Original Article

Access this article online

Quick Response Code:

Website: www.jehp.net

DOI: 10.4103/jehp.jehp_632_20

Establishing criterion validity for the Revised Critical Nutrition Literacy Tool in U.S. college students

Janette Bedoyan, Jade McNamara[1], Melissa D. Olfert[2], Carol Byrd-Bredbenner[3], Geoffrey W. Greene

Abstract:

BACKGROUND: Critical nutrition literacy (CNL) plays an important role in how college students make everyday decisions about nutrition choices. Increasing CNL is an aim of many introductory nutrition courses, but there are limited instruments measuring this construct. This study aimed to assess the changeability of CNL and the relationship between CNL and markers of diet quality in young adults.

DESIGN: This was a two-phase research project consisting of a nonexperimental, pre–post study and a cross-sectional assessment from 2018 to 2019. Participants were U.S. college students, 18-24 years old, recruited from introductory-level courses from three participating universities, located in Rhode Island, West Virginia, and New Jersey.

SUBJECTS AND METHODS: Interventions consisted of (1) a 4-credit, 13-week nutrition course and (2) a cross-sectional, online behavior, environment, and perception survey. CNL was measured using the Revised CNL Tool (CNLT-R) instrument across both phases. Measures for phases include: (1) the changeability of CNL and (2) the relationship between CNL and markers of diet quality.

ANALYSIS: Paired *t*-tests and multivariate analysis of variance were utilized through SPSS version 25.0.

RESULTS: CNL score significantly increased from baseline to postintervention from 3.38 ± 0.48 to 3.61 ± 0.55 ($P = 0.014$). There was an overall significant effect of CNL on markers of diet quality, such as cups of fruits and vegetables (F/V) and teaspoons of added sugar ($F [2,1321] = 3.12$, $P < 0.05$; Wilks' $\Lambda = 0.99$).

CONCLUSIONS: This research found that an introduction to nutrition course was associated with an increase in CNL and that CNL is related to diet quality. The instrument could be used by nutrition educators as an outcome assessment. Future research should investigate other components of the CNL construct as well as predictive validity.

Keywords:

Decision-making, health behavior, health education, health literacy, young adult

Department of Nutrition and Food Sciences, University of Rhode Island, Kingston, RI, USA, [1]School of Food and Agriculture, University of Maine, Orono, ME, USA, [2]Division of Animal and Nutritional Sciences, Davis College of Agriculture, Natural Resources, and Design, West Virginia University, Morgantown, WV, USA, [3]Department of Nutritional Sciences, Rutgers, The State University of New Jersey, New Brunswick, NJ, USA

Address for correspondence:
Ms. Janette Bedoyan, Department of Nutrition and Food Sciences, University of Rhode Island, 125 Fogarty Hall, 41 Lower College Rd, Kingston, RI 02881, USA.
E-mail: jnbedoya@uri.edu

Received: 06-06-2020
Accepted: 16-12-2020
Published: 28-01-2021

Introduction

Limited health literacy among adults is a public health problem.[1-5] Health literacy, the collection of skills necessary for accessing, understanding, and processing health information,[2] is essential for making important health decisions and can lead to better health outcomes.[6-12] Although research in health literacy has grown exponentially, most studies do not explicitly focus on topics of nutrition- or food-related outcomes.[13,14] Nutrition literacy, a more specific set of abilities defined by Velardo[14] and derived from Nutbeam's[2] definition of health literacy, is concerned with the ability to understand basic nutrition information and services needed to make appropriate nutrition decisions.[13-15] Nutrition literacy

How to cite this article: Bedoyan J, McNamara J, Olfert MD, Byrd-Bredbenner C, Greene GW. Establishing criterion validity for the Revised Critical Nutrition Literacy Tool in U.S. college students. J Edu Health Promot 2021;10:37.

is important to examine because limited research has focused on the role of health literacy in the context of nutrition-related and dietary behaviors and how these behaviors can lead to better management and decreased risk of nutrition-related diseases.

Currently, three levels of nutrition literacy have been defined: functional nutrition literacy (applying basic information through reading and writing), interactive nutrition literacy (translating knowledge into behavior), and critical nutrition literacy (CNL) (critically analyzing information and social engagement).[2,13,14] Previous studies have established that functional and interactive nutrition literacy are indicators of diet quality[16,17] and can be improved after participating in nutrition programming.[18-20] Although a recently developed instrument (Revised CNL Tool [CNLT-R]) was found to have strong psychometric properties through exploratory and confirmatory factor analysis determining validity and reliability,[21] to the authors' knowledge, no studies have investigated the changeability of CNL and the relationship between CNL and indicators of diet quality. Exploring these relationships will provide guidance on the development of future healthful eating interventions directed at college students.

