Validity and Reliability of a Brief Dietary Assessment Questionnaire in a Cardiac Rehabilitation Program

Ellen Schaaf Aberegg, MA, LD, RDN, FAACVPR; Karen K. Collins, MS, RDN, CDN; Judith M. Hinderliter, MPH, RDN, LDN; Sharon L. Smalling, MPH, RD, LD; Teresa T. Fung, ScD, RD; Ziya Gizlice, PhD; Larry F. Johnston, MA; Alice S. Ammerman, DrPH; Thomas C. Keyserling, MD, MPH

Purpose: Dietary assessment is vital to inform individualized nutrition care and to evaluate the success of interventions aimed at improving diet for participants in cardiac rehabilitation (CR) programs. The purpose of this study was to assess the validity and reliability of an instrument developed to reflect current evidence-informed dietary recommendations advocated to reduce cardiovascular risk.

Methods: This study was conducted at a single CR program at the University of North Carolina, Chapel Hill. Two dietary assessments were administered: Picture Your Plate (PYP) and a reference instrument, the Harvard/Willett Food Frequency Questionnaire (HWFFQ). The PYP is a modification of a previously validated instrument, the Dietary Risk Assessment-New Leaf (DRA-New Leaf). Concurrent validity was assessed by comparing the PYP total score with 3 diet quality indexes (Alternative Health Eating Index [AHEI], Dietary Approaches to Stop Hypertension [DASH], and Alternative Mediterranean Diet [aMED]) calculated from the HWFFQ and by assessment of agreement in tertile cross-classification. An intraclass correlation (ICC) was calculated to assess test-retest reliability.

Results: Among the 108 participants, crude and adjusted Spearmen correlation coefficients between the PYP and 3 indexes of dietary quality were AHEI-2010 (0.71-0.72), DASH (0.70-0.71), and aMED (0.52-0.58) ($P < .0001$, all comparisons). Agreement of tertiles comparing PYP and AHEI-2010 was 67% and the score in opposite tertiles was 6%. The weighted kappa value (κw) = 0.71. The test-retest ICC was 0.91 (95% CI, 0.85-0.93; n = 91).

Conclusions: Results support the PYP as a valid and reliable dietary assessment tool for use in CR programs. Continued research in additional CR program populations is recommended.

Key Words: cardiac rehabilitation • diet quality index • dietary assessment • reliability • validity

Author Affiliations: *UNC Cardiac Rehabilitation Program, Chapel Hill, North Carolina (Ms Hinderliter); Memorial Hermann Hospital–Texas Medical Center, Houston (Ms Smalling); Department of Nutrition, Simmons University, Boston, Massachusetts (Dr Fung); Department of Nutrition, T. H. Chan School of Public Health, Boston, Massachusetts (Dr Fung); UNC Department of Nutrition, Gillings School of Global Public Health (Dr Ammerman), and Department of Medicine, School of Medicine (Dr Keyserling), UNC Center for Health Promotion and Disease Prevention (Dr Gizlice and Mr Johnston), Chapel Hill, North Carolina. Ms Aberegg is a consultant, Westerville, Ohio. Ms Collins is a consultant, Jamestown, New York.*

The authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.jcrpjournal.com).

Correspondence: *Ellen Schaaf Aberegg, MA, LD, RDN, FAACVPR, 1217 Chatham Ridge Rd, Westerville, OH 43081 (Ellen.Aberegg@att.net).*

DOI: 10.1097/HCR.0000000000000505

For diet assessment tools to be useful in cardiac rehabilitation (CR) programs, they need to be relatively quick to complete and score, easy to interpret, and provide sufficient detail to identify patients who may benefit from more intensive nutrition education or individualized diet instruction.[1] In a review of 35 tools, most were focused primarily on low total fat intake and few addressed the full spectrum of a healthy dietary pattern.[2] The Dietary Risk Assessment (DRA) is a tool developed for use by nutrition specialists and non–dietetics-trained health professionals[3] to assess diet qualities associated with cardiovascular disease (CVD) risk and to guide dietary counseling.[4] It is a valid and reliable brief diet assessment tool previously tested in a variety of populations[4] but not specifically in a CR population. The New Leaf version of the DRA (DRA-New Leaf)[4,5] was suggested as pre- and post-CR diet measure in some CR programs in the United States. However, the DRA-New Leaf assessment was developed almost 20 yr ago and does not fully align with current dietary guidelines. Consequently, the Picture Your Plate (PYP)[6] questionnaire was developed as a modification of the DRA-New Leaf by a committee of registered dietitians to align with current guidelines for a healthful diet (2015-2020 Dietary Guidelines for Americans[7] [2015 DGA] and Recommended Dietary Patterns to Achieve Adherence to the American Heart Association [AHA]/American College of Cardiology Guidelines[8] [AHA Recommended Dietary Pattern]). These guidelines reflect dietary patterns associated with reduced CVD risk[8] and other important health outcomes[9] and best practices in CR programming.[1] This study reports the validity and reliability of this revised DRA tool assessed in a CR population.

