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Reliability and Predictive Validity of Caloric Intake Measures from the 24-Hour Dietary Recalls of Homebound Older Adults

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Abstract

24-hour dietary recalls are used frequently to study homebound older adults' eating behaviors. However, the reliability and predictive validity of this method have not been established in this population. The purpose of this study is to examine whether homebound older adults provide reliable and valid measures of total caloric intake in 24-hour dietary recalls. 230 homebound older adults were interviewed in their homes using a questionnaire to assess eating behaviors and factors that could affect those behaviors. Participants completed three 24-hour dietary recalls at baseline and again at 6-month follow-up. Two sub-samples were identified for analyses. For participants who were not hospitalized during the 6-month interval and had their weight measured at both assessments ($n = 52$), sufficient test-retest reliability of caloric intake was observed ($r = 0.59$); but caloric intake deficiencies relative to estimated energy requirements did not predict actual weight loss ($r = 0.08$). When this sample was supplemented with 91 participants who experienced any adverse event (weight loss of 2.5% or more, hospitalization, institutionalization, or mortality) in the 6-month period ($n = 143$), adverse events were more likely to occur for those with insufficient caloric intake (odds ratio = 3.49, $p = .009$), and in White participants compared to African American participants (odds ratio = 3.13, $p = 0.016$). Adequate test-retest reliability of the 24-hour dietary recall was demonstrated, but additional research with larger samples and longer follow-up intervals are needed to better evaluate the predictive validity of caloric intake measures for this population.

Keywords

reliability; validity; 24-hour dietary recall; older adults

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Introduction

Insufficient caloric intake in older adults is a serious problem and is related to unintentional weight loss, functional decline, morbidity, mortality, and quality of life (1,2,3,4,^{5,6,7,8,9,10,11,12}). It is important that reliable and valid methods be used to assess caloric intake in older adults, especially homebound older adults who are particularly vulnerable to experiencing under-eating.

24-hour dietary recalls are a widely used methodology for collecting data on eating behaviors and measuring caloric intake, including in homebound older adults (13,14,15,16,17). There are several advantages to the 24-hour recall (18). Thompson and Subar note that because responses are recorded by an interviewer, high levels of physical functioning and literacy of participants are not required. This reduces the potential for both nonresponse bias and respondent burden. Further, because the recall period is immediate, participants are able to recall most of the foods and beverages consumed in the preceding day. A final advantage pointed out is that because dietary recalls occur after the food has been consumed, the likelihood that these self-reports will interfere with typical dietary behavior is minimized.

There are also potential disadvantages to the use of 24-hour dietary recalls that frequently call into question their reliability or validity, especially among older adults (18). Because of knowledge, memory problems, or factors associated with the interview situation, individuals may not reliably report their food intake (18). Some research shows that the validity of dietary information collected from both older adults and younger adults are comparable to each other; and that recall can be enhanced by supplementing standard methods with memory strategies and probes (19,20). Studies conducted specifically with older adults generally have found that 24-hour recall estimates are similar to observed intakes (21,22). Similar to younger populations, those with lower actual intakes tend to over-report caloric intake, whereas those with higher actual intakes tend to under-report (21,22). We are unaware of any research that has examined the reliability or validity of self-reported caloric intake among homebound older adults—a population in which dietary recalls are frequently used. Assessment of reliability and validity is necessary to estimate the extent of bias of the 24-hour dietary recall in this population.

Reliability refers to the extent to which a measure yields the same results under similar circumstances; while validity refers to the extent to which a measure actually measures what it is designed to measure (23). Test-retest reliability is commonly used to estimate the reliability or stability of a measure by comparing the results of the same measure at two points in time. Test-retest reliability is an especially important consideration when data will be collected longitudinally to assess changes in intake over time. Predictive validity is a type of validity especially important in assessing 24-hour dietary recalls. Predictive validity evaluates whether a measure predicts an outcome that it would be expected to predict. In this study, we would expect that not consuming enough calories would predict subsequent adverse events such as weight loss.

The aim of this study was to examine the 6-month test-retest reliability and predictive validity of caloric intake measures from the 24-hour dietary recalls of homebound older adults. The focus of the study was on: 1) the test-retest reliability of self-reported caloric intake in order to examine the consistency of the measurement from baseline to six-months, and 2) the predictive validity of 24-hour dietary recalls by evaluating the effect of caloric intake deficiencies at baseline on observed weight loss and the occurrence of adverse events during the 6-month follow-up interval.