CNL involves the use of critical appraisal skills. Critical appraisal requires consumers to consider information, interpret facts, identify what is most important, weigh different options, and then bring all evidence together to form a choice.[22,23] Researchers have found that college students who have stronger critical appraisal skills made fewer poor decisions in everyday life and were less likely to take big risks.[24] These findings and others suggest that having stronger critical appraisal skills may result in better decisions for everyday tasks.[10,12,24] Although critical appraisal skills can be improved in student courses,[10,24,25] and the related construct of critical health literacy has been found to be associated with improved health outcomes,[26] the specific area of CNL has not been studied previously. Assessing the criterion validity of the CNLT-R could allow educators to use the instrument as a measure of critical appraisal skills related to everyday decisions about nutrition choices.

Thus, the purpose of this research was to measure CNL using the CNLT-R in U.S. college students to understand the changeability of CNL in a pre–post design and the relationship between CNL and diet quality in a larger sample of young adults. The first phase of the study will determine if an introductory-level nutrition course designed to increase nutrition knowledge will increase CNL. The second phase will examine the relationship between CNL and markers of diet quality to determine if higher CNL is associated with better diet quality. These two phases will provide the initial criterion validity of the CNLT-R.

Subjects and Methods

For this study, the CNLT-R was used to assess CNL. The initial version of the CNLT was developed and validated by Guttersrud *et al*.[27] using university nursing students in Norway. This tool was designed with two scales to assess nursing students' social engagement in promoting healthful eating behavior (engagement scale) as well as their ability to take a critical stance toward nutrition claims and their sources (claim scale).[27] McNamara psychometrically validated the 11-item claim scale of the CNLT in a cross-sectional convenience sample of approximately 1700 U.S. college students.[21] Validation resulted in a 7-item instrument CNLT-R, with two factors: (1) critical appraisal of media sources (Cronbach's alpha [α] = 0.73) and (2) critical appraisal of evidence-based nutrition sources (α = 0.64). The overall 7-item instrument was found to have sound psychometrical validity and reliability (α = 0.69).

Details of the methods are presented by phase [Figure 1]. It was hypothesized in Phase 1 that participants will increase CNL scores after participation in a nutrition course. In Phase 2, participants with higher CNL will consume a more healthful diet than participants with lower CNL. The study was approved and accepted by the University of Rhode Island (URI) Institutional Review Board (7/25/2018), IRB # HU1616-142.

Phase 1: To determine if a college-level introductory nutrition course with a required laboratory component is associated with an increase in critical nutrition literacy

The design of Phase 1 was a nonexperimental, pre–post study design of a 4-credit, 13-week, academic course intervention in a sample of college students from URI enrolled in Applied General Nutrition, an

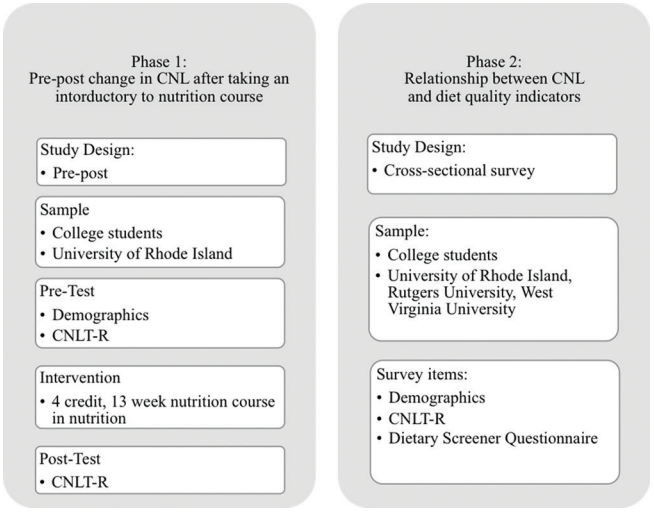

Figure 1: Study implementation

introductory-level nutrition course. Students who consented to participate in research completed a pre- and posttest that was administered online and consisted of questions assessing CNL and demographics. The posttest was administered at the end of the course.

The applied general nutrition course, taught by a registered dietitian, aims to increase students' nutrition knowledge with application to the individual, community, and beyond. The course is comprised of: two, 1¼-h lectures weekly, and weekly 1-h and 50-min laboratories throughout the semester. Students learn basic concepts in lecture and apply these concepts in the hands-on laboratory. Course content focuses on how nutrients are digested, absorbed, metabolized, and utilized as well as how to apply this information to analysis of dietary intake, energy balance, and disease prevention. Goals of the course included demonstrating knowledge and understanding regarding (1) the classes of nutrients and their functions and sources, (2) credible and noncredible diet-related information, and (3) basic concepts of planning healthy dietary intake, including the U.S. Dietary Guidelines, MyPlate, and food label reading.

Phase 1 sample

Participants were recruited in the spring of 2019. Recruitment was conducted by making classroom announcements. Eligibility criteria included: participants were students attending URI, 18–24 years of age, consented to be included in the study, and provided the data for the CNLT-R scale. All procedures were approved by the Institutional Review Board at URI.

