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Literacy, Numeracy, and Portion-Size Estimation Skills

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Abstract

Background—Portion-size estimation is an important component of weight management. Literacy and numeracy skills may be important for accurate portion-size estimation. It was hypothesized that low literacy and numeracy would be associated with decreased accuracy in portion estimation.

Methods—A cross-sectional study of primary care patients was performed from July 2006 to August 2007; analyses were performed from January 2008 to October 2008. Literacy and numeracy were assessed with validated measures (the Rapid Estimate of Adult Literacy in Medicine and the Wide Range Achievement Test, third edition). For three solid-food items and one liquid item, participants were asked to serve both a single serving and a specified weight or volume amount representing a single serving. Portion-size estimation was considered accurate if it fell within ±25% of a single standard serving.

Results—Of 164 participants, 71% were women, 64% were white, and mean (SD) BMI was 30.6 (8.3) kg/m^2. While 91% reported completing high school, 24% had <9th-grade literacy skills and 67% had <9th-grade numeracy skills. When all items were combined, 65% of participants were accurate when asked to serve a single serving, and 62% were accurate when asked to serve a specified amount. In unadjusted analyses, both literacy and numeracy were associated with inaccurate estimation. In multivariate analyses, only lower literacy was associated with inaccuracy in serving a single serving (OR=2.54; 95% CI=1.11, 5.81).

Conclusions—In this study, many participants had poor portion-size estimation skills. Lower literacy skills were associated with less accuracy when participants were asked to serve a single serving. Opportunities may exist to improve portion-size estimation by addressing literacy.

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Introduction

Following dietary recommendations is an effective component of prevention and treatment for many common diseases.[1] The current super-sizing of many foods may lead Americans to overestimate what a normal portion should be,[2–4] and the overestimation of portion size may lead to overeating and contribute to obesity.[5–8] Patients with diabetes or other chronic illnesses often require accurate portion-size estimation to assess carbohydrate or other nutrient intake.[9] In addition, dietitians and other healthcare providers often rely on portion size to communicate with patients.[9]

In the U.S., it is estimated that more than 90 million people have low literacy skills, and 110 million have low numeracy skills.[10] Patients with low literacy skills can have difficulty following medical instructions, understanding health information, and performing self-management tasks, leading to decreased disease knowledge and poorer clinical outcomes.[11–14] Numeracy is an important component of literacy, and recent studies have suggested that lower literacy or numeracy skills are associated with a poorer understanding of food labels, poorer performance of diabetes-related self-management tasks, and increased BMI.[15–17] Numeracy skills are important for estimation, measurement, and understanding spatial relationships.[18] Literacy and numeracy skills are crucial for interpreting nutrition information, but have not been well-studied in that context.[14,15] This study sought to determine individuals' ability to estimate portion size and to evaluate the relationship between portion-size estimation skills and literacy and numeracy skills.

Methods

Patients aged >18 years who presented for routine visits at an academic primary care clinic were referred by clinic staff for possible participation in this study. Exclusion criteria included dementia, the inability to speak English, and corrected visual acuity ≥20/50 as measured by a Rosenbaum pocket vision screener. Participants were enrolled between July 2006 and August 2007. Participants gave verbal consent and received $20 after study completion, which took approximately 45 minutes. This study was approved by the IRB of Vanderbilt University.

Measures

Demographic and anthropometric information was obtained from patient interview. Patients completed a questionnaire about dietary habits and education. Literacy was measured using the Rapid Estimate of Adult Literacy in Medicine (REALM), a validated measure of health literacy.[19] Numeracy was assessed with the Wide Range Achievement Test, third edition (WRAT-3),[20] a well-validated measure to assess general numeracy skills.

