

Development and validation of the nutrition literacy measure for Taiwanese college students

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Objectives: To develop a nutrition literacy measure for Taiwanese college students and evaluate its reliability and validity. **Methods:** A cross-sectional study using convenience sampling was adopted to evaluate the measure and six universities in Taiwan were included. A total of 1,269 students were recruited and 1,264 valid questionnaires were returned. The ratio of men to women was 0.87. Most students were sophomore (38.1%) and junior (26.1%). The nutrition literacy measure was formulated based on the Dietary Guidelines for Taiwanese and the Daily Food Guides and consisted of 8 self-rated items and 32 scenario-based test items. Cronbach's α coefficient was used to evaluate the internal consistency reliability, while a confirmatory factor analysis was conducted to validate the measure. **Results:** Cronbach's α for the self-rated scale and the scenario-based test was 0.85 and 0.81, respectively. The measure showed a good model fit in 2 parts and the difficulty parameters of the scenario-based test ranged from -3.22 to 0.11 in the item response theory analysis (acceptable range= -4 to 2). Furthermore, scores for 2 parts of the measure were both positively correlated with the healthy-eating behavior scale ($r = .417$, $p < .001$ and $r = .125$, $p < .001$, respectively). **Conclusions:** The devised instrument was a valid and reliable measure for assessing nutrition literacy among Taiwanese college students. Specifically, it could be used by practitioners for needs assessment before the implementation of a nutrition education program. (*Taiwan J Public Health*. 2018;37(5):582-597)

Key Words: nutrition literacy, college students, measure, eating behavior, validation

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INTRODUCTIONS

Most college students are at the stage of emerging adulthood, which is both crucial to independence and also a major turning point in their lives. This population has a relatively higher risk of becoming overweight or obese, developing poor eating habits, and physical inactivity, compared with other age groups [1]. This stage is critical in the formation of an individual's eating behavior, because students are habitually affected by their families and schools before starting college; however, their dietary choices are typically made

independently thereafter. Food choices made during college influence whether students will gain weight or maintain a healthy lifestyle during adulthood [2, 3]. It is a public health nutrition priority in Taiwan to actively deal with students' unhealthy eating patterns. Recent findings indicate eating-related problems such as frequent consumption of fast foods and sugar-sweetened beverages, combined with inadequate intake of fruit and vegetables, are prevalent among this population [4].

The concept of nutrition literacy (NL) is derived from health literacy (HL) and can be defined as "the capacity to obtain, process, and understand nutrition information and skills needed to make appropriate nutrition decisions" [5-8]. This definition is based on the US National Institute of Medicine's definition of HL and the word "health" is replaced by "nutrition" [9]. Like HL, NL is context-specific; therefore, the definition and connotation of NL vary internationally [10], which causes variation in NL measures. Some measures relevant to NL are available in the literature. For instance, Diamond [11] developed the Nutrition Literacy Scale that targeted patients. Aihara et al. [5] developed an NL assessment tool for elderly Japanese adults. Gibbs et al. [12] designed the Nutrition Literacy Assessment Instrument to allow dietitians to assess patients' NL to provide better individualized service. Finally, the Newest Vital Sign Scale (NVS) [13] is a widely used measure of HL in primary care, and is sometimes used to represent the concept of NL [8].

As college students already have a certain level of education, a general emphasis on reading and writing skills in HL need not be the focus of measures. Instead, the focus should be on the nutrition knowledge and skills that college students should possess to make sensible and healthy decisions relating to the context of their diet in daily life. As mentioned

above, the transition to college is a critical time associated with significant and rapid weight gain due to poor dietary choices; therefore, developing measures to enhance NL among college students to address their unhealthy eating patterns is critical. Although Cha et al. [14] verified a positive correlation between HL and food label use behavior among college students using the NVS, it is still necessary to develop a localized and audience-specific NL measure since NL is a new concept that emphasizes the nutrition-related knowledge and skills that an individual should possess when facing daily dietary situations. The Chinese diet that Taiwanese college students practice is different from a typical Western style diet. Traditionally, the Chinese diet is low in fat, sugar, and meat, and high in starch. However, high-energy dense Western foods have become incorporated within the Chinese diet as part of globalization. Despite this, the Chinese diet has several unique characteristics. For example, the Chinese diet usually consists of cooked and hot or warm foods, while American foods are usually cold, raw, sweet, and large in portion size [15]. Therefore, the unique dietary contexts that Taiwanese college students face must be considered when developing a new NL measure.

Internationally, dietary guidelines have been established for promoting healthy dietary intake and preventing the development of diet-related chronic diseases [16]. In Taiwan, these guidelines were initially established 40 years ago, and the newest version reflects updates in 2011 [17, 18]. Dietary Guidelines for Taiwanese and the Daily Food Guides could feasibly be used to guide the development of NL measures for Taiwanese college students. Therefore, this study aimed to develop a NL measure for Taiwanese college students based on the Dietary Guidelines for Taiwanese and the Daily Food Guides, as well as the dietary

contexts they face. The psychometric properties of the new NL scale were also evaluated with the hope of providing a main reference from which NL intervention programs for this population can be formulated in the future.