Phase 1 methods

CNL was measured using the CNLT-R.[21] Examples of the items include, "I have confidence in the various diets that I read about in newspapers, magazines, etc." and "I am concerned that the dietary information that I read may not be based on science." Items were evaluated using a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. The responses of the 7 items were averaged, producing an overall CNL score ranging from 1 to 5, where 1 indicated lower CNL and 5 indicated higher CNL.

Phase 1 analysis

For Phase 1, data were analyzed in SPSS version 25.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Armonk, NY, USA). Any missing responses or selection of "choose not to answer" were excluded from data analysis. Descriptive variables were found to be normally distributed.[28] Baseline differences were assessed by Chi-square for categorical variables and independent *t*-tests for continuous data. *T*-tests were used to assess if students increased their CNL score after completing the course.

Phase 2: To evaluate if critical nutrition literacy is associated with markers of diet quality

Phase 2 was an analysis of a cross-sectional survey of college students from three different northeastern universities: URI, West Virginia University (WVU), and Rutgers University (Rutgers). Students participated in an online survey that assessed students' health-related behavior[29] and CNL using the CNLT-R.[21] This survey also included dietary assessment and demographics. Among demographic variables, students specified whether they lived on or off campus. For all three universities, living on campus requires a meal plan.

Phase 2 sample

Participants were recruited in the spring of 2018. Recruitment methods varied depending on the university, for example, sending out a campus-wide link advertising the survey, making classroom announcements, and providing incentives such as extra credit opportunities. Eligibility criteria for this phase were as follows: students attending one of the three universities, 18–24 years of age, and provided informed consent. All procedures were approved by the Institutional Review Boards at each of the participating universities.

Phase 2 methods

Dependent variables

Fruit and vegetable (F/V) and added sugar consumption was measured using the National Cancer Institute (NCI) Dietary Screener Questionnaire.[30] Participants' daily F/V intake is reported in cup equivalents based on NCI scoring procedures for 10 items.[31] The added sugar variable is reported in teaspoon equivalents per day based on 8 items.

Independent variable

CNL was measured using the CNLT-R.[21] CNL scores were then divided into tertiles to produce three equally distributed groups of participants where a score of 1.0–3.21 indicated lower CNL, 3.21–3.79 indicated moderate CNL, and 3.79–5.0 indicated higher CNL.

Phase 2 analysis

For Phase 2, data were analyzed in SPSS version 25.0. Any missing responses or selection of "choose not to answer" were excluded from data analysis. Descriptive variables were found to be normally distributed.[28] Baseline differences between completers and noncompleters and between universities were assessed by Chi-square for categorical variables and univariate analysis of variance (ANOVA) for continuous data. To examine the relationship between the CNL tertiles and cup equivalents of F/V per day and teaspoon equivalents of added sugar per day, a multivariate ANOVA (MANOVA) was conducted. ANOVA and *post hoc* Tukey's tests were utilized

to determine significant differences between CNL tertiles and dependent variables independently.

Results

Phase 1 results: Pre–post critical nutrition literacy score after completing a nutrition intervention

Out of the 118 consenting students, 50 students had complete data for CNL and demographics and were between the ages of 18 and 24 [Table 1]. The average age was 18.4 ± 1.0 years; the majority were white (71%), female (78%), freshmen (58%), and lived on campus (75.5%). Participants significantly increased their CNL score from baseline to postintervention from 3.38 ± 0.48 to 3.61 ± 0.55 ($P = 0.014$).

Phase 2 results: Relationship with markers of diet quality

A total of 1820 students from three universities took the survey, with 1388 students providing complete data for demographics, CNL, and dependent variables. There were no significant baseline differences, including demographics, between completers and noncompleters. Within the students that provided complete data, the majority were female (72.7%), white (81.3%), and lived off campus (60.9%), and their average reported age was 20.4 ± 1.7 years old [Table 2].

Comparing by university

There were no significant differences between age or gender among URI, WVU, and Rutgers students. A significantly greater proportion of URI and WVU students were white (77.9% and 84.9%, respectively) compared to Rutgers students (45.6%). Rutgers students were comprised of 14.4% Hispanic/Latino, 11.3% African American, 20.6% Asian/Pacific Islander, and 8.0% other. A significantly greater number of students attending WVU lived off campus (70.3%) compared to URI and Rutgers (51.4% and 50.6%, respectively). F/V intake was highest among URI students (2.55 ± 1.01), followed by Rutgers (2.36 ± 1.19) and then WVU (2.17 ± 0.96). Furthermore, added sugar was highest in the WVU population (13.09 ± 8.24), followed by URI (12.20 ± 8.46) and then Rutgers (10.82 ± 5.76). There were no significant differences between universities by CNL scores.

