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Research article

Development and Validation of the Knowledge Test on Balanced Diet Consumption for Cambodian University Students

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Abstract

Objective: To develop and validate the Knowledge Test on Balanced Diet Consumption (KTBDC) for Cambodian university students based on the recommendation for balanced diet consumption of the World Health Organization. **Methods:** Literature review and individual face to face interview with Cambodian university students were used to guide the development of the KTBDC. The developed KTBDC consisted of 25 questions with the contents on knowledge on general recommendations for balanced diet consumption, calorie comparison and estimation of the amount of carbohydrate, protein, and fiber in food. Three response options for each question were “yes”, “no” and “don’t know”. Each question was assessed for its face validity and content validity, using item objective congruence index (IOC), by 3 experts. Subsequently, the KTBDC was administered to 95 university students at bachelor’s degree level in Cambodia. Difficulty index (P_i) and discrimination power index (D_i) were calculated for each question. The overall difficulty and discrimination power of the KTBDC were calculated from the average difficulty index ($\bar{p}$) and the average discrimination power index ($\bar{D}$) respectively. The reliability of the test was assessed using Kuder-Richardson 20 (KR-20). **Results**: Fifty subjects were female (52.6%). Mean age of the subjects was 22.3±1.9 (rage: 18-27) years old. All 25 questions being developed had the IOC score> 0.5. The overall difficulty index of the KTBDC was at moderate level ($\bar{p}$: 0.49) and the overall discrimination power index was at an excellent level ($\bar{D}$ >0.67). The overall reliability was 0.92. **Conclusion**: The KTBDC was congruent with the objective of the test, and the internal consistency of the test was high, suggesting that it was a valid and reliable test to assess knowledge about balanced diet consumption in Cambodian university students. The future study should focus on the generalizability of the test to other populations and contexts to ensure that it is appropriate for broader use.

Keywords: balanced diet consumption, university students, Cambodia, the Knowledge Test on Balanced Diet Consumption

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บทความวิจัย

การพัฒนาและการประเมินแบบวัดความรู้เกี่ยวกับการบริโภคอาหารอย่างสมดุลสำหรับนักศึกษามหาวิทยาลัยชาวกัมพูชา