MATERIALS AND METHODS

In this study, the Nutrition Literacy Measure for Taiwanese College Students (NL-TCS) was developed in four stages, and a cross-sectional study design was adopted to collect data for validation of the NL-TCS. Since the tool was designed for assessing college students' performance on decisions of their dietary choices, healthy-eating behaviors were measured to allow determination of the association between the NL-TCS and healthy-eating behaviors. The study process was shown in Figure 1.

Participants

Convenience sampling was adopted to recruit participants. Six universities were selected from the national and private universities in the northern, central, and southern areas of Taiwan. Approximately 220 participants were recruited from each university with a maximum of 45 students from each department. In addition, in each school, the total

number of students with medical, public health, and nutrition related majors were limited to 45 students to avoid sample bias because students from those majors may have higher awareness of healthy eating. Overall, 1,269 questionnaires were returned. Any questionnaire missing more than one third of the data was excluded from further analysis, resulting in 1,264 valid questionnaires (response rate = 99.6%).

Data collection occurred from April 2016 to June 2016. The trained research assistants approached students on campus wherever the students were (e.g., classrooms, school hallways, or college dorms), provided information about the study, and invited them to participate. A description of the study purpose and protocol was provided to potential participants prior to administration of the questionnaire. Only those who were willing to participate were offered questionnaires and completed them directly at the recruitment site. Participants were asked to complete the questionnaire by their own opinion without discussing with others or checking answers on Internet. They were also informed that they could withdraw at any time without adverse personal consequences. The questionnaire took approximately 30 minutes to complete and a voucher was offered in appreciation of their participation.

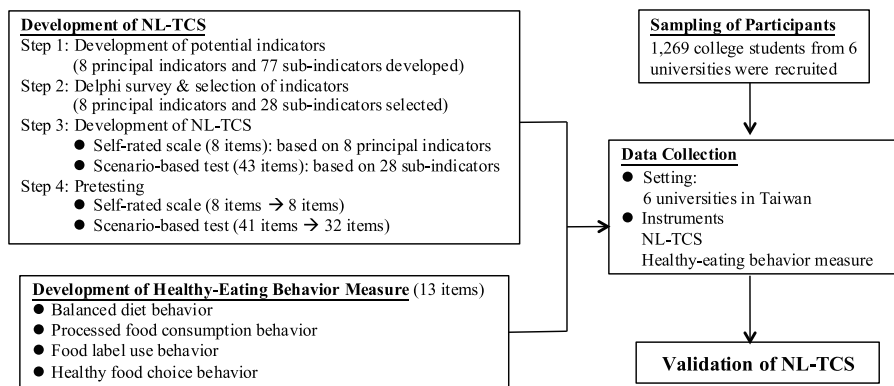


Figure 1 Flow chart of the study process

Ethic Consideration

This study adhered to ethical research standards and regulations. Ethical approval was obtained from the National Cheng Kung University Human Research Ethics Committee (NCKU-HREC No. 104-300-2).

Development of the NL-TCS

The development of the NL-TCS went through 4 stages between August 2015 and April 2016 and included development of potential indicators, a Delphi survey and selection of indicators, test development, and pretesting.

1. Development of potential indicators: According to the definitions of NL in the literature [5-8, 19], an individual with NL should possess 5 capacity domains: *obtain*, *understand*, *analyze*, *appraise*, and *apply* nutrition information. After repeated discussions to form a consensus by the research team, comprising professors of nutrition and health, 8 principal indicators and 77 sub-indicators were formulated.
2. Delphi survey and selection of indicators: A panel of 28 experts participated in a 2-round Delphi survey to form a consensus on college students' NL indicators based on their relevance, representativeness, and importance ranking. As a result, 8 principal indicators and 28 sub-indicators were retained. Detailed information for stage 1 and 2 has been published elsewhere [20].
3. Test development: The NL-TCS included 2 parts, a self-rated scale and a scenario-based test. The self-rated scale was developed based on the connotations of the 8 principal indicators: 2 items for *obtain* (e.g., "For me, when there are nutrition-related issues, to know where to find the right information is ..."), 2 items for *understand* (e.g., "For me, to be able to understand the contents of