Critical nutrition literacy

Out of the 1,388 students that completed the survey in full, 459 students (33.1%) were classified with lower CNL, 453 (32.6%) with moderate CNL, and 478 (34.4%) with higher CNL according to scoring described in the Methods. There was a small yet significant effect on both living on campus ($F [1,1715] = 29.16$, $P < 0.001$) and age ($F [6,1434] = 5.78$, $P < 0.001$) on CNL total score. Those living on campus had a lower CNL score than those living off campus, and younger participants had lower CNL scores than those who were older [Table 3].

Age and living on campus were not significant covariates after completing MANOVA tests and thus were not included in the final model. The final model suggests that there was an overall significant effect of CNL on daily consumption of F/V and added sugar ($F [2,1321] = 3.121$, $P < 0.05$; Wilks' $\Lambda = 0.991$). When examining each dependent variable, students with lower CNL consumed a greater number of

Table 1: Phase 1 baseline characteristics for completers of Critical Nutrition Literacy Tool

Categorical variables	Completers, *n* (%)	χ^2
Gender (*n*=50)		
Female	39 (78.0)	15.7*
Male	11 (22.0)	
Ethnicity (*n*=48)		
White	34 (70.8)	78.5*
Black/African American	3 (6.3)	
Hispanic/Latino	6 (12.5)	
Asian	2 (4.2)	
Mixed	3 (3.3)	
Other	0.0	
Live on or off campus† (*n*=49)		
On	37 (75.5)	12.8*
Off	12 (24.5)	
Meal plan (*n*=50)		
Yes	36 (72.0)	9.68*
No	14 (28.0)	

*$P<0.05$. †For the University of Rhode Island, living on campus requires a meal plan. Categorical variables were assessed using Pearson Chi-Square

Table 2: Phase 2 baseline demographics for completers of Critical Nutrition Literacy Tool

Categorical variables	Completers, *n* (%)	χ^2
Gender (*n*=1388)		
Female	1009 (72.7)	144.36*
Male	379 (27.3)	
Ethnicity (*n*=1382)		
White	1123 (81.3)	43.42*
Hispanic/Latino	65 (4.7)	
Black/African American	61 (4.4)	
Asian/Pacific Islander/native American	83 (6.0)	
Other	50 (3.6)	
University† (*n*=1387)		
University of Rhode Island	116 (8.4)	157.35*
Rutgers University	171 (12.3)	
West Virginia University	1100 (79.3)	
Live on or off campus‡ (*n*=1380)		
On	540 (39.1)	122.41*
Off	840 (60.9)	

*$P<0.01$. †Universities included the University of Rhode Island, West Virginia University, and Rutgers University, ‡For all three universities, living on campus requires a meal plan. Categorical variables were assessed using Pearson Chi-Square

daily teaspoons of added sugar compared to those with higher CNL (P = 0.043). The mean added sugar intake was 13.54 ± 9.0, respectively, for students with lower CNL and 12.27 ± 7.6 for those with higher CNL. Although not statistically significant, there was a trend for students with lower CNL to consume fewer cups of F/V than those with higher CNL (P = 0.093). The mean F/V intake was 2.15 ± 0.89, respectively, for students with lower CNL and 2.28 ± 0.96 for those with higher CNL [Table 4].

Discussion

Results indicated that there was evidence to support the criterion validity of the CNLT-R using two interrelated studies that were comprised of U.S. college students. Results showed that CNL increased after participating in an experiential learning nutrition course and that CNL was significantly related to markers of diet quality. The CNLT-R instrument has previously been found to be psychometrically sound. However, to the authors' knowledge, this is the first study to show the criterion validity of the CLNT-R instrument and its sensitivity to change in two samples of U.S. college students.

The CNLT-R incorporates items that focus specifically on the ability to use critical appraisal skills to evaluate media sources as well as to evaluate evidence-based nutrition sources.[21] It is important to recognize that these items do not assess the full breadth of the construct as it does not encompass the social engagement construct, which includes understanding social determinants of health and engagement in collective action.[32] Although the CNLT-R does not capture the social and engagement domains, it is one of the first of its kind to measure the critical analysis of nutrition information.[21] By having the ability to understand and apply scientific nutrition information, individuals should be better prepared to determine the differences between evidence-based and nonevidence-based nutrition claims.[13]

Phase 1 of the study showed that within-group CNL scores improved after students participated in a nonexperimental, introductory-level nutrition course. Results indicated that students increased their ability to evaluate media and nutrition sources after exposure of the intervention. This is a novel finding because other studies assessing behavioral outcomes after participating

Table 3: Phase 2 relationship between baseline demographics and critical nutrition literacy† tertiles for completers of Critical Nutrition Literacy Tool