Methods

Sample and Design

Homebound older adults were enrolled in a longitudinal study designed to assess eating behaviors, factors associated with those eating behaviors, and health outcomes associated with those eating behaviors. The study protocol was reviewed and approved by the UAB Institutional Review Board. The sample and design are described in-depth in other papers (17,24,25). Briefly, in order to be eligible for the study participants had to be community dwelling, receiving Medicare home health services, able to communicate verbally with interviewers in English, free of significant cognitive impairment, free of terminal illness, and not receiving nutrition through a feeding tube.

230 participants were assessed at baseline, and 173 participants completed a 6-month follow-up assessment. 24-hour dietary recalls were collected at both assessments, and the actual weight of the participants was measured at both assessments for those who were able to stand.

Two sub-samples were drawn for the analyses. The first consisted of 52 participants who had actual measured weight at both interviews and who had not been hospitalized between the two assessments. Because recent hospitalization was found to be a strong predictor of undereating in the baseline analysis (17), participants who were hospitalized were excluded from this sub-sample in order to eliminate this known source of variability in the reliability analysis. This sub-sample was used to evaluate the test-retest reliability of caloric intake and the predictive validity of caloric intake deficiencies on actual observed weight loss over a 6-month period. This group was selected purposefully because these participants should have had relatively stable diets across the time period, making them good candidates for examining test-retest reliability.

The second sub-sample consisted of 143 participants who had measured weight at both interviews or had any adverse outcomes (i.e., weight loss of 2.5% or more of baseline body weight, hospitalization, long-term care institutionalization, or mortality) between baseline and the 6-month assessment. This sub-sample was used to evaluate predictive validity only. Because weight loss is not the only adverse outcome that participants may experience as a consequence of under-eating, this larger sub-sample may be more a more sensitive and comprehensive way to evaluate predictive validity because of its inclusion of other important competing hazards.

Procedure and Measures

24-hour dietary recalls—During structured interviews in the participants' homes, 24-hour dietary recalls were conducted using standard protocols (26). Interviewers were formally trained in the 24-hour recall methods at the Nutrition Coordinating Center at the University of Minnesota. The recalls were conducted using standardized probing questions, two-dimensional food models to estimate portion size, and a multiple-pass methodology. The interviewer inspected refrigerators and kitchen storage space to better determine foods actually eaten by participants and the materials in which they were prepared or consumed; and, if necessary, caregivers provided supplementary information. Participants were contacted by telephone two more times over the next two weeks to obtain two additional 24-hour dietary recalls, one of which was obtained for a weekend day. Mean daily caloric intake was obtained by taking the average of the three 24-hour dietary recalls.

Caloric intake discrepancy and under-eating—Caloric intake discrepancy and under-eating were defined as the difference between a participant's mean daily caloric intake and his/her Estimated Energy Requirements (EER) at baseline. Caloric intake discrepancy is the actual

difference measured as a continuous variable and under-eating was a dichotomized variable (described below). EER is calculated based on a formula established by the Institute of Medicine (27). For women, the formula is: Energy (kcal)=354.1-(6.91×Age[y])+Physical Activity Coefficient[1 for sedentary] ×(9.36×Weight[kg]+726×Height[m]); For men, the formula is: Energy (kcal)=661.8-(9.53×Age[y])+Physical Activity Coefficient[1 for sedentary] ×(15.91×Weight[kg]+539.6×Height[m]). Depending upon the analyses, the difference between mean daily caloric intake and EER was analyzed as a continuous variable reflecting caloric intake discrepancy or was coded as a dichotomous variable, under-eating (yes/no), indicating whether a person was not consuming enough calories to maintain his/her current body weight.

Weight Loss—Weight change was derived by subtracting a participant's actual baseline weight from their 6-month weight. Weight change was analyzed both as a continuous variable in kilograms and as a dichotomous variable, indicating whether a participant experienced weight loss that was equal to or greater than 2.5% of their baseline weight.

Other Adverse Outcomes—Adverse outcomes included the participant experiencing any one of the following events between baseline and the 6-month assessment: hospitalization, institutionalization (either nursing home or assisted living facility), mortality, or loss of weight of 2.5% or more of their baseline body weight; and was coded as a dichotomous variable.