METHODS

STUDY INSTRUMENTS

Two dietary assessment questionnaires were administered: the PYP and a reference instrument, the semiquantitative Harvard/Willett Food Frequency Questionnaire (HWFFQ) previously validated to reliably reflect dietary intake[10] and subsequently shown to identify dietary behavior patterns associated with CVD and other health outcomes.[8,9]

The 48-item PYP was provided as a printed document and was designed for administration in 15-20 min. The format is similar to the previously validated versions[3-5] of the DRA. The questions are grouped into 10 categories (see Supplemental Digital Content 1, available at: http://links.lww.com/JCRP/A160). PYP readability was assessed,[11] and the readability consensus based on 8 readability formulas was seventh-grade reading level, fairly easy to read.

The HWFFQ was selected as the reference instrument because it has been shown to provide reasonably valid estimates of a wide variety of nutrients and favorably perform in

comparison with 24-hr recall.[12] The 2007 booklet version[13] of the HWFFQ was used, which includes 164 food items. A portion size was specified for each food item, and participants were asked how often, on average, a specified quantity was consumed during the past year. Nutrient analysis was done at the Harvard T. H. Chan School of Public Health.

DATA COLLECTION

This study was conducted at a CR program at the University of North Carolina (UNC-CH). All English-speaking patients who were referred to CR were invited to take part in this study. Study data were collected from April through October 2018. This study was approved and monitored by the institutional review board at the UNC-CH. At the CR orientation visit, the study staff described the study and invited questions from potential participants. Patients who agreed to participate reviewed and signed the consent form.

Both questionnaires were placed in a folder ordered according to a computer-generated random numbers listing. Participants completed both questionnaires as time permitted at the orientation visit. The research staff answered questions and assisted as needed. Shortly after participants were enrolled in this study, the UNC Health Systems electronic medical record was accessed to complete a baseline medical history and demographic survey. The PYP was readministered at the first CR exercise session, typically scheduled 1 wk after the CR orientation visit in order to assess test-retest reliability.

STATISTICAL ANALYSES

The HWFFQ data were used to calculate the following indexes of diet quality: Alternative Health Eating Index (AHEI-2010),[14] Dietary Approaches to Stop Hypertension (DASH) score,[15] and Alternative Mediterranean Diet (aMED).[16] The components of these indexes and scoring range are included in Supplemental Digital Content 1 (available at: http://links.lww.com/JCRP/A160). The AHEI-2010, as compared with the DASH and aMED, has more items, a broader scoring range, and is based on reported dietary intake rather than distribution of reported intake relative to others in this sample.

Content validity was assessed prior to the study by a team of dietitians who specialize in cardiovascular dietetics and by an expert in nutrition research. In this study, concurrent validity is assessed by comparing the PYP total score with the total scores of calculated indexes. Reliability was assessed by measuring test-retest correlations. An interval of ≥1 to 4 wk between tests is common in evaluating reliability of dietary assessment tools.[2,17]

Based on a one correlation power analysis, the required sample size was 84 for power of 80% and 112 for power of 90% using significant correlations of 0.3, 0.4, and 0.5 with $\alpha = .05$ as the basis for analysis. Study sample characteristics were summarized using descriptive statistics. Spearman correlation coefficients were used to examine the crude and adjusted associations between the total PYP score and the 3 indexes of diet quality adjusting for total energy intake as assessed by the Food Frequency Questionnaire (FFQ) instrument and with further adjustment for age, gender, and body mass index (BMI). To assess test-retest reliability, the Shrout and Fleiss[18] method was used to calculate intraclass correlations (ICC) between repeated measures. Cross-classification of participants for agreement between the PYP and AHEI-2010 tertile ranking was used to calculate the percentage of participants correctly classified in the same category and the percentage misclassified in the opposite category.[17] We required a minimum of 2 d between test and retest PYP questionnaire administration to be included in the reliability analysis. A $P < .05$ was considered significant. All analyses were conducted using SAS version 9.4 (SAS Institute). No adjustments were made for multiple comparisons.