Continuous variables	Mean±SD			*F*-test
	Lower CNL, (*n*=459)	Moderate CNL, (*n*=453)	Higher CNL, (*n*=478)	
Age	20.2±1.58	20.2±1.67	20.65±1.73	12.18**
Categorical variables	**Lower CNL, *n* (%)**	**Moderate CNL, *n* (%)**	**Higher CNL, *n* (%)**	χ^2
Gender				
Female	314 (68.4)	319 (70.5)	337 (70.6)	0.76
Male	145 (31.6)	134 (29.5)	141 (29.4)	
Ethnicity				
White	352 (76.7)	361 (79.6)	403 (84.4)	17.00
Hispanic/Latino	22 (4.7)	19 (4.3)	22 (4.7)	
Black/African American	27 (5.8)	19 (4.3)	17 (3.6)	
Asian/Pacific Islander/Native American	36 (7.8)	37 (8.1)	21 (4.6)	
Other	22 (4.9)	17 (3.6)	15 (3.1)	
Live on or off Campus‡				
Off	112 (24.5)	164 (36.3)	126 (26.3)	22.07*
On	347 (75.5)	289 (63.7)	352 (73.7)	

P<0.05. **P<0.01, †CNL was measured using the 7-item, CNLT-R. Items were evaluated using a 5-point Likert scale ranging from 1=Strongly disagree to 5=Strongly agree. Tertiles divided as the following: 1.0-3.21=Lower CNL, 3.2101-3.79=Moderate CNL, and 3.7901-5.0=Higher CNL, ‡For all three universities, living on campus requires a meal plan. Continuous variables were assessed using ANOVA. Categorical variables were assessed using Pearson Chi-square. CNL=Critical nutrition literacy, CNLT-R=Critical Nutrition Literacy Tool, SD=Standard deviation

Table 4: Phase 2 relationship between critical nutrition literacy† tertiles and fruits/vegetables and added sugars for completers

DSQ Wilks' Λ=0.991, F=3.12*	Mean±SD			*F*-test
	Lower CNL (*n*=459)	Moderate CNL (*n*=453)	Higher CNL (*n*=478)	
Added sugar (tsp)/day‡	13.54±9.0	12.76±7.8	12.25±7.6	2.79*
F/V cup equivalents§	2.15±0.89	2.26±1.1	2.29±0.97	2.46

*P<0.05, †CNL was measured using the 7-item, CNLT-R. Items were evaluated using a 5-point Likert scale ranging from 1=strongly disagree to 5=strongly agree. Tertiles divided as the following: 1.0-3.21=Lower CNL, 3.2101-3.79=Moderate CNL, and 3.7901-5.0=Higher CNL, ‡Added sugar was measured using the NCI Dietary Screener Questionnaire; variable is reported in teaspoon equivalents per day based on 8 items, §F/V indicates fruits/vegetables. F/V was measured using the 10 items from the NCI Dietary Screener Questionnaire and is reported in cup equivalents. Variables were assessed using MANOVA. CNL=Critical nutrition literacy, CNLT-R=Critical Nutrition Literacy Tool, SD=Standard deviation, NCI=National Cancer Institute, MANOVA=Multivariate analysis of variance

in a nutrition course have only focused on functional and interactive components of nutrition literacy.[18-20] Examples of such components include increasing students' food label reading, food choice behaviors, and nutrition knowledge.[18-20] This study extends the literature by showing that the final and critical component of nutrition literacy could also serve as a marker of learning in college students after participating in an introductory nutrition course.

The increase in CNL in Phase 1 may be attributed to the design of the nutrition course. For example, the course is taught by a registered dietitian and the students attend three lectures a week, plus a weekly laboratory where the instructor engages the students by raising questions, encouraging discussion, and using small group activities to elaborate on ideas. The instructor provides students with evidence-based nutrition information and addresses health trends. Students also receive guidance in the laboratory about how and where to access information online, which may have affected their ability to evaluate media sources.[33-35] Measuring CNL before and after an introductory nutrition course allows instructors to evaluate how their students utilize nutrition information to determine false from true claims. Future research is needed to determine if increasing CNL scores is related to improved dietary behavior.

Findings showed that there was an overall multivariate effect between CNL and added sugars as well as F/V intake. While the univariate relationship between CNL and F/V intake was not statistically significant, it is a promising finding that CNL was treading toward a significant relationship with F/V intake. Young adults attending college do not consume enough F/V, and many factors influence optimal intake.[36] Previous research cite barriers to the consumption of F/V inclusive of availability, convenience, affordability, peer influence, and time management.[33,36-38] These barriers may influence students' decisions on what to eat when presented with healthful and less-healthful food options on campus.[33,36-38] Thus, compared to interventions that target changes in other diet quality markers, interventions to change F/V intake are known to be more intensive.[19,39] Such interventions include nutrition courses and online sessions that go beyond simple marketing campaigns on social media, in advertisements, and in newsletters.[19,39] The findings in this study support that future research should further explore the role CNL plays in F/V intake through experimental interventions, in order to see positive nutrition-related outcomes in college students.