Dietary Guidelines for Taiwanese is ..."), 1 item for *analyze* ("For me, to choose foods from the nutritional point of view to distinguish food groups and functions is ..."), 2 items for *appraise* (e.g., "For me, to judge whether the nutrition information on the network is correct or not is ..."), and 1 item for *apply* ("For me, to use the right nutrition information in daily life for healthy eating is ..."). This was a subjective self-assessment. A 4-point Likert scale ranging from 1 (*very difficult*) to 4 (*very easy*) was employed, and the sum of each item score means the self-rated NL scale score; higher scores reflected better NL. The response scale for the self-rated questions in this study was adopted from health literacy studies found in the literature, including the European Health Literacy Survey Questionnaire [21], Health Literacy Questionnaire [22], and Mandarin Multidimensional Health Literacy Questionnaire [23]. These scales assess self-reported difficulties in accessing, understanding, appraising, and applying information in tasks concerning decision-making in the specific domain of health literacy. The scenario-based test was formulated under connotations of the 28 sub-indicators, considering the background of daily dietary situations that college students often experience including 43 items across 8 scenarios. Multiple choice questions with 3 response options were employed and only one option was correct. One point was scored with the correct answer, and the sum of each item score means the scenario-based NL test score. The *understand* domain included 19 items measuring basic nutrition knowledge. The *analyze* domain included 12 items measuring an individual's ability to differentiate and analyze food groups, ingredients, and calories in everyday situations. The *appraise* domain included

6 items measuring an individual's ability to judge and appraise whether a diet was healthy in the context of daily situations. Lastly, the *apply* domain included 6 items measuring an individual's ability to select or adjust their diet for the sake of their health in the context of daily situations. Example questions for each domain are displayed in Table 1.

4. Pretesting: Six nutrition professors reviewed the draft test. They were asked to provide a score on the relevance between the meaning of each item and the purpose of the test. A content validity index (CVI) was calculated based on their scores [24]. Eight items were retained for the self-rated scale because the average CVI = 1. For the scenario-based test, 2 items with a CVI < 0.8 were deleted. Forty-one items were pretested: 18 for the *understand* domain, 11 for the *analyze* domain, 6 for the *appraise* domain, and 6 for the *apply* domain. College students (N = 499) from 2 universities, one in North Taiwan and the other in South Taiwan, returned the questionnaire (response rate = 98.6%). The pretest results of the self-rated scale showed that the instrument was reliable (Cronbach's $\alpha = 0.87$) and had good content validity (mean CVI = 1). For the scenario-based pretest results, 32 items were retained for the actual test after considering factors such as low factor loading (nonsignificant), similarity of difficulty parameters, low correlation with the total test score after items were modified, and importance of item content. Evaluation of the scenario-based test showed good internal consistency (Cronbach's $\alpha = 0.84$) and good content validity (mean CVI = 0.99).

Measure of Healthy-Eating Behavior

Each participant completed a measure of healthy-eating behavior and provided

background information. The healthy-eating behavior scale, developed by the researchers based on the purpose of the study, included 13 items on behaviors related to a balanced diet (e.g., "I eat foods from each of the 6 food groups every day"), processed food consumption (e.g., "When choosing foods, I try to select foods without artificial additives"), food label use (e.g., "I read nutrition facts before I eat or buy foods"), and healthy food choice behavior (e.g., "I choose or modify my diet according to the principles of health"). A 5-point Likert scale was employed: *never* (0 day per week), *seldom* (1-2 days per week), *sometimes* (3-4 days per week), *often* (5-6 days per week), and *always* (7 days per week). Scores ranged from 1 to 5, and the sum of each item score means the healthy-eating behavior score; higher scores indicated more frequent healthy-eating behaviors. The healthy-eating behavior scale also went through the expert review process and pretest along with the NL-TCS. Cronbach's α was 0.87 and mean CVI was 0.99.

Statistical Analysis

We examined the Cronbach's α coefficient in SPSS to evaluate internal consistency. A confirmatory factor analysis (CFA) was conducted with maximum likelihood estimation using Analysis of Moment Structures (AMOS) to validate the scenario-based test, and because of the large sample size, the estimation of indices could be easily overestimated. Therefore, Bollen and Stine's procedure was used to calibrate the indices [25]. The overall goodness-of-fit of the model was used as the evaluation criteria of validity [26-31]. We used the "lrm" package in R to perform 1-parameter logistic Rasch model for the estimation of item difficulty parameters. In order to confirm that the data complied with the assumption of

Table 1. Example of questions and corresponding indicator for each domain of the Scenario-based Test in the NL-TCS

Domain: understand nutrition information

Please answer the following questions based on the contents of this picture.

Q1.1. What is the meaning of this picture? 【Corresponding indicator: 1-1-1】

- A. Daily dietary recommendations suitable for the general population
- B. Daily dietary recommendations suitable for chronic disease patients
- C. Daily dietary recommendations suitable for overweight or obese people

Domain: analyze nutrition information

Ruei is a sophomore. Recommended portions of 6 food groups for him are as follows:

Recommended portions of 6 food groups	
Whole grains (bowl)	3 bowls
Whole grains (non-refined)	1 bowl
Whole grains (others)	2 bowls
Beans, fish, meats, and eggs	5 portions
Low fat milk or dairy products	1.5 cups
Vegetables	3 dishes
Fruits	2 portions
Oil, nuts and seeds	5 portions
Oil	4 teaspoons
Nuts and seeds	1 portion

Q2.1. According to recommended portions for Ruei, which of the following recommendations of whole grains are more suitable for him? 【corresponding indicator: 2-5-1】