Control Variables—We controlled for body mass index (BMI), comorbidity, age, gender, and ethnicity in our analyses. BMI was assessed by obtaining height and weight on all participants who were able to stand (55% of 230 participants) and categorized according to NHLBI Clinical Guidelines(28). For those who were unable to stand, self-report of height and weight was obtained. Comorbidity was assessed using the Charlson Comorbidity Index (29, 30,31). Age, gender, and ethnicity were assessed by self-report.

Statistical Methods

Data analyses were performed using SAS version 9.1. Descriptive statistics were completed first to characterize the sub-samples.

Test-retest reliability was assessed with the Pearson product-moment correlation between the means of the 24-hour dietary recalls at baseline and the 6-month assessment using the first sub-sample of 52 participants.

Predictive validity of the 24-hour dietary recall was tested initially in a Pearson's correlation analysis by comparing caloric intake discrepancy and weight loss, and then, by generalized linear models (GLM) and logistic regression models that assessed the effects of under-eating on weight loss of 2.5% or more, while controlling for other variables. These analyses were performed for the sub-sample of 52 participants. The numeric value of observed weight change (6-month weight minus baseline weight) was used in the GLM procedure, whereas a categorical weight loss variable of 2.5% or more of baseline body weight was used in the logistic regression models.

Next, logistic regression models were examined to assess the multivariate effects of under-eating on adverse outcomes, while controlling for other variables. These analyses were performed using the second analytic sub-sample of 143 participants.

Results and Discussion

Descriptive statistics

Table 1 presents baseline characteristics for the two analytical samples. The subgroup of 52 participants was similar to the group of 143 participants. However, the group of 143 had a higher average caloric intake discrepancy than the group of 52. At the 6-month follow-up, 25% of the 52 participants and 37.8 % of the 143 had weight loss of 2.5% or more of baseline body weight. Additionally, for the 143 participants, 28 had been hospitalized, 5 were institutionalized, and 56 died.

Test-Retest Reliability

Pearson's correlation coefficient shows a statistically significant linear relationship between caloric intake at baseline and 6 months for the subgroup of 52 ($r = 0.59$, $p < 0.0001$). Our findings indicate that there exists substantial test-retest reliability over a 6-month time period for total caloric intake measures obtained from homebound older adults using 24-hour dietary recalls ($r = 0.59$). This relationship was true for participants who were not hospitalized and who had two measured weights at both baseline and the 6-month assessment. These findings are consistent with previous reports in the literature of young and middle-aged adults, including studies reporting test-retest correlations ranging from 0.40 to 0.92 (32,33,34,35).

Predictive Validity

A low and non-significant correlation was observed between caloric intake discrepancy (baseline caloric intake minus EER) and weight loss for the subgroup of 52 ($r = 0.08$, $p = 0.58$). Table 2 presents the relationships between weight loss and under-eating for the subgroup of 52 participants. In both regression analyses, under-eating was not associated with observed weight loss.

Table 3 presents the multivariate effects of predictors on adverse outcomes for the subgroup of 143 participants. While controlling for other variables that might affect outcomes, participants who were under-eating were 3.5 times more likely to experience an adverse outcome ($p = 0.009$) compared with those who were not under-eating.

Concerning predictive validity, we hypothesized that a relationship would exist between caloric intake discrepancy (caloric intake minus EER) and observed weight loss in the homebound older adults. Because of their frailty and already compromised health status, the criteria of actual measured weight and non-hospitalization were used to identify a subgroup that we speculated may have been more reliable to study the predictive validity of self-reported caloric intake. Our findings, however, revealed a low correlation between caloric intake discrepancy and actual weight loss in the subsample of 52 participants. Further, there was no association between caloric intake discrepancy and weight loss in either the logistic regression or GLM analyses for this subsample. Although the odds ratio of 2.06 in the logistic regression analysis was in the predicted direction, the p -value was not significant.

Because those who were unable to be weighed or who had been hospitalized were excluded from the smaller sub-sample, our power to detect predictive effects may have been limited by the decision to exclude those who were more frail or more ill. This assumption was confirmed by our analyses conducted on the larger sub-sample of 143, which combined mortality with weight loss, hospitalization, and institutionalization as a more complex composite adverse outcome measure. In these analyses, under-eating was clinically and statistically associated with adverse outcomes.