Portion-size estimation was assessed by asking participants to serve three solid-food items and one liquid item. The items were pasta (standard serving size: 1 cup, or 140g); canned pineapple (standard serving size: ½ cup, or 90.5g); cooked ground beef (standard serving size: 3 oz., or 84g); and cranberry juice (standard serving size: 8 oz., or 236g). Standard serving sizes were based on guidelines of the U.S. Food and Drug Administration and the U.S. Department of Agriculture.[21,22] For each item, participants were given three directions: (1) *Serve how much of this food you normally eat in a typical meal*; (2) *Serve what you think is a standard serving size of this food* (Question 1); and (3) *A standard serving size is equal to ___ (e.g., ½ cup for canned fruit). Please show us how much this is* (Question 2). Participants completed the three directions for each food item prior to proceeding to the next item.

Participants were asked to serve each food item from a large container (64 oz.) onto a 12-inch plate or into a 16-oz. cup. Each amount served was weighed, using a Salter digital diet scale. Participants were asked to rate how much they liked each food item and how many times per

week they ate the item. To minimize response bias, participants were not told the scale weights or their accuracy.

Statistical Analysis

Analyses were performed from January 2008 to October 2008 using Stata version 9.2. Descriptive analyses of all variables were performed. Numeracy and literacy skills were examined as categorical variables, categorized a priori as <9th grade or ≥9th grade. The WRAT-3 scores were standardized for age.

There is no accepted definition of portion-size accuracy. Accuracy within 25% was explored for associations with literacy and numeracy, as determined a priori. This value was chosen for further exploration because the authors believe it to be the most clinically relevant. The weights for each item served by the participants for each question were divided by the standard serving size, creating a standardized score with 1 equal to the standard serving size. To examine a participant's overall portion-size estimation skills for a simulated meal, the standard servings for the four food items were averaged to create the average standardized serving for each question. Participants were then categorized as under (average standardized serving <0.75); accurate (average standardized serving 0.75–1.25); or over (average standardized serving >1.25).

Characteristics of participants who served more or less than 25% of a standard serving size were analyzed using the Kruskal–Wallis test or Fisher's exact test, as appropriate. The association with average-standardized-serving category and continuous variables was explored, using the Kruskal–Wallis test for each question. If the variable differed by the average-standardized-serving category, then pair-wise comparison testing was performed, using Wilcoxon rank sum. Overestimators or underestimators were compared to those accurate within 25%. Similar methods were used when testing categorical variables, except that Fisher's exact test was used for the pair-wise comparison test. A Bonferroni correction for the two tested hypotheses was applied to the *p*-value for multiple comparisons.

Multivariate logistic regression analyses were performed for Questions 1 and 2 to examine associations of characteristics with portion-size accuracy. The model included literacy and numeracy as well as age; gender; race (dichotomized as white and nonwhite); income (dichotomized as <$20,000 per year or ≥$20,000 per year); BMI (kg/m^2); and previous portion-size education. The outcome of each model was accuracy (±25% of the standard serving) compared to inaccuracy (overestimation or underestimation).

Results

From July 2006 to August 2007, a total of 248 patients were referred for possible study participation. Of these, 77 declined to participate because of time constraints or lack of interest; two patients were ineligible because of the inability to speak English or poor vision. Of the 169 who consented to participate, 164 (97%) completed the study.

Participant characteristics are presented in Table 1. The mean age (SD) was 46 (16) years; 71% were women, 64% were white, and 24% reported yearly income of <$20,000. Ninety-one percent of participants reported completing high school. Twenty-four percent had <9th-grade literacy skills as assessed by the REALM, and 67% had <9th-grade numeracy skills as measured by the WRAT-3. The mean BMI (SD) was 30.6 (8.3) kg/m^2. The majority of participants reported having received nutrition education, and half stated that they were specifically educated in portion-size estimation. Twenty percent stated that they routinely measured the portions of their food.