- A. Choose to eat a white steamed bun for at least one of the 3 meals per day
- B. Choose to eat a bowl of brown rice for at least one of the 3 meals per day
- C. Choose to eat a bowl of peanut soup for at least one of the 3 meals per day

Domain: appraise nutrition information

The weather becomes cool. Ruei, Hua, and Lily decide to have a hot pot together at Ruei's house. Ingredients that each of them chooses for having a hot pot are as follows:

Ruei	Pork slices, fish dumplings, squid balls, mini sausages, cabbage
Hua	Bean curd skin, beef slices, pumpkin, green bean noodle, shungiku
Lily	Squid, shrimp, milkfish balls, pork liver, needle mushroom

Q6.1. According to the ingredients for having a hot pot that each of them chooses, whose choice may include more processed foods? 【corresponding indicator: 3-8-2】

- A. Ruei
- B. Hua
- C. Lily

Domain: apply nutrition information

Ruei's food lists of intake are as follows:

Breakfast	Lunch	Dinner	Late-night supper
Breakfast shop: A cup of iced black tea (300 c.c.) A portion of hamburger with egg	Student restaurant: A lunch box with deep-fried chicken thigh A cup of pearl milk tea with half amount of sugar added (700 c.c.)	Café diner: A portion of spaghetti with bacon and cream sauce A bowl of corn thick soup	Braised dishes from a night market: A portion of black cake A portion of green bean noodle

Q3.7. According to RUEI's food lists, **if he wants to reduce intake of oil**, which of the following could be selected to **replace the main dish, deep-fried chick thigh**, of his lunch box in order to practice a healthy choice? 【corresponding indicator: 4-6-1】

- A. Braised chick thigh
- B. Chick thigh with honey
- C. Sweet and sour pork ribs

unidimensionality of the Rasch model, principal components analysis (PCA) was used in this study. PCA is a widely used method in which the number of eigenvalues greater than 1 [32] or scree plots [33] are used to determine the number of dimensions. If the first eigenvalue (denoted as V1) is substantially larger than the second eigenvalue (denoted as V2), then the unidimensionality assumption is likely to hold.

Two criteria were adopted to determine whether each question should be retained. The first one was that the standardized loading of the CFA for the question must reach a statistically significant level. If the factor loading was low, the decision of whether the question was retained or deleted was made by the research team based on the importance of the item in relation to the connotation in the NL measure. The second one was that the difficulty level of a question must be between -4 and +2 from Rasch model. In setting the difficulty level, since the purpose of the NL measure was to test general life abilities to deal with diet-related situations, the difficulty level was set relatively easier than that of the general ability test.

Descriptive statistics were conducted to summarize the participant characteristics. Results were given as frequencies and percentages for categorical variables. The percentage correct and standard deviation for each item were also calculated. In order to examine associations between the measures, Kolmogorov-Smirnov test (K-S test) and Shapiro-Wilk test (S-W test) were conducted to test the normality of the collected data due to a large sample in this study. If the normality assumption was violated, Spearman's rank correlation was adopted to examine associations; if not, Pearson product-moment correlation was adopted instead. These procedures were conducted using SPSS.

RESULTS

Participants' Characteristics

Characteristics of participants were shown in Table 2. The ratio of men to women was 0.87. In terms of students' grades, sophomores accounted for the highest proportion (38.1%), followed by juniors (26.1%). Most of the participants' parents had at least a high school education (90.3%). Approximately half of the respondents lived in school dormitories (52.5%) and only a small portion lived with their families (15.6%). More than half of the respondents expressed that they ate out for all their meals (52.6%). Almost all (93.0%) had received nutrition-related information, which refers to nutrition-related messages disseminated through the mass media and/or through health promotion activities during their university years. However, those who had taken nutrition-related formal courses provided in universities accounted for less than one third of the respondents, and more than 70% felt they needed increased access to nutritional information.

Reliability, Validity, and Difficulty Analysis of the NL-TCS

The test version of the NL-TCS was 8 self-rated items plus 32 scenario-based items. Cronbach's α for the self-rated scale and the scenario-based test was 0.85 and 0.81 respectively, which reached the standard of 0.70 [34]. Both parts of this measure met all recommended standards (for example, GFI = .993 > .90, AGFI = .988 > .90, RMSEA = .019 < .08 in the self-rated scale; GFI = .926 > .90, AGFI = .913 > .90, RMSEA = .015 < .08 in the scenario-based test) after the CFA (Table 2) and the standardized loadings for each item all reached statistical significance ($p < .001$). Although eight questions had factor loadings