There was a significant relationship between CNL and lower intakes of added sugar from drinks. This is an important finding because sugar-sweetened beverages make up almost half of all added sugar consumed by Americans and contribute to weight gain and obesity prevalence among young adults.[40] Specifically, on college campuses, sugar-sweetened beverages are heavily promoted through advertisements and promotional campaigns.[41-43] Some of the most heavily promoted drinks, such as sports drinks, could be perceived as healthy drink options, despite their high content of added sugars.[43,44] Understanding that these seemingly "healthy" products contain high amounts of added sugar requires young adults to have CNL, so that they may be less influenced by marketing techniques.

The ability to understand diet information is challenging to master and media can have a negative effect on food and beverage choices.[45-47] Advertisements promoted by sugar-sweetened beverage companies target youth and young adults by incorporating images that are appealing and attractive to this audience, such as athleticism, friendship, and happiness: qualities that are desirable of young adults at this age.[48] Research has shown that students contemplating a reduction in sugar-sweetened beverages had greater knowledge about their nutritional properties than students who were not thinking about changing consumption.[49,50] However, in general, having nutrition knowledge is not sufficient to change food consumption patterns, and other skills, including CNL, may be warranted for behavior change.[46]

This study provided evidence that higher levels of CNL were associated with a lower added sugar intake, which suggests that CNL plays a role in dietary behavior and is important in order to make healthy choices regarding sugar-sweetened beverages.[17,46] To the authors' knowledge, this is the first study to show a relationship between CNL and dietary behaviors in young adults, along with the ability to increase CNL by taking an introductory nutrition course. Future research using a randomized controlled trial is needed to determine if an increase in CNL is associated with an increase in diet quality in young adults, which would result in improved overall health behaviors, weight status and decreased risk of chronic disease as students reach adulthood.[18]

Limitations

It is important to recognize the limitations of the study. This study explored one component of CNL in a predominately female, white, college student sample. Other environmental factors, such as culture, food availability and access, transportation, and access to technology, were not assessed. Measures of CNL were self-reported, and some students may overrate their abilities when it comes to finding and interpreting information.[35] Although a strength of the study is that the CNLT-R is the first instrument to measure the critical analysis of nutrition information in a US population of young adults, it only measures one of the components of CNL. The relationship between social

engagement and nutrition outcomes cannot be assessed by this instrument. Furthermore, although an increased intake of F/V and less added sugar are important components of a healthful diet and are typically below recommendations in college students, they are not a complete measure of diet quality. Studies that have assessed the relationship between functional and interactive nutrition literacy and more comprehensive measures of diet quality have found significant positive relationships.[16,17] A more comprehensive measurement of diet quality in future research might determine a stronger relationship between CNL and diet quality. Phase 1 of the study was limited to within-group pre- and post-CNL scores and was not an experimental design. Thus, randomization is needed in future studies. Finally, the long-term effects of the nutrition course on CNL were not measured, and it will be necessary to assess if the gains in nutrition literacy are stable over time. However, this study did find that the CNLT-R was sensitive to change and associated with markers of diet quality.

Implications

Based on the increase in CNL scores observed after an introductory nutrition course, the CNLT-R could be used by nutrition educators as an outcome evaluation of nutrition courses offered to college students that are designed to increase the ability to understand and apply nutrition information. Future studies should further explore CNL by examining more comprehensive and sensitive measures than the CNLT-R that encompass more than the critical analysis of nutrition information, to identify social determinants of health and engagement in social or community action. It also will be important to explore other potential mediating and moderating factors that may play a role in the relationship between CNL and diet quality, such as demographic variables, social support, and self-efficacy, to help describe the influence on nutrition behavior outcomes. Finally, future studies are needed to determine if a change in CNL is associated with change in diet quality.

Researchers should continue to evaluate CNL and assess the relationship it has with other criteria in various settings. However, psychometric validation will be necessary before assessing these relationships.[51] Future research is needed to apply this tool to other populations who may be more vulnerable to influences from the media. When considering populations beyond college students, specifically those in diverse groups, it will be important to consider how differing demographics' skills are influenced by nutrition literacy and how nutrition literacy relates to accessing and using nutrition resources when making decisions.

Acknowledgments

The authors appreciate the support of the USDA National Institute of Food and Agriculture, Hatch Multi-State project accession no. 1011301 at URI, the New Jersey Agricultural Experiment Station, and the West Virginia Agricultural Experiment Station, WVA00689. This research was conducted through the Nutrition Assessment Lab at URI, contributing to Janette Bedoyan's thesis work.

Financial support and sponsorship

This study was financially supported by the USDA National Institute of Food and Agriculture, Hatch Multi-State project accession no. 1011301 at the University of Rhode Island, the New Jersey Agricultural Experiment Station, and the West Virginia Agricultural Experiment Station, WVA00689.

Conflicts of interest

There are no conflicts of interest.