Table 1

Baseline Characteristics of Study Participants (N = 108)[a]

Demographics	
Age, yr	66 ± 12.1
Male	73 (68)
Ethnicity	
Not Hispanic or Latino	107 (99)
Hispanic or Latino	1 (1)
Race	
White or Caucasian	93 (86)
Black or African American	10 (9)
American Indian or Alaska Native	1 (1)
Asian	1 (1)
Other race	3 (3)
Waist circumference, in	41 ± 6.7
Weight, kg	89 ± 21.1
Body mass index, kg/m^2	30 ± 6.7
Primary diagnosis	
MI with/without CABG	26 (24)
CABG	6 (6)
PCI with/without MI	43 (40)
Valve repair/replacement	17 (16)
Stable angina	7 (7)
Heart failure with reduced ejection fraction	7 (7)
Secondary diagnosis	
MI with/without CABG	2 (2)
CABG	3 (3)
PCI with/without MI	14 (13)
Valve repair/replacement	3 (3)
Stable angina	0 (0)
Systolic heart failure	6 (6)
Heart transplant	1 (1)
High blood pressure[b]	94 (87)
Diabetes	26 (24)
Statin	95 (88)
Other cholesterol-lowering medications	4 (4)
Hemoglobin A_{1c}, %	6.1 ± 1.4
Total cholesterol, mg/dL	172.5 ± 45.4
HDL, mg/dL	51.2 ± 17.5
LDL, mg/dL	97.2 ± 39.6
Triglycerides, mg/dL	125.0 ± 4.3

Abbreviations: CABG, coronary artery bypass grafting; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; MI, myocardial infarction; PCI, percutaneous coronary intervention.

[a]Data reported as mean ± SD or n (%).

[b]Defined as systolic blood pressure >140 mm Hg, diastolic blood pressure >90 mm Hg, or both.

RESULTS

A total of 108 CR patients completed baseline measures and comprised the study sample as described by demographics

Table 2

Total Score and Spearman Correlation Coefficients for PYP and Calculated Indexes From Harvard/Willett Food Frequency Questionnaire

		PYP	AHEI-2010	DASH	aMED
n[a]		105	106	106	106
Mean ± SD		63.9 ± 11.7	63.1 ± 13.9	24 ± 5.8	4.2 ± 2.2
Range		31-87	30-91	11-35	0-9
Spearman correlation coefficient[b]	Crude		0.72	0.70	0.52
	Adjusted for energy intake		0.72	0.71	0.60
	Adjusted for energy intake, age, sex, BMI		0.71	0.70	0.58

Abbreviations: AHEI-2010, Alternative Health Eating Index; aMED, Alternative Mediterranean Diet; BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension; PYP, Picture Your Plate.
[a]Of 108 participants, 2 did not complete the Harvard/Willett Food Frequency Questionnaire, of the 106 who did, one did not complete the PYP.
[b]$P < .0001$.

and diagnosis in Table 1. Participants age was 66 ± 12 yr and BMI was 30 ± 6.7; 73 (68%) were male; 93 (86%) were white and 10 (9%) were African American. For 75 (70%) participants, the primary indication for CR included a recent ischemia-related cardiac event. Dietary assessment scores and values for selected nutrients as assessed by the HWFFQ are reported in Supplemental Digital Content 2 (available at: http://links.lww.com/JCRP/A161). The mean energy intake was 1681 kcal, with 34.2% of calories from fat and 10.8% from saturated fat.

Table 2 lists the total PYP score results and the calculated index scores derived from the HWFFQ and Spearmen correlation coefficients depicting the nonlinear association between PYP and the 3 indexes of dietary quality. For the DASH and AHEI-2010 indexes, crude and adjusted correlation coefficients range from 0.70 to 0.72 ($P < .0001$ for all comparisons). A partial residual scatter plot depicting the association between the adjusted PYP and the AHEI-2010 index is shown in Supplemental Digital Content 3 (available at: http://links.lww.com/JCRP/A162). Concordance in tertiles of PYP and AHEI-2010 scores was achieved for 70 (67%) participants, whereas opposite tertile classification was observed for 4 (4%) participants. The weighted kappa value (κw) = 0.71. The cross-tabulation table in tertiles is provided in Supplemental Digital Content 4 (available at: http://links.lww.com/JCRP/A163).