Table 2. Characteristics of participants

Variable	Number	Percent (%)
Region		
North District	419	33.1
Central District	417	33.0
Southern District	403	31.9
Missing	25	2.0
Grade		
Freshman	237	18.8
Sophomore	481	38.1
Junior	330	26.1
Senior	207	16.4
Missing	9	0.7
Gender		
Male	581	46.0
Female	669	52.9
Missing	14	1.1
Education level of parents		
Junior high school and lower	79	6.2
High school	414	32.8
University	558	44.1
Graduate school and above	169	13.4
Don't know or can't answer	27	2.1
Missing	17	1.3
Residency		
Live in a dormitory	663	52.5
Rent a room outside school	377	29.8
Live with family	197	15.6
Other	12	0.9
Missing	15	1.2
Eat out situation		
Never or seldom eat out	17	1.3
1~3 meals/week	114	9.0
4~6 meals/week	142	11.2
1 meal/day	78	6.2
2 meals/day	238	18.8
3 or more meals/day	665	52.6
Missing	10	0.8
Has ever received nutrition-related information during university		
Never	78	6.2
Seldom	420	33.2
Sometimes	517	40.9
Often	173	13.7
Always	66	5.2
Missing	10	0.8
Has ever taken nutrition-related course during university		
Yes	388	30.7
No	855	67.6
Missing	21	1.6
Self-perceived need for access to nutrition information		
No need at all	44	3.5
Somewhat of a need	307	24.3
Has a need	738	58.4
Has a great need	163	12.9
Missing	12	0.9

< 0.3 in the scenario-based test, they were retained because of their importance in relation to the connotations to NL.

In terms of the PCA, Figure 2 presents the scree plots of the self-rated scale and scenario-based test. Since the first eigenvalues of each factor were obviously larger than the latter

ones, the assumptions of a single construct were met. The attribute of the test belonged to a scale for detecting ability, so we used the “ltm” package of R to estimate the difficulty level of items in the scenario-based test and found that the difficulty parameters were between -3.22 and 0.11 within the acceptable range -4 to 2

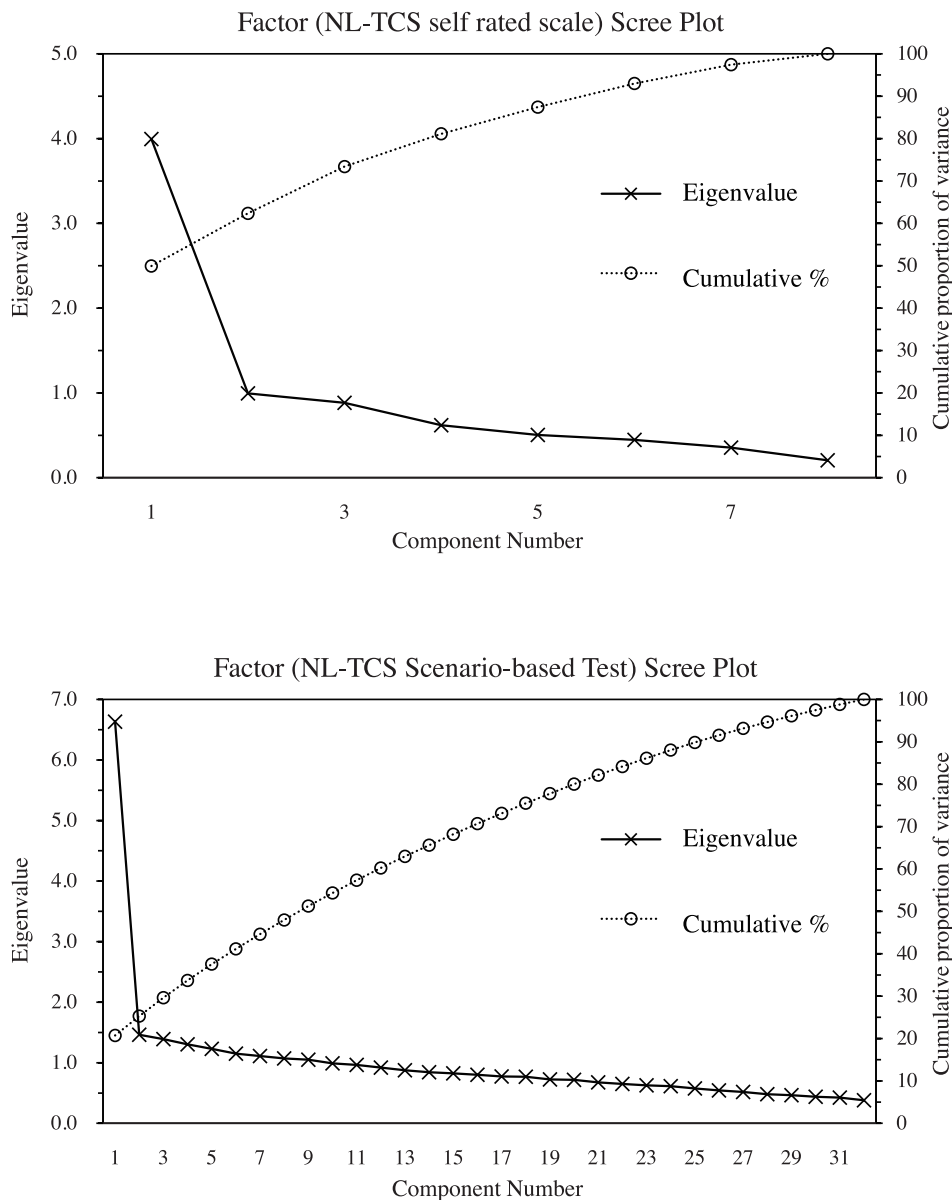


Figure 2 Scree plots of eigenvalues for principal components analysis of the Self-rated Scale and Scenario-based Test of the NL-TCS.