References

1. Sørensen K, van Den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, *et al.* Health literacy and public health: A systematic review and integration of definitions and models. BMC Public Health 2012;12:80.
2. Nutbeam D. Defining, measuring and improving health literacy. Heal Eval Promot 2015;42:450-6.
3. Nutbeam D, McGill B, Premkumar P. Improving health literacy in community populations: A review of progress. Health Promot Int 2018;33:901-11.
4. Van den Broucke S. Health literacy: A critical concept for public health. Arch Public Heal 2014;72:10.
5. National Center for Health Statistics. Healthy People 2010: Final Review. Hyattsville, MD: National Center for Health Statistics; 2012.
6. Osborn CY, Paasche-Orlow MK, Bailey SC, Wolf MS. The mechanisms linking health literacy to behavior and health status. Am J Health Behav 2011;35:118-28.
7. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low Health Literacy and Health Outcomes: An Updated Systematic Review. Ann Intern Med 2011;155:97-07.
8. Homamodin Javadzade S, Sharifirad G, Radjati F, Mostafavi F, Reisi M, Hasanzade A. Relationship between health literacy, health status, and healthy behaviors among older adults in Isfahan, Iran. J Educ Health Promot 2012;1:31.
9. Bahramian M, Najimi A, Omid A. Association between health literacy with knowledge, attitude, and performance of health-care providers in applying health literacy education strategies for health education delivery. J Educ Health Promot 2020;9:10.
10. Karimi N, Saadat-Gharin S, Tol A, Sadeghi R, Yaseri M, Mohebbi B. Problem-based learning health literacy intervention program on improving health-promoting behaviors among girl students. J Educ Health Promot 2019;8:251.
11. Reisi M, Javadzade H, Heydarabadi AB, Mostafavi F, Tavassoli E, Sharifirad G. The relationship between functional health literacy and health promoting behaviors among older adults. J Educ Health Promot 2014;3:119.
12. Mohebbi B, Tol A, Sadeghi R, Yaseri M, Somar NA, Agide FD. The efficacy of social cognitive theory-based self-care intervention for rational antibiotic use: A randomized trial. Eur J Public Health 2018;28:735-9.
13. Carbone ET, Zoellner JM. Nutrition and health literacy: A systematic review to inform nutrition research and practice. Acad Nutr Diet 2012;112:254-65.