Participant characteristics associated with portion-size estimation skills are shown in Table 2. When asked to estimate a single serving (Question 1), 65% of participants were accurate for all four combined food items. For individual food items, accuracy ranged from 34% (for pasta) to 56% (for pineapple). In unadjusted analyses, participants who overestimated were more likely to have lower literacy or numeracy skills than those who estimated accurately (55% vs 17%, $p>0.001$; 95% vs 65%, $p=0.008$, respectively). When asked to serve the specific amount of a standard serving (Question 2), 62% were accurate for all four combined food items. For individual food items, accuracy ranged from 30% (for beef) to 53% (for juice). In unadjusted analyses, low literacy—but not low numeracy—was associated with inaccuracy (47% vs 27%, $p=0.007$; 87% vs 65%, $p=0.24$, respectively). In pair-wise comparison, low literacy did not remain significantly associated with inaccuracy ($p=0.064$). There was no significant relationship between participants' preference for or frequency of use of each food item and accuracy of their portion-size estimation.

In multivariate analyses, higher literacy was associated with 2.5-fold higher odds of accuracy compared to inaccuracy when participants were asked to serve a single serving (OR=2.54; 95% CI=1.11, 5.81; $p=0.027$; Table 3). No significant relationships were found when participants were asked to serve the specified amount of a single serving.

Discussion

Portion-size estimation is an important component of weight management and the management of other chronic illnesses. In this study, it was found that many participants had poor portion-size estimation skills. In unadjusted analyses, both literacy and numeracy were associated with overestimation when participants were asked to serve a single serving; however, in multivariate analyses, only literacy remained significantly associated. Inaccuracy in portion-size estimation was not associated with other patient characteristics.

Low literacy and numeracy skills were common in this study, as in others.[11,14,15] It would be expected that such skills are important for a host of nutrition- and weight-related self-management behaviors. The interpretation of food labels is strongly associated with both literacy and numeracy skills.[15] After a consumer correctly interprets food labels, he or she must still estimate portion sizes to meet dietary intake goals. This study found that low literacy skills were associated with the overestimation of portions when participants were asked to serve a single portion. However, low literacy skills were not associated with overestimation when participants were asked to serve a specified amount. The order in which the questions were asked also may have affected the results; participants were asked to measure a specific quantity (Question 2) as they finished dealing with each food item, and participants tended to serve themselves less food with each successive question. This finding also may indicate that patients with low literacy have less knowledge about the specific amount of a single portion and that, once informed, they are better able to accurately estimate portion size. The lack of association between portion-size estimation accuracy and numeracy may be due to the high prevalence of low numeracy in this study, leaving it underpowered to detect a significant association.

This study has several limitations. First, because it is cross-sectional, causation should not be inferred. Power is limited by the small sample size. Social-desirability bias may have caused participants to alter their servings to a perceived socially acceptable amount.[23] The size of the containers may have created an artificial upper limit. Also, because of time limitations, participants were asked to serve each item once per question. A mean of several measurements would allow a better understanding of a participant's ability to estimate portion sizes.

Portion-size estimation is important in medical nutrition therapy for a variety of chronic illnesses. The identification of patients who are unable to estimate portion sizes accurately and the use of tailored education interventions or compensation—such as clear instructions about the specific amount of a serving and the appropriate use of measuring cups or divided plates—may help patients achieve dietary recommendations. Low literacy skills are associated with inaccuracy in the estimation of portion sizes. More work is needed to understand the role of literacy in portion-size education.

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Table 1

Participant characteristics (*n*=164)

Characteristic	*n* (%)[a]
Age (years), M±SD	45.8±5.5
Female	116 (71)
Nonwhite race	59 (36)
Education (years), M±SD	14.2±2.9
Annual income <$20,000	38 (24)
Literacy status (REALM)	
<9th grade	39 (24)
≥9th grade	125 (76)
Numeracy status (WRAT-3)	
<9th grade	110 (67)
≥9th grade	54 (33)
BMI, M±SD	30.6±8.3
Hypertension	62 (38)
Diabetes	28 (17)
Hyperlipidemia	42 (26)
Coronary artery disease	12 (7)
Ever been on a diet	75 (46)
Prior nutrition education	88 (54)
Prior portion-size education	82 (50)
Currently measures portions	30 (20)