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บทคัดย่อ

วัตถุประสงค์: เพื่อพัฒนาและประเมินแบบวัดความรู้เกี่ยวกับการบริโภคอาหารอย่างสมดุล (the Knowledge Test on Balanced Diet Consumption: KTBDC) สำหรับนักศึกษาชาวกัมพูชาที่สร้างขึ้นจากคำแนะนำการการบริโภคอาหารอย่างสมดุลขององค์การอนามัยโลก **วิธีการ:** ผู้วิจัยได้พัฒนาแบบวัดความรู้จากการทบทวนวรรณกรรมและการสัมภาษณ์กลุ่มตัวอย่างนักศึกษากัมพูชาแบบซึ่งหน้า แบบวัด KTBDC ที่พัฒนาขึ้นมีคำถามจำนวน 25 ข้อ ซึ่งมีเนื้อหาครอบคลุมในประเด็นความรู้ทั่วไปเกี่ยวกับคำแนะนำในการบริโภคอาหารอย่างสมดุล การเปรียบเทียบแคลอรี่ และการประมาณปริมาณของคาร์โบไฮเดรท โปรตีน ไฟเบอร์ในอาหาร คำตอบของคำถามแต่ละข้อเป็นแบบ 3 ตัวเลือก คือ “ใช่” “ไม่ใช่” และ “ไม่ทราบ” คำถามแต่ละข้อได้รับการประเมินความตรงเชิงประจักษ์ และความตรงตามเชิงเนื้อหาด้วยดัชนีความสอดคล้องระหว่างข้อคำถามกับวัตถุประสงค์ (item objective congruence index: IOC) โดยผู้เชี่ยวชาญ จำนวน 3 คน หลังจากนั้น นักศึกษามหาวิทยาลัยระดับปริญญาตรีในกัมพูชาจำนวน 95 คนตอบแบบสอบถาม KTBDC การศึกษาคำนวณดัชนีความยาก (P_i) และดัชนีอำนาจการจำแนก (D_i) ของข้อคำถามรายข้อ และคำนวณดัชนีความยากและดัชนีอำนาจการจำแนกของภาพรวมของแบบวัด KTBDC จากค่าเฉลี่ยดัชนีความยากรายข้อ ($\bar{p}$) และค่าเฉลี่ยดัชนีอำนาจการจำแนก ($\bar{D}$) ตามลำดับ ความเที่ยงของแบบวัดความรู้ประเมินโดยค่า Kuder-Richardson 20 (KR-20) **ผลการวิจัย**: กลุ่มตัวอย่าง 50 ราย (ร้อยละ 52.6) เป็นเพศหญิง ค่าเฉลี่ยอายุของตัวอย่างเท่ากับ 22.3±1.9 (พิสัย:18-27) ปี ข้อคำถามทั้ง 25 ข้อมีค่า IOC > 0.5 ดัชนีความยากโดยรวมของแบบวัด KTBDC อยู่ในระดับปานกลาง ($\bar{p}$: 0.49) และดัชนีอำนาจจำแนกโดยรวมอยู่ในระดับดีเยี่ยม ($\bar{D}$ >0.67) ความเที่ยงเท่ากับ 0.92 **สรุป**: แบบวัด KTBDC มีความตรงตามวัตถุประสงค์ของการประเมินและความสม่ำเสมอของคำถามในแบบวัดอยู่ในระดับที่สูง ซึ่งบ่งชี้ว่า แบบวัดมีความตรงและความเที่ยงในการประเมินความรู้เกี่ยวกับการบริโภคอาหารอย่างสมดุลในกลุ่มนักศึกษามหาวิทยาลัยชาวกัมพูชา การศึกษาในอนาคตควรเน้นในเรื่องความสามารถขยายผลเพื่อนำแบบวัดไปใช้ในประชากรกลุ่มอื่นและบริบทอื่น เพื่อให้มั่นใจว่าแบบวัดสามารถประยุกต์ใช้ได้ในวงกว้าง

คำสำคัญ: การบริโภคอาหารที่สมดุล นักศึกษามหาวิทยาลัย กัมพูชา แบบวัดความรู้เกี่ยวกับการบริโภคอาหารอย่างสมดุล

Introduction

Balanced diet consumption (BDC), according to WHO, refers to a consumption with the total energy intake at 2,000 kcal per day, having carbohydrates at 55-75% of total energy intake, protein at 10-15% of the total energy intake, fruits, and vegetables at least 400g per day, and sugar intake less than 50g for healthy eating and less than 25g for health benefits (1). BDC is one of health promotion strategies for general well-being and prevention of non-communicable diseases, especially diabetes mellitus. Data published in 2010 revealed that the crude prevalence of diabetes in Cambodia was 2.9% and that in urban areas was 2.4 times higher than that in the rural areas (5.6% vs.2.3%) (2). Although the prevalence of diabetes in Cambodia is not yet at an alarming rate compared to global rate, interventions to prevent diabetes should be carried out as soon as possible to avoid death or illness caused by diseases and economic burdens. One of the recommended measures is BDC.

Young adults like university students should be one of the major targets for the promotion of BDC because when students begin their study in university after graduation from high school, there is a tendency for less healthy eating behaviors. Factors contributing to this change have not yet well understood (3). According to several previous studies, people exposed to more food choices when they became university or college students compared to when they were younger (4–6). Previous studies indicated that college students gained more weight than individuals who did not go to college (7,8).

The Theory of Integrated Behavioral Model (IBM) is one of health behavioral models used to explain factors affecting BDC (9). The IBM was developed based on the Theory of Reasoned Action and the Theory of Planned Behavior (TPB) and other relevant theories i.e., the Health Belief Model (HBM) (9). The IBM is similar to the TPB in that it proposes that attitude, perceived norm, and personal agency determine the behavior via intention. In addition, the IBM also proposes that five factors (knowledge, skills, habit, salience, and perceived environmental constraints) directly determine the behavior. In short, the IBM consists of 2 types of independent variables, i.e., cognitive domain (knowledge) and psychological domains (intention, attitude, perceived norm, and personal agency, skills, perceived environmental constraints, salience, and habit) (9). The first step to employ the IBM to study health behavior is to develop valid and reliable measurement tools for all variables in the model.