Summary Statement

This study is the first to examine the reliability and predictive validity of caloric intake measures from the 24-hour dietary recalls of homebound older adults. While the reliability results are encouraging, the validity analyses were limited by the relatively small sample size. Our other analyses and findings have suggested that future studies might use larger sample sizes with better control of caloric intake underreporting, to examine the relationship between weight loss and caloric intake discrepancy in longitudinal studies with more repetitive observations. Future studies might also investigate further the effects of under-eating on mortality or other adverse outcomes through the intervening effect of under-eating on unintentional weight loss.

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Table 1

Descriptive Statistics for Subgroups of Participants

Variables	Subgroup (Mean (SD) or N (%))	
	N=52 ^a	N=143 ^b
Age	81.0 (8.5)	79.5 (8.7)
Gender		
Female	38 (73.1)	106 (74.1)
Male	14 (26.9)	37 (25.9)
Ethnicity		
African American	23 (44.2)	49 (34.3)
White	29 (55.8)	94 (65.7)
Charlson Comorbidity Index	3.1 (2.2)	3.7 (2.7)
Weight at Baseline	72.7 (19.8)	76.7 (22.6)
Weight at 6-month	73.7 (20.0)	75.0 (22.3)
Caloric intake at Baseline	1672 (493.9)	1527 (469.8)
Caloric intake at 6-month	1653 (464.6)	1633 (494.4)
Body Mass Index at Baseline		
Underweight	3 (5.8)	10 (7.0)
Normal Weight	26 (50)	62 (43.4)
Overweight	12 (23.1)	33 (23.1)
Obese Class I	2 (3.9)	15 (10.5)
Obese Class II or III	9 (17.3)	23 (16.1)
Body Mass Index at 6-month		
Underweight	2 (3.9)	6 (5.0)
Normal Weight	24 (46.2)	56 (46.7)
Overweight	12 (23.1)	24 (20.0)
Obese Class I	5 (9.6)	18 (15.0)
Obese Class II or III	9 (17.3)	16 (13.3)
Caloric Intake Discrepancy (kcal/day)	-84 (559.6)	-275 (614.6)
Under-Eating	31(60)	97(68)

^a Participants who had actual measured weight at both baseline and six-month and who had not been hospitalized between baseline and six-month

^b Participants who either had any adverse outcomes between baseline and six month or had measured weight at both times

Table 2
Generalized Linear and Logistic Regression Models of Weight Loss for the Subgroup of 52 Participants

Predictor	Generalized Linear Model		Logistic Regression Model			
	Estimate	p	Estimate	Odds-ratio	95% CI	p
Under-eating (Yes vs. No)	-0.316	0.808	0.7217	2.06	0.58-7.35	0.267
BMI at Baseline	-0.083	0.378	-0.0072	0.99	0.90-1.09	0.880
Gender (Male vs. Female)	0.803	0.550	0.1723	1.19	0.34-4.12	0.786
Ethnicity(AA vs. White)	2.405	0.046*	-0.9428	0.39	0.12-1.28	0.119
Age	-0.017	0.802	0.0014	1.00	0.94-1.07	0.967

* p<0.05

Table 3

Logistic Regression Models for Multivariate Effects of Predictors on Adverse Outcomes^a for the Subgroup of 143 Participants

Predictor	Multivariate Model			
	Estimate	Odds-ratio	95% CI	p
Under-eating (Yes vs. No)	1.251	3.49	1.37-8.91	0.009**
Gender (Male vs. Female)	-0.393	0.68	0.25-1.80	0.432
Ethnicity (AA vs. White)	-1.126	0.32	0.13-0.81	0.016*
Age	-0.019	0.98	0.93-1.03	0.453
Charlson Comorbidity Index	0.096	1.10	0.93-1.30	0.253
BMI Category				
<18.5 vs. 18.5-25	0.718	2.05	0.39-10.89	0.400
25-30 vs. 18.5-25	0.252	1.29	0.46-3.61	0.633
30-35 vs. 18.5-25	1.047	2.85	0.51-15.80	0.231
>35 vs. 18.5-25	-0.581	0.56	0.16-1.97	0.366

^a Adverse outcomes included death, weight loss of 2.5% or more of baseline body weight, hospitalization, longer-term care institutionalization

* p<0.05

** p<0.01