For test-retest reliability, 94 participants had baseline and retest data. The goal for the collection of retest data was 1 wk (time between CR orientation and the first exercise visit). The mean ± SD and median (interquartile range [IQR]) time intervals between assessments were 10.5 ± 8.6 and 8 (4, 12) d, respectively, with a range of 2 to 42 d. The ICC was 0.91 (95% CI, 0.85-0.93).

DISCUSSION

The 2015 DGA[7] and the AHA Recommended Dietary Pattern[8] emphasize dietary pattern as the foundation of their conceptual models and conclusions. This study examined the validity of the PYP by comparing it with the calculated indexes of overall diet pattern quality, AHEI-2010, DASH, and aMED, which are associated with CVD morbidity and mortality in multiple populations.[9] Overall, this instrument was found to have a robust correlation with all 3 indexes of dietary quality, exceeding general standards for a correlation coefficient of ≥0.50.[2,17] The correlation coefficient between the PYP and AHEI-2010 scores was 0.72 (Spearman $P < .0001$). The DASH and aMED scores also correlate similarly (Table 2). Because higher AHEI-2010, DASH, and aMED scores are associated with a lower risk of CVD morbidity and mortality, the close association of the PYP score with the indices and the high test-retest ICC (0.91), indicating good to excellent reliability,[17] suggests that the PYP is a valid and reliable instrument for measuring overall diet quality relevant to CVD.

Lombard et al[17] states that an optimal outcome is >50% of the rankings in the same tertile and <10% in the opposite tertile. The agreement level of the tertile rankings (67% agree, <4% disagree) exceeds this standard. The Cohen weighted kappa (κw) = 0.71 similarly indicates a good agreement of these tertile rankings.[17]

The demographics of our study population are similar in sex, race, weight, and BMI to recently reported larger CR cohorts (a 12 984-member CR cohort in the United States during 2000-2009[19] and a 5396-member cohort[20] in Vermont collected over 20 yr). Participants in this study reported dietary fat composition and fiber intake that are very similar to NHANES dietary intake data reported for 2015-2016[21] but, on average, reported about 300 kcal less energy intake/d and almost half the sodium intake. Underreporting of energy and sodium intake in the study sample may be attributed to the difference in data collection methodology (an FFQ vs a 24-hr diet recall for NHANES), recall bias, and perhaps compliance in accord with prior diet counseling due to preexisting CVD. In general, accuracy of the FFQ in assessing sodium content is limited. Underreporting of energy intake is commonly observed when using FFQs versus other methodologies but is a problem in all dietary surveys.

The primary strength of this study is that it assessed the validity of a dietary assessment instrument that aligns with current evidence-informed data of a healthful dietary pattern for reducing CVD risk by comparing it with 3 generally recognized healthful dietary pattern indexes. Additional strengths include the use of a previously well-studied and validated reference FFQ and an adequate sample size for our planned analysis. Time to complete the tool (15-20 min) fits into the constraints of most CR programs. Reading level of the PYP was also evaluated as less than that of the average US adult.

There are also limitations, including the use of a comparison FFQ that shares the same source of diet information relying on subject memory (introducing recall bias) versus observation or direct documentation of food intake. This lack of independence may lead to spurious correlations. Also, we enrolled a convenience sample at one CR program and, given resource constraints, were not able to assess and

examine associations between the PYP and biomarkers of dietary intake. Thus, our findings may not generalize to other CR populations, although the demographics were similar to others reported.

CONCLUSIONS

Our results suggest the PYP is a valid and reliable dietary assessment tool for use in CR populations. These results support the use of the PYP in CR programs and have potential for use in the American Association of Cardiovascular and Pulmonary Rehabilitation registry with continued research in additional CR program populations.

ACKNOWLEDGMENT

This study was funded by the Center for Health Promotion and Disease Prevention and the Division of Cardiology at the University of North Carolina and the Sports, Cardiovascular and Wellness Nutrition (SCAN), dietetic practice group of the Academy of Nutrition and Dietetics. The authors thank Drs J. Beto, L. Van Horn, and R. Krauff and Ms C. To for their assistance.