A valid and reliable knowledge test could provide accurate feedback to individuals about their strengths and weaknesses in the cognitive domains, which can help to motivate behavior change. Based on our intensive literature review, there is no information about consumption behavior of university students in Cambodia nor instruments on knowledge domain which is one of the important parts of the IBM which will be applied to study BDC among Cambodian university students. Therefore, the objective of this study was to develop and validate the Knowledge Test on Balanced Diet Consumption (KTBDC) for Cambodian university students.

According to educational evaluation concept, there are two main types of evaluation, i.e., norm - referenced evaluation and criterion-referenced evaluation (10). In the latter type, learners are assessed or judged based on standards and criteria that are pre-determined (11). This type of evaluation is suitable for pre-test and post-test of health literacy training as tasks or training contents are designed to be aligned with the learning outcomes. Therefore, the criterion-referenced evaluation is used in this study.

Methods

The research protocol was approved by the Khon Kaen University Ethics Committee for Human Research based on the Belmont Report and Good Clinical

Practice in social and behavioral research (HE652240) and the National Ethics Committee for Health Research in Cambodia (No. 317 NECHR). The test developed in the study was called the Knowledge Test on Balanced Diet Consumption or KTBDC. Development and validation process of the KTBDC was depicted in figure 1.

Knowledge Test Development

Content of the KTBDC (table 2) was designed to cover 5 domains including knowledge on general recommendation for BDC (Q1-Q5), knowledge about protein (Q6-Q10), knowledge about carbohydrates (Q11-Q15), knowledge about fruit and vegetable (Q16-Q20), and knowledge about sugar (Q21-25). Literature review and individual face to face interview with 3 Cambodian university students were used to guide the constructions of questions in the KTBDC. The initial version of the KTBDC, written in English language, consisted of 25 questions with three response options, i.e., “yes”, “no” and “don’t know”. Of 25 questions, 21 required a correct answer of “yes” and the remaining 4 required a correct answer of “no”. A score of 1 was given for the correct answer, while "don't know" and incorrect answers were both given a score of 0.

Assessment of Validity

The initial version of the KTBDC was assessed for face validity by 3 experts with experiences in nutrient field for at least 5 years. The KTBDC was revised according to the experts’ recommendation and was sent to the same experts to assess content validity, using the Item Objective Congruence (IOC) index. The experts assigned a score for each knowledge question, from -1 (obviously incongruent), 0 (cannot determine), and 1 (obviously congruent). The scores given by 3 experts were then averaged. An average score > 0.5 indicates satisfactory and an average score <0.5 indicates that the questions needed to be removed or amended (12,13). All 25 questions remained in the KTBDC after assessing content validity and making minor amendments (the second version of KTBDC).

The second version of the KTBDC was translated into Khmer language (the third version) by the first author and then assessed for language clarity by 3 Cambodian university students. Some questions