(Table 3). The item information curves for each item were as shown in Figure 3.

Association between the NL-TCS and Healthy-Eating Behavior Scale

Participants' scores on the self-rated NL scale of the NL-TCS ranged between

2.64 and 2.99 out of 4.0 (Mean = 2.8 ± 0.46). Therefore, students' self-rated scores were in the intermediate level but closer to the easy level. The average percentage correct for the scenario-based test was 77.4% (Mean = 24.77 ± 0.16) (Table 3). Regarding healthy-eating behaviors, the scores ranged between 2.44 and

Table 3 Model Fit of the NL-TCS

Overall fit index	Criteria ^a	Self-rated Scale NL-TCS	Scenario-based Test NL-TCS
Absolute Fit Index			
GFI	$\geq .90$	.993	.926
AGFI	$\geq .90$	.988	.913
RMSEA	$\leq .08$	.019	.015
Relative Fit Index			
NFI	$\geq .90$	.993	.926
NNFI	$\geq .90$	.997	.981
CFI	$\geq .90$	.998	.983
Simplified Fit Index			
PGFI	$\geq .50$	.709	.855
LR χ^2/df	≤ 3	1.469	1.283

Notes:

^a Model fit cut-off criteria were from reference # 23-28.

GFI = global fit index; AGFI = adjusted global fit index; RMSEA = root mean square error of approximation; NFI = normed fit index; NNFI = nonnormed fit index; CFI = comparative fit index; PGFI = parsimony goodness of fit index; LR = likelihood ratio; df = degree of freedom.

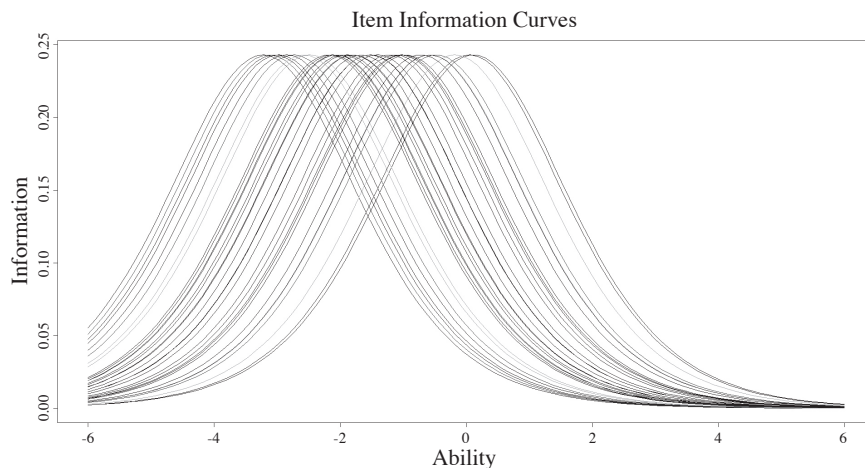


Figure 3 Item Information Curves (IIC) for the Scenario-based Test of the NL-TCS

Table 4 Summary table of item difficulty and percentage correct of each item in the Scenario-based Test of the NL-TCS