14. Velardo S. The nuances of health literacy, nutrition literacy, and food literacy. Nutr Educ Behav 2015;47:385-9.
15. Truman E, Bischoff M, Elliott C. Which literacy for health promotion: Health, food, nutrition or media? Health Promot Int 2020;35:432-444.
16. Gibbs HD, Ellerbeck EF, Gajewski B, Zhang C, Sullivan DK. The nutrition literacy assessment instrument is a valid and reliable measure of nutrition literacy in adults with chronic disease. Nutr Educ Behav 2018;50:247-257.
17. Zoellner J, You W, Connell C, Smith-Ray RL, Allen K, Tucker KL, *et al*. Health literacy is associated with healthy eating index scores and sugar-sweetened beverage intake: Findings from the rural lower mississippi delta. Am Diet Assoc 2011;111:1012-20.
18. Tallant A. First-year college students increase food label-reading behaviors and improve food choices in a personal nutrition seminar course. Am J Heal Educ 2017;48:331-7.
19. Ha EJ, Caine-Bish N. Effect of nutrition intervention using a general nutrition course for promoting fruit and vegetable consumption among college students. Nutr Educ Behav 2009;41:103-9.
20. Nani M, Gordon K, Caine-Bish N. P45 Impact of a college nutrition course on nutrition knowledge and dietary intake of undergraduate students. Nutr Educ Behav 2019;51:S52.
21. McNamara J, Kunicki ZJ, Olfert MD, Byrd-Bredbenner C, Greene G. Revision and psychometric validation of a survey tool to measure critical nutrition literacy in young adults. Nutr Educ Behav 2020;52:726-31.
22. Kurtzman ET, Greene J. Effective presentation of health care performance information for consumer decision making: A systematic review. Patient Educ Counsel 2016;99:36.
23. Demiris G. Consumer health informatics: Past, present, and future of a rapidly evolving domain. Yearb Med Inform 2016; Suppl 1(Suppl 1):S42-7.
24. McNamara J, Sweetman S, Connors P, Lofgren I, Greene G. Using interactive nutrition modules to increase critical thinking skills in college courses. Nutr Educ Behav 2020;52:343-50.
25. Kong LN, Qin B, Zhou Y qing, Mou S yu, Gao HM. The effectiveness of problem-based learning on development of nursing students' critical thinking: A systematic review and meta-analysis. Int J Nurs Stud 2014;51:458-69.
26. Mogford E, Gould L, Devoght A. Teaching critical health literacy in the US as a means to action on the social determinants of health. Health Promot Int 2011;26:4-13.
27. Guttersrud O, Dalane JO, Pettersen S. Improving measurement in nutrition literacy research using Rasch modelling: Examining construct validity of stage-specific "critical nutrition literacy" scales. Public Health Nutr 2014;17:877-83.
28. Harlow LL. The Essence of Multivariate Thinking. 2nd ed. New York, NY: Routledge; 2014.
29. McNamara J, Olfert MD, Sowers M, Colby S, White A, Byrd-Bredbenner C, *et al*. Development of an instrument measuring perceived environmental healthfulness: behavior environment perception survey (BEPS). Nutr Educ Behav 2020;52:152-61.
30. Dietary Screener Questionnaires (DSQ) in the NHANES 2009-10: DSQ. National Cancer Institute Website. Accessed December 6, 2020. Available from: https://epi.grants.cancer.gov/nhanes/dietscreen/questionnaires.html.
31. Dietary Screener Questionnaire (DSQ) in the NHANES 2009-10: Data Processing & Scoring Procedures. National Cancer Institute Website. Accessed December 6, 2020. Available from: http://epi.grants.cancer.gov/diet/screeners/fruitveg/scoring/allday.html.
32. Chinn D. Critical health literacy: A review and critical analysis. Soc Sci Med 2011;73:60-7.
33. Garcia AC, Sykes L, Matthews J, Martin N, Leipert B. Perceived facilitators of and barriers to healthful eating among university students. Can J Diet Pract Res 2010;71:e28-33.
34. Halawah I. Factors influencing college students' motivation to learn from students' perspective. Education 2011;132:379-390.
35. Catalano A. Patterns of graduate students' information seeking behavior: A meta-synthesis of the literature. J Document 2013;69:243-274.
36. Greene GW, Schembre SM, White AA, Hoerr SL, Lohse B, Shoff S, *et al*. Identifying clusters of college students at elevated health risk based on eating and exercise behaviors and psychosocial determinants of body weight. Am Diet Assoc 2011;111:394-400.
37. Seguin R, Connor L, Nelson M, LaCroix A, Eldridge G. Understanding barriers and facilitators to healthy eating and active living in rural communities. Nutr Metab 2014;2014:146502.
38. Graham DJ, Pelletier JE, Neumark-Sztainer D, Lust K, Laska MN. Perceived social-ecological factors associated with fruit and vegetable purchasing, preparation, and consumption among young adults. Acad Nutr Diet 2013;113:1366-74.
39. Greene GW, White AA, Hoerr SL, Lohse B, Schembre SM, Riebe D, *et al*. Impact of an online healthful eating and physical activity program for college students. Am J Health Promot 2012;27:47-58.
40. World Health Organization. Sugars Intake for Adults and Children. World Health Organization; 2015.
41. Jasti S, Rubin R, Doak CM. Sugar-sweetened beverage knowledge and consumption in college students. Heal Behav Policy Rev 2016;4:37-45.
42. Yang CC, Bin CW. Substitution of healthy for unhealthy beverages among college students. Health-concerns and behavioral-economics perspective. Appetite 2010;54:512-6.
43. Bawadi H, Khataybeh T, Obeidat B, Kerkadi A, Tayyem R, Banks A, *et al*. Sugar-sweetened beverages contribute significantly to college students' daily caloric intake in Jordan: Soft drinks are not the major contributor. Nutrients 2019;11:1058.
44. Attila S, Çakir B. Energy-drink consumption in college students and associated factors. Nutrition 2011;27:316-22.
45. Hawkins LK, Farrow C, Thomas JM. Do perceived norms of social media users' eating habits and preferences predict our own food consumption and BMI? Appetite 2020;49:104611.
46. Spiteri Cornish L, Moraes C. The impact of consumer confusion on nutrition literacy and subsequent dietary behavior. Psychol Mark 2015;32:558-74.
47. Naigaga DA, Pettersen KS, Henjum S, Guttersrud Ø. Assessing adolescents' perceived proficiency in critically evaluating nutrition information. Int J Behav Nutr Phys Act 2018;15:1-13.
48. Brownbill AL, Miller CL, Braunack-Mayer AJ. The marketing of sugar-sweetened beverages to young people on Facebook. Aust N Z J Public Health 2018;42:354-60.
49. Zoellner J, Chen Y, Davy B, You W, Hedrick V, Corsi T, *et al*. Talking Health, A pragmatic randomized-controlled health literacy trial targeting sugar-sweetened beverage consumption among adults: Rationale, design & methods. Contemp Clin Trials 2014;37:43-57.
50. Gase LN, Robles B, Barragan NC, Kuo T. Relationship between nutritional knowledge and the amount of sugar-sweetened beverages consumed in los Angeles county. Heal Educ Behav 2014;41:431-9.
51. Mohebbi B, Tol A, Shakibazadeh E, Yaseri M, Sabouri M, Agide FD. Testing psychometrics of healthcare empowerment questionnaires (HCEQ) among Iranian reproductive age women: Persian version. Ethiop J Health Sci 2018;28:341-6.