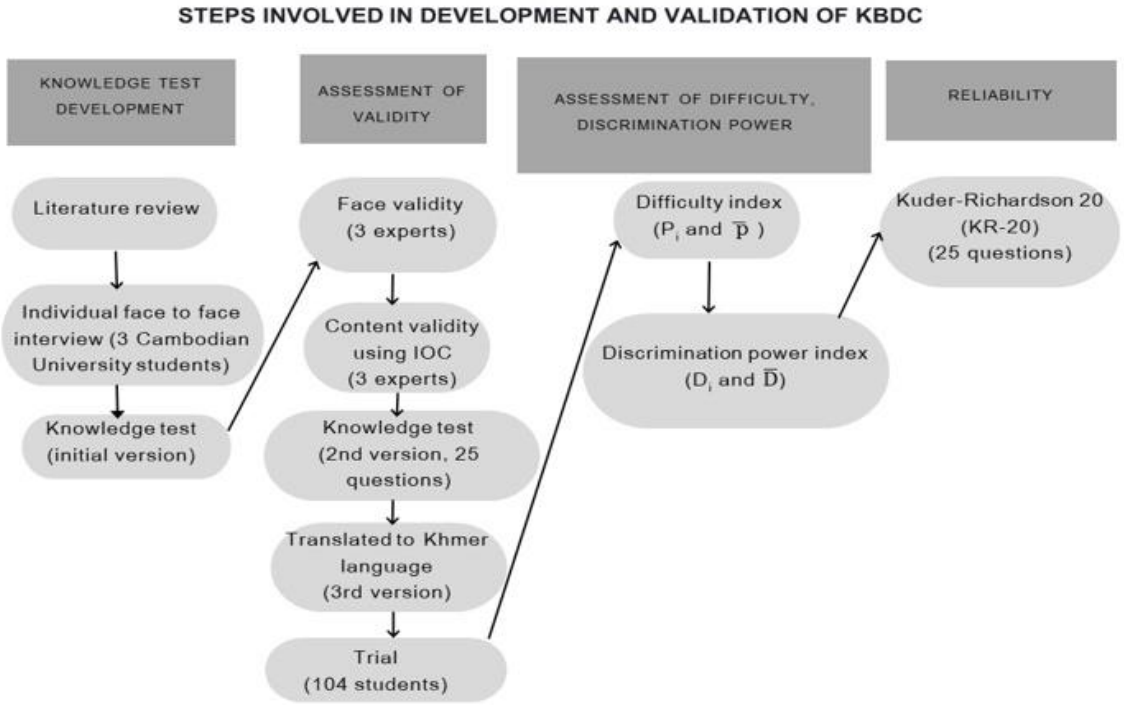


Figure 1. Steps involved in development and validation of the KTBDC

were revised due to their ambiguity on units (portion, gram), wording, or technical terms. The correctness of translation from English to Khmer was reassessed by experts on ASEAN languages and cultures at Faculty of Humanities and Social Sciences at Mahasarakham University. A certificate on translation was issued. The third version of the KTBDC was then tested for difficulty, discrimination power, and reliability. Items in the test are shown in table 2.

Population and Sample

The KTBDC was tested for its difficulty, discrimination power, and reliability in undergraduate students in Cambodia. It was recommended that a sample size of 30 or more is reasonable for pre-testing the questionnaire (14). Based on this recommendation, the study planned to recruit 100 subjects so that after dividing subjects into 3 equal groups based on score on the KTBDC, i.e., high score group (HSG), moderate score group (MSG) and low score group (LSG), we could obtain approximately 30 subjects in each group.

Convenient sampling was employed to recruit subjects as the researchers could not access student database or contact details. Twenty five out of 51 universities in Phnom Penh were randomly selected and contacted to participate in the study. The author also asked for an e-mail of the persons who would assist in data collection from the universities. Twenty-two agreed to participate. An e-mail was sent to each of the 22 universities to ask for their assistance in disseminating the electronic invitation to participate in the study to students via Telegram application or messenger application. The participation was on a voluntary basis. Consent by action was used. The link to the consent form was attached to the electronic invitation letter.

Data Collection

An online survey via Facebook messenger and Telegram application was employed for data collection. After the students clicked “agree” to participate in the survey, they were directed to “Google form”. The form consisted of 2 parts. The first part was the questions on sociodemographic information, and the second part was the 25 questions KTBDC. The data collection system was opened for one month (from Jan 05 to Jan 31, 2023).

Statistical Analysis

The analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics were used to analyze background information of the participating students. The KTBDC was assessed as follows.