No. of Item	Corresponding Indicator	Difficulty	Percentage Correct(%)	StD
<i>Understand</i> (13 Items with 9 indicators)				
1.1	1-1-1 Understand meaning of the Daily Food Guides	-3.22	93.9	0.24
1.2	1-1-1 Understand meaning of the Daily Food Guides	-3.05	93.0	0.26
1.3	1-1-1 Understand meaning of the Daily Food Guides	0.05	49.5	0.50
1.4	1-1-2 Understand classification of the 6 food groups and dietary values	-0.95	69.1	0.46
1.5	1-1-2 Understand classification of the 6 food groups and dietary values	-3.13	93.4	0.25
1.6	1-1-3 Understand influence of well-balanced diets on health	-1.12	72.1	0.45
1.7	1-4-1 Understand influence of adequate intake of wholegrain foods on health	-0.72	65.0	0.48
3.1	1-2-1 Understand relationship between healthy body weight and risk of chronic diseases	-0.18	54.2	0.50
3.2	1-2-2 Understand definition of healthy body weight and calculation of body mass index	-1.96	83.8	0.37
5.1	1-11-1 Understand food hygiene and safety precautions when buying foods	-1.90	83.1	0.37
5.2	1-11-1 Understand food hygiene and safety precautions when buying foods	-0.48	60.3	0.49
7.1	1-3-1 Understand purpose of physical activity	-2.85	91.8	0.27
8.1	1-7-1 Understand that drinking enough boiled water is important to health	-2.98	92.6	0.26
<i>Analyze</i> (9 Items with 7 indicators)				
2.1	2-5-1 Analyze the types and quantity of wholegrain foods an individual should consume daily	-1.81	82.0	0.38
3.3	2-2-1 Analyze personal healthy body weight and energy requirements	-1.53	78.2	0.41
3.4	2-2-1 Analyze personal healthy body weight and energy requirements	-0.57	54.2	0.49
4.1	2-2-2 Analyze the energy of packaged foods based on nutrition facts	-0.58	62.3	0.48
4.2	2-6-1 Analyze the sodium content of packaged foods based on nutrition facts	-2.18	86.2	0.35
4.3	2-6-2 Analyze the types of high sodium foods eaten in daily life	-1.66	80.1	0.40
4.4	2-6-3 Analyze the types of high calorie low nutrient density foods	-1.52	78.2	0.41
4.5	2-6-3 Analyze the types of high calorie low nutrient density foods	-2.74	91.0	0.29
8.2	2-7-1 Analyze the calories of commercial sugar-sweetened beverages	0.11	48.3	0.50
<i>Appraise</i> (6 Items with 5 indicators)				
2.2	3-1-1 Appraise whether an individual's daily diet conforms to the recommended types and quantity of foods from the 6 groups	-2.48	89.0	0.31
2.3	3-1-1 Appraise whether an individual's daily diet conforms to the recommended types and quantity of foods from the 6 groups	-1.22	73.6	0.44
3.5	3-2-1 Appraise whether an individual's daily diet conforms to personal energy requirements	-2.13	85.7	0.35
6.1	3-8-2 Appraise whether an individual's diet contains too many excessively processed foods	-2.07	85.0	0.36
7.2	3-3-1 Appraise whether an individual's physical activity is appropriate and adequate	-1.01	70.1	0.46
8.3	3-7-1 Appraise whether an individual's daily boiled water intake is sufficient	-1.41	76.6	0.42
<i>Apply</i> (4 Items with 4 indicators)				
3.6	4-2-1 Choose or modify personal diet based on personal energy requirements	-2.06	84.9	0.36
3.7	4-6-1 Choose the low oil cooking method and dishes for personal health reasons	-1.04	70.6	0.46
6.2	4-8-1 Choose not excessively processed foods for personal health reasons	-2.57	89.7	0.30
6.3	4-8-2 Choose plant foods more often for personal health reasons	-1.79	81.8	0.39
Average			77.4	0.16

Notes: Multiple choice questions with 3 response options were employed, one point for the correct answer and 0 point for the wrong answer.

For nutrition literacy abilities (e.g., 1-1-1), the first number refers to the type: 1 indicates understand; 2, analyze; 3, appraise; and 4, apply. The middle number refers to different health themes according to the Dietary Guidelines for Taiwanese; and the third number corresponds to the serial number.

3.53 out of 5.0 (Mean = 3.07 ± 0.60), showing that students “sometimes” (3 to 4 days per week) performed healthy-eating behaviors.

After K-S test and S-W test, the collected data in all measures was found to violate the normality assumption. Thus, Spearman’s rank correlation was conducted to examine the correlations. The correlation analysis revealed that the self-rated scale positively correlated with the scenario-based test ($r = .155, p < .001$). Additionally, both the self-rated scale and the scenario-based test positively correlated with healthy-eating behaviors ($r = .417, p < .001$ and $r = .125, p < .001$, respectively).

DISCUSSIONS

The development of the NL-TCS was based on the NL indicators for Taiwanese college students. Because the development of those indicators considered several imperative factors, the NL-TCS comprised well-grounded face and content validity. Factors considered in the process of developing the indicators included the Dietary Guidelines for Taiwanese, multidimensional definitions of NL, and recommendations of nutrition experts collected through a Delphi study. Moreover, the psychometric properties of the NL-TCS revealed that it was a valid and reliable measure. The scale can thus be used to evaluate the NL of college students in daily life. However, using the 4 subscales of understand, analyze, appraise, and apply in the scenario-based test separately is not recommended. Additionally, because the NL-TCS includes only items relating to nutrition, as compared to being a measure of general HL, assessment results from this tool are likely to be more conducive to the development of nutrition intervention programs. This measure could also be used as a reference for designing intervention strategies based on responses to

each question. The self-rated scale positively correlated with the scenario-based test, meaning that the assessment results from these 2 parts could be used in combination. Exploring the NL of college students simultaneously from subjective and objective perspectives could provide a powerful basis for conducting NL interventions.

Both the self-rated scale and the scenario-based test positively correlated with healthy-eating behaviors. This finding is consistent with findings from Wall et al., showing NL had a positive effect on creating a healthier dietary eating pattern [35]. Until now, most NL-related studies have focused on patients. Among these patient-oriented measures, some are disease-specific nutrition knowledge tests [11, 36], and some target the effective use of food labels [13, 37]. Research by Wall et al. [35], and the present study, are among the few studies to date that are not patient-based. Wall et al. focused on midlife years and related NL to nutrition knowledge-based outcomes (cardiovascular disease risk), while the present study focused on college students and related NL to general healthy-eating behaviors, considering participants’ dietary contexts and recommended dietary guidelines.

