire by adding product names and pictures, as well as ask participants to specify the products they consumed. Although often overlooked, instrument development, such as that reported here, has the potential to vastly improve dietary assessment methods. This is particularly true when the nutrient under consideration is a nutrient such as omega-3s for which the food environment is rapidly changing.

Abbreviations: Eicosapentaenoic Acid (EPA), Docosahexaenoic Acid (DHA), food frequency questionnaire (FFQ)

Competing interests: The authors declare they have no competing interests.

Authors' contributions: Jennifer A. Hanson (PhD, RD, Assistant Professor) designed the study, collected and entered the data, performed the data analysis and drafted the manuscript. Richard R. Rosenkranz (PhD, Assistant Professor) assisted with the survey development and provided critical review of the manuscript. Carol Ann Holcomb (PhD, Professor Emerita) guided the statistical analysis and assisted with interpretation of the results. Mark D. Haub (PhD, Associate Professor) provided administrative support and critical review of the manuscript.

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REFERENCES

1. Barnes PM, Bloom B, Nahin RL: Complementary and alternative medicine use among adults and children: United States, 2007. Natl Health Stat Report 2008, 12:1-23.
2. Ismail A: Omega 3s' potential in foods: as the market continues its growth credibility among consumers will be the key to future success. Nutraceuticals World 2009, June: 32-40.
3. Mintel: Omega-3 – US. London: Mintel International; 2008.
4. Sublette ME, Segal-Isaacson CJ, Cooper TB, Fekri S, Vanegas N, Galfalvy HC, Oquendo MA, Mann JJ: Validation of a food frequency questionnaire to assess intake of n-3 polyunsaturated fatty acids in subjects with and without major depressive disorder. J Am Diet Assoc 2011, 111:117-123.
5. Mina K, Fritschi L, Knuiman M: A valid semiquantitative food frequency questionnaire to measure fish consumption. Eur J Clin Nutr 2007, 61:1023-31.
6. Fred Hutchinson Cancer Research Center: Food Frequency Questionnaires (FFQ). [http://www.fhcrc.org/science/shared_resources/nutrition/ffq]
7. Willet W: Nutritional Epidemiology (2nd ed.). New York: NY Oxford Press; 1998.
8. U.S. Department of Agriculture, Agricultural Research Service: USDA National Nutrient Database for Standard Reference, Release 22; 2010: http://www.ars.usda.gov/nutrientdata