Assessment of Difficulty and Discrimination Power

Difficulty: The difficulty index of each question of the KTBDC was calculated using the formula $P_i = A_i/N_i$ where P_i is difficulty index of question i, A_i is number of participants who answered correctly in question i and N_i is number of participants answered correctly plus number of participants answered incorrectly in question i (15). P_i was interpreted as follows; $\leq$0.29 (too difficult), 0.30-0.79 (moderate), $\geq$0.8 (too easy) (16). The overall difficulty index ($\bar{p}$) was calculated by averaging the P_i of each knowledge question.

Discrimination power: The discrimination power index of each knowledge question was calculated using the formula: $D_i = (HSG_{\text{correct answers}} - LSG_{\text{correct answers}})/(N/2)$ where D_i is a discrimination power index of question i, $HSG_{\text{correct answers}}$ is number of participants in the HSG who correctly answered in question i, $LSG_{\text{correct answers}}$ is number of participants in the LSG who correctly answered in question i, and N/2 is total numbers of participants in HSG and LSG were divided by 2. The value of D_i was interpreted as follows:<-0.01 (worst), 0.00-0.19 (poor), 0.20-0.29 (moderate), 0.30-0.39 (good), >0.39 (excellent) (15). The overall discrimination power index ($\bar{D}$) was calculated by averaging the D_i of each knowledge question.

Assessment of Reliability

The reliability of the KTBDC was assessed using the Kuder-Richardson 20 (KR-20) (17). The value

>0.7 indicated that the knowledge test had an acceptable internal consistency.

Results

Characteristics of the Respondents

One hundred and four students from 22 universities in Cambodia responded to the survey. Nine were excluded because they were students in master's degree and doctoral degree. The remaining 95 were used for data analysis. Table 1 shows characteristics of Cambodian university students in the study. Fifty subjects were female (52.6%). The majority of subjects studied in non-health sciences related area (n=65, 68.4%), had normal body mass index (BMI) (n=60, 63.1%). The mean age was 22.3±1.9 (range: 18-27) years old. Their median monthly allowance was 775,000 Riel or around 6,200 Baht (IQR: 600,000, range: 5,000-6,000,000 Riel).

The total KTBDC scores of students were ranked and divided into 3 groups ($\leq$ 33rd percentile, 34th-66th percentile, and $\geq$ 67th percentile). Thirty-two students with score $\leq$ 33rd percentile (score from 0 to 9) was labelled as "low score group" (LSG). Twenty-six students with score 34th to 66th percentile (score from 10 to 15) was labelled as "moderate score group" (MSG). The remaining 37 students having scores from 67th percentile and over (score from 16 to 25) were labelled as "high score group" (HSG). Their sociodemographic information is shown in table 1.

Validation of the KTBDC

All 25 questions being developed had IOC index > 0.5, indicating that the questions were congruent with the objective of the assessment. Table 2 shows difficulty index and discrimination power index of the KTBDC. $\bar{p}$ was 0.49 (moderate). P_i of 21 from 25

Table 1. Characteristics of Cambodian university students in the study (n=95)

	Frequency (percent)			
Sociodemographic	Total	High score group	Moderate score group	Low score group
Number of subjects	95	37	26	32
Gender				
Female	50 (52.6)	25 (67.6)	10 (38.5)	15 (46.9)
Male	45 (47.4)	12 (32.4)	16 (61.5)	17 (53.1)
BMI (kg/m^2)				
< 18.50 (underweight)	26 (27.4)	8 (21.6)	6 (23.1)	12 (37.5)
18.50 – 24.99 (normal weight)	60 (63.1)	27 (73.0)	18 (69.3)	15 (46.9)
25.00 – 29.99 (overweight)	8 (8.4)	2 (5.4)	1 (3.8)	5 (15.6)
> 30.00 (obese)	1 (1.1)	0 (0.0)	1 (3.8)	0 (0.0)
Area of study				
Non-health sciences	65 (68.4)	23 (62.2)	15 (57.7)	27 (84.4)
Health sciences	30 (31.6)	14 (37.8)	11 (42.3)	5 (15.6)
Year of study				
1st year	5 (5.3)	1 (2.7)	3 (11.5)	1 (3.1)
2nd year	26 (27.4)	8 (21.6)	7 (27.0)	11 (34.4)
3rd year	8 (8.4)	1 (2.7)	4 (15.4)	3 (9.4)
4th year	42 (44.2)	19 (51.4)	9 (34.6)	14 (43.7)
5th year	14 (14.7)	8 (21.6)	3 (11.5)	3 (9.4)