REFERENCES

1. Aberegg ES. Nutritional guidelines. In: Ehrman JK, Savage PD, eds. *Guidelines for Cardiac Rehabilitation and Secondary Prevention*. Champaign, IL: Human Kinetics; 2020.
2. England CY, Andrews RC, Jago R, Thompson JL. A systematic review of brief dietary questionnaires suitable for clinical use in the prevention and management of obesity, cardiovascular disease and type 2 diabetes. *Eur J Clin Nutr*. 2015;69(9):977-1003.
3. Ammerman AS, Haines PS, DeVellis RF, et al. A brief dietary assessment to guide cholesterol reduction in low-income individuals: design and validation. *J Am Diet Assoc*. 1991;91(11):1385-1390.
4. Jilcott SB, Keyserling TC, Samuel-Hodge CD, Johnston LF, Gross MD, Ammerman AS. Validation of a brief dietary assessment to guide counseling for cardiovascular disease risk reduction in an underserved population. *J Am Diet Assoc*. 2007;107(2):246-255.
5. Rosamond WD, Ammerman AS, Holliday JL, et al. Cardiovascular disease risk factor intervention in low-income women: the North Carolina WISEWOMAN project. *Prev Med*. 2000;31(4):370-379.
6. Picture Your Plate. https://pictureyourplate.org. Accessed September 23, 2019.
7. US Department of Agriculture, US Department of Health and Human Services. *2015-2020 Dietary Guidelines for Americans*. 8th ed. Rockville, MD: Office of the Assistant Secretary for Health, Office of the Secretary, US Department of Health and Human Services; 2015.
8. Van Horn L, Carson JAS, Appel LJ, et al. Recommended dietary pattern to achieve adherence to the American Heart Association/American College of Cardiology (AHA/ACC) guidelines: a scientific statement from the American Heart Association. *Circulation*. 2016;134(22):e505-e529.
9. Schwingshackl L, Bogensberger B, Hoffmann G. Diet quality as assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and Health Outcomes: an updated systematic review and meta-analysis of cohort studies. *J Acad Nutr Diet*. 2018;118(1):74-100.e11.
10. Hu FB, Rimm E, Smith-Warner SA, et al. Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire. *Am J Clin Nutr*. 1999;69(2):243-249.
11. Readability Formulas. Automatic Readability Checker (our free text readability consensus calculator). http://www.readabilityformulas.com/free-readability-formula-tests.php. Accessed May 6, 2019.
12. Yuan C, Spiegelman D, Rimm EB, et al. Relative validity of Nutrient Intakes Assessed by Questionnaire, 24-Hour Recalls, and Diet Records as Compared With Urinary Recovery and Plasma Concentration Biomarkers: findings for women. *Am J Epidemiol*. 2017;187(5):1051-1063.
13. Harvard T. H. Chan School of Public Health Department of Nutrition. Directory listing of /health/FFQ/files. https://regepi.bwh.harvard.edu/health/FFQ/files. Accessed April 2, 2019.
14. Chiuve SE, Fung TT, Rimm EB, et al. Alternative dietary indices both strongly predict risk of chronic disease. *J Nutr*. 2012;142(6):1009-1018.
15. Fung TT, Chiuve SE, McCullough ML, Rexrode KM, Logroscino G, Hu FB. Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. *Arch Intern Med*. 2008;168(7):713-720.
16. Fung TT, Rexrode KM, Mantzoros CS, Manson JE, Willett WC, Hu FB. Mediterranean diet and incidence of and mortality from coronary heart disease and stroke in women. *Circulation*. 2009;119(8):1093-1100.
17. Lombard MJ, Steyn NP, Charlton KE, Senekal M. Application and interpretation of multiple statistical tests to evaluate validity of dietary intake assessment methods. *Nutr J*. 2015;14(1):40.
18. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. *Psychol Bull*. 1979;86(2):420-428.
19. Gordon NF, Salmon RD, Sperling LS, et al. Multicenter study of temporal trends in the achievement of atherosclerotic cardiovascular disease risk factor goals during cardiac rehabilitation. *J Cardiopulm Rehabil Prev*. 2017;37(1):11-21.
20. Gaalema DE, Savage PD, Leadholm K, et al. Clinical and demographic trends in cardiac rehabilitation: 1996-2015. *J Cardiopulm Rehabil Prev*. 2019;39(4):266-273.
21. US Department of Agriculture, Agricultural Research Service. What we eat in America, NHANES 2015-2016. https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/wweia-data-tables. Accessed May 6, 2019.