The results showed that the average percentage correct for the scenario-based test in college students was 77.4%. Even if the difficulty level of this tool tended to be intermediate, indeed, close to easy, the NL performance of college students in this sample was still not ideal. Furthermore, the students did not practice every healthy-eating behavior based on dietary guidance during their daily lives. If the NL of college students could be enhanced effectively, their healthy-eating behaviors would be improved. Currently, there is a formal curriculum for the teaching of health education (including nutrition) from elementary school to high school in Taiwan.

However, the present study found that most of the educational strategies used at the university level were media information promotion or health education activities, and prize solicitation activities were commonly used. The impact of such intervention methods on behavioral change is limited [38, 39]. Only about one-third of the participants had ever taken formal nutrition-related courses at university which could provide a solid knowledge base. As a result, students could only rely on nutrition knowledge they had learned in 1st to 12th grade health education courses to cope with the dietary challenges they faced at university. The majority of the participants in this study, therefore, still considered themselves as having nutrition knowledge or information needs. Education about food and nutrition is effective in improving dietary practices and maintaining nutritional intake which is essential for the health and well-being in people of all ages [40]. As college years represent a major milestone in forming good eating behaviors, how to strengthen nutrition education in the framework of higher education is indeed a crucial public health nutrition issue.

It is noteworthy that although the two parts of the NL-TCS were significantly related, the strength of the correlation was lower than expected. Thus, these two parts of the measurement may represent different components of NL, that is, there is indeed a gap between individuals' subjective perceptions and their actual ability relating to NL. It is recommended that cross-referencing between both parts is conducted in practice. Future research should explore these related but separate components of NL in detail.

This study has some limitations. First, because convenience sampling was employed, the results may not be generalizable to all college students in Taiwan. Second, the NL-TCS was developed based on the Dietary

Guidelines for Taiwanese and the dietary contexts of Taiwanese college students. Researchers need to reexamine its applicability to ensure that the NL-TCS is suitable for use with other populations. Third, questions in the scenario-based scale developed in this study were generally easy, and only a quarter of the questions did not reach the level of 70% or higher participant accuracy. In future research, it is recommended that the difficulty level of such tests is increased to prevent a ceiling effect. Finally, the "obtain" domain of NL was included in the self-rated scale, but not in the scenario-based test. NL in the "obtain" domain emphasized the ability to "know where to find the precise information," which is directly related to one's information-searching capacity. Its objective measurement depends on the performance of the actual operation of Internet skills. Therefore, objective test forms of this domain can be further developed when applicable.

Implications for Research and Practice

In this study, the authors developed and validated the NL-TCS. This tool was confirmed as a valid and reliable NL measure, and an empirical assessment of college students' NL was completed through this process. This study provides a model of the process for developing an NL measure for college students. Future research aiming to develop similar tools for assessing NL could also use national dietary guidelines and daily food guides to formulate potential indicators, and then launch a Delphi study incorporating expert opinion to select suitable indicators for the study population. Subsequently, a valid and reliable measure could be developed as demonstrated here. The measure could be used to investigate the influencing factors of college students' NL as to be the basis to design the college students' NL intervention program.

This study found that the correlation coefficient for the relationship between the scenario-based test and healthy-eating behaviors was small. More accurate and objective measures of eating behaviors, such as food records or diaries, should be used to make stronger tests of the predictive validity of the measure in future research.

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台灣大學生營養素養測量工具之發展與驗證

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目標：發展適用於台灣大學生之營養素養測量工具，並進行信效度驗證。**方法：**本研究採用便利取樣的方式，由國內六所大學中選取1,269位學生參與此橫斷面研究，評價研究素養測量工具之信效度。本研究回收1,264份有效問卷，男女比例為0.87，大部分學生為大二（38.1%）和大三（26.1%）。營養素養測量工具的發展乃根據台灣之每日飲食指南和國民飲食指標，包括自陳式量表（8題）和情境式測驗量表（32題），以Cronbach's α 係數來驗證測量工具的內部一致性信度，效度考驗則採用驗證性因素分析。**結果：**自陳式量表和情境式測驗量表之Cronbach's α 係數分別為0.85和0.81，營養素養測量工具兩部分量表都達到良好模式適配度指標，而情境式測驗量表以項目反應理論分析困難度參數介於-3.22和0.11（可接受範圍介於-4~2）之間。此外，營養素養測量工具兩部分量表都與健康飲食行為呈正相關（ $r=0.417$, $p<0.001$ 和 $r=0.125$, $p<0.001$ ）。**結論：**本研究所發展之台灣大學生營養素養測量工具為一個具有信效度之測量工具，可應用在營養教育介入計畫執行前之需求評估。（台灣衛誌 2018；37(5)：582-597）

關鍵詞：營養素養、大學生、測量工具、飲食行為、信效度驗證

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