Table 2. Difficulty index and discrimination power index of the knowledge questions (n=95)

Domains	Objectives	Questions	P_i	D_i
Knowledge on general recommendation for BDC	The total recommended energy intake per day by WHO	1. The recommended total energy intake, by the world health organization (WHO), for adult is 2,000 calories per day.	0.58	0.75
	Recommended fruit and vegetable intake per day by WHO	2. The world health organization (WHO) recommends adults to consume at least 400 grams of fruit and vegetable per day.	0.65	0.72
	Recommended sugar intake per day by WHO	3. The world health organization (WHO) recommends adults to consume not more than 10 – 12 teaspoons of sugar.	0.64	0.81
	Calories exchange between starch food and meat	4. 100 grams of cooked rice provides the same calories as 100 grams of meat. *	0.19	0.14
	Calories exchange between carbohydrate and protein	5. 1 gram of carbohydrate provides the same calories as 1 gram of protein.	0.13	0.20
Protein	Number of calories in protein	6. 1 gram of protein provides 4 calories.	0.48	0.84
	Amount of protein in meat	7. 100 grams of meat (such as chicken or beef) contains approximately 26-28 grams of protein.	0.46	0.81
	Weight estimation of meat	8. A palm size of cooked meat weight approximately 90-100 grams.	0.55	0.87
	Recommended meat per day	9. Adults should consume approximately 270-300 grams of meat per day.	0.54	0.78
	Weight estimation of meat	 Fried fish 10. Cooked fish of the size shown in this picture weigh approximately 90-100 gram.	0.57	0.55
Carbohydrate	Number of calories in 1 gram of carbohydrate	11. 1 gram of carbohydrate provides 9 calories.	0.09	0.12
	Amount of carbohydrate in 100 grams of cooked rice	12. 100 gram of cooked rice contains approximately 28 grams of carbohydrate.	0.48	0.96
	Calories comparison between common starchy food in 1 serve (bread and cooked rice)	13. 3.5 slices of bread provide approximately the same number of calories as 1 small bowl of cooked rice.	0.49	0.87

Table 2. Difficulty index and discrimination power index of the knowledge questions (n=95) (continue)

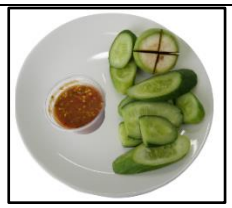
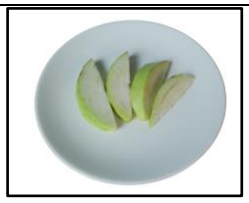
Domains	Objectives	Questions	P_i	D_i
	Calories comparison in same weight between common starchy food (noodle and cooked rice)	14. 1 bowl of noodle weighting the same amount of 1 small bowl of cooked rice will provide approximately the same calories.	0.48	0.84
	Calories estimation in common starch food (1 slice of bread)	 15. One slice of bread shown in this picture provides approximately 80 calories.	0.48	0.84
Fiber, fruit and vegetable	Source of fiber from fruit and vegetable	16. Fruit and vegetable are the main sources of fiber.	0.74	0.61
	weight estimation of vegetables	 17. Vegetables, similar to this picture, weigh about 50 grams. *	0.13	0.03
	Weight estimation of vegetables	 18. Vegetables, similar to this picture, weigh about 100 grams.	0.55	0.64
Fiber, fruit and vegetable	Weight estimation of fruit	 19. Half of an apple, similar to this picture, weighs about 50 grams.	0.65	0.67
	Weight estimaiton of fruit	 20. 4 slices of guava, similar to this picture, weighs about 50 grams.	0.55	0.64