[a] Unless otherwise noted

REALM, Rapid Estimate of Adult Literacy in Medicine; WRAT-3, Wide Range Achievement Test 3

Table 2

Participant characteristics by accuracy of a single serving and the specified amount of a serving

	Question 1: Serve a single serving				Question 2: Serve a specified amount			
	≤25% of standard serving *n* (%)[a]	Within 25% of standard serving *n* (%)[a]	>25% of standard serving *n* (%)[a]	*p*-value[b]	≤25% of standard serving *n* (%)[a]	Within 25% of standard serving *n* (%)[a]	>25% of standard serving *n* (%)[a]	*p*-value[b]
Participants	36 (22)	106 (65)	22 (13)		48 (29)	101 (62)	15 (9.2)	
Age (years), M±SD	51±17	45±16	44±11	0.2	46±16	47±16	39±13	0.18
Female	32 (89)	74 (70)	10 (45)	0.002	37 (77)	72 (72)	7 (47)	0.087
Nonwhite race	12 (33)	34 (32)	13 (59)	0.068	12 (33)	36 (36)	10 (67)	0.025
Completed high school	30 (83)	97 (92)	21 (95)	0.33	47 (98)	89 (88)	12 (80)	0.33
Prior portion-size education	21 (58)	52 (50)	9 (41)	0.45	28 (58)	50 (50)	4 (27)	0.10
Measures portions	8 (22)	23 (22)	2 (9)	0.42	13 (27)	18 (18)	2 (13)	0.40
Low literacy[c]	9 (25)	18 (17)	12 (55)[e]	0.001	5 (10)	27 (27)	7 (47)	0.007
Low numeracy[d]	20 (55)	69 (65)	21 (95)[e]	0.002	32 (67)	65 (65)	13 (87)	0.24
BMI (kg/m^2), M±SD	29.4±6.5	30.5±8.5	32.7±10	0.48	29.7±8.7	30.8±7.7	31.5±11	0.45

Note: Standard serving size calculated by dividing the participant's serving by the weight of the standard serving.

[a] Unless otherwise noted

[b] *p*-value, if significant, for performed Kruskal–Wallis pair-wise comparison

[c] Low literacy is <9th-grade literacy skills, according to the Rapid Estimate of Adult Literacy in Medicine.

[d] Low numeracy is <9th-grade numeracy skills, according to Wide Range Achievement Test 3.

[e] Pair-wise comparison to accurate group <0.05 after Bonferroni adjustment for two hypotheses tested

Table 3

Association of patient characteristics with accuracy compared to inaccuracy

Characteristics	Question 1: Serve a single serving OR (95% CI)	Question 2: Serve a specified amount OR (95% CI)
Literacy		
<9th grade	ref	ref
≥9th grade	2.60 (1.10, 6.19)	0.53 (0.22, 1.30)
Numeracy		
<9th grade	ref	ref
≥9th grade	0.95 (0.42, 2.13)	1.64 (0.75, 3.58)
Age[a]	0.98 (0.96, 1.00)	1.00 (0.98, 1.03)
Gender		
Female	ref	ref
Male	1.16 (0.54, 2.51)	0.88 (0.42, 1.83)
Race		
White	ref	ref
Nonwhite	0.67 (0.29, 1.56)	1.01 (0.45, 2.30)
Income		
<$20,000 per year	ref	ref
≥$20,000 per year	0.87 (0.36, 2.11)	0.93 (0.39, 2.22)
BMI (kg/m^2)[b]	1.01 (0.96, 1.05)	1.01 (0.97, 1.06)
Prior portion-size education		
No	ref	ref
Yes	0.93 (0.46, 1.88)	0.91 (0.46, 1.81)

[a] OR compared to 1-year higher age

[b] OR compared to 1-kg/m^2 higher BMI