Table 2. Difficulty index and discrimination power index of the knowledge questions (n=95) (continue)

domains	objectives	questions	P_i	D_i
Sugar	Recommended sugar consumption in gram per day	21. For healthy bennefits, adult should consume less than 25g of sugar per day.	0.65	0.67
	Amount of sugar in 1 teaspoon to gram	22. 1 teaspoon of sugar is approximately equal to 5g of sugar.	0.52	0.81
	Amount of sugar in 1 teaspoon of common sweetener (condense milk) to gram	23. 1 teaspoon of condense milk provides approximately 4-5g of sugar.	0.58	0.87
	Amount of sugar (in common beverage) in 1 can of soda soft drink to gram	24. 1 can of soda soft drink contains more than 25g of sugar.	0.49	0.75
	Comparison of amount of sugar between common beverage	25. Refrigerated can-coffee has less sugar than freshly prepare ice coffee.	0.51	0.84

Note: "No" is the correct answer in question 4, 5, 11 and 17.

questions of the KTBDC were between 0.30 – 0.80, indicating an acceptable level of difficulty or not being too difficult nor too easy. The other 4 questions (Q4, Q5, Q11 and Q17) appeared to be relatively difficult (P_i < 0.30). $\overline{D}$ was 0.67 (excellent). D_i of 22 from the total of 25 questions was ≥0.20, indicating either moderate, good, or excellent discrimination power. The D_i of the remaining 3 questions (Q4, Q11 and Q17) was at poor level (D_i < 0.20). Reliability of the KTBDC with 25 items was 0.92, indicating high internal consistency. The details of the information are shown in table 2.

The distribution of total scores of the KTBDC in the groups with high score, moderate score and low score was normally distributed. The average score of each group is shown in table 3.

Discussion and Conclusions

Overall results of the study showed that the KTBDC was a valid and reliable tool for assessing knowledge on BDC in Cambodian university students. Each of the 25 questions was congruent with the objective of the assessment. High internal consistency of the KTBDC suggested that all questions were highly correlated.

Although four questions of the KTBDC seemed to be relatively difficult compared to the rest of the developed questions, they were essential to measure the knowledge domain of BDC. In addition, the IOC of these 4 questions were more than 0.5, suggesting that in experts' view, these 4 questions were congruent with the test objective. Therefore, they should be kept in the

Table 3. Mean and standard deviation of the total KTBDC score of participants

group	number of subjects	mean±SD[1]	minimum	maximum
high score group	37	19.11±2.00	16	22
moderate score group	26	12.27±1.61	10	15
low score group	32	4.16±3.36	0	9
all participants	95	12.20±6.84	0	22

1: Full score of the KTBDC is 25.

KTBDC. However, these questions may need to be simplified. The finding also suggested that their eye balling estimation of the weight of common vegetables was not yet accurate.

Mean score of the KTBDC of the participants was about half of the highest possible score. For the calculation of the difficulty and discrimination power, those with incorrect answers and those with "don't know" answers were combined. However, the proportion of those who answered "don't know" outweighed the proportion of those who answered incorrectly. These findings suggested that participants lack knowledge about BDC.

In this study, a few strategies were employed to minimize potential bias. Frist, the response "don't know" was also provided to minimize the information bias due to students' guessing for the correct answer. Second, in the instruction to perform the test, it was requested that students refrained from using outside sources to assist test taking as the intention was to assess their current and necessary knowledge on BDC. Since the test was administered via online, it was not known if all participants complied with this instruction. It is important to note that the KTBDC was first developed in English language and then translated into Khmer language by native Khmer speaker and was intended to be used with university students. Therefore, the KTBDC needed to be reassessed for difficulty and discrimination power if it is planned to be used in other Cambodia population whose socio-demographic characteristics differ from those of the participants in this study. Generalizability of the result of this study should be done with caution. In this study, convenient sampling was employed for sample recruitment because the researchers cannot gain access to the databases of all university students. Hence, the representativeness of the sample to the population cannot be assessed. The small sample size may also limit the generalizability of the developed KTBDC. In the future, the KTBDC should be tested in a larger group of samples. Its construct validity should be investigated. Modern test theory such as item response theory should also be applied.

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