Original Article

Psychometric Properties of the Heart Disease Knowledge Scale: Evidence from Item and Confirmatory Factor Analyses

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Abstract

Background: **Heart disease knowledge is an important concept for health education, yet there is lack of evidence on proper validated instruments used to measure levels of heart disease knowledge in the Malaysian context.**

Methods: **A cross-sectional, survey design was conducted to examine the psychometric properties of the adapted English version of the Heart Disease Knowledge Questionnaire (HDKQ). Using proportionate cluster sampling, 788 undergraduate students at Universiti Sains Malaysia, Malaysia, were recruited and completed the HDKQ. Item analysis and confirmatory factor analysis (CFA) were used for the psychometric evaluation. Construct validity of the measurement model was included.**

Results: **Most of the students were Malay (48%), female (71%), and from the field of science (51%). An acceptable range was obtained with respect to both the difficulty and discrimination indices in the item analysis results. The difficulty index ranged from 0.12–0.91 and a discrimination index of ≥ 0.20 were reported for the final retained 23 items. The final CFA model showed an adequate fit to the data, yielding a 23-item, one-factor model [weighted least squares mean and variance adjusted scaled chi-square difference = 1.22, degrees of freedom = 2, P-value = 0.544, the root mean square error of approximation = 0.03 (90% confidence interval = 0.03, 0.04); close-fit P-value = > 0.950].**

Conclusion: **Adequate psychometric values were obtained for Malaysian undergraduate university students using the 23-item, one-factor model of the adapted HDKQ.**

Keywords: *heart disease, knowledge, factor analysis, universities, psychometrics*

Introduction

Cardiovascular disease (CVD) such as heart disease is the number one cause of death in the world (1) including Malaysia (2). Heart disease continues to result in high mortality and hospital admission cases (3,4). The prevalence of heart disease-related risk factors e.g. hypertension, is much less apreciated in young adults (5).

However, there was an increase in body mass index, ≥ 85% percentile from 15–34% in students aged 12–19 years (6) in the United States, while hypertension ≥ 95% percentile increased from 3–4% (7). In 2010, an increased prevalence of pre-hypertension and hypertension was demonstrated in a study on Malay adolecence in Putrajaya, Malaysia (8) of 11% and 12% respectively. Increasing blood pressure in children and adolescents over the last decade was partially attributed to the increased prevalence of overweight (9).

Strong evidence from pathobiological studies suggests that atherosclerotic CVD begins at a young age (10,11). Thus, early health education e.g. knowledge about heart disease programmes play an important role in disease prevention in young adults. Hunt (12) defined knowledge as the characteristic of a person who influences his or her own behavioural potential. Health knowledge is prerequisite to making health decisions and initiating behaviour change (13,14). A suboptimal level of knowledge about CVD was highlighted in earlier studies on young adults (15–17). Thus, a psychometrically sound instrument is required to determine individual health knowledge of heart disease and to apply it to disease prevention.

Research on heart disease knowledge, with the inclusion of healthy adults or at-risk populations, has mainly focused on risk factors (14,18). Although numerous studies had been conducted on the heart disease knowledge scale, few have reported information on the psychometric properties of the instrument used (19–21). In Malaysia, only a few publications exist on heart disease knowledge, while information has not been published on the instrument's reliability or validity (22,23).

The measurement of heart disease knowledge is very broad, and there may be variation between studies. As young adults are at optimal risk of heart disease, their knowledge in this regard should be assessed according to important domains, such as medical treatment, symptoms and epidemiology, in order to acquire an accurate picture of heart disease knowledge (24). Young adults' understanding of the treatment, symptoms and epidemiology of heart disease is important because it influences the identification and management of the disease in future.

Psychometric properties include an instrument's validity and reliability (25). "Validity" is defined as the degree to which an instrument measures what it is intended to measure (26). "Reliability" is the extent to which repeated measurements of a relatively stable phenomenon yield the same or a very similar result (27). The instrument developed by Bergman et al. (24), the Heart Disease Knowledge Questionnaire (HDKQ), was tested for its reliability and validity. HDKQ measures knowledge of heart disease among university students, and covers a wide range of knowledge concepts, e.g. medical, symptom, dietary, risk factors and epidemiology. It has been claimed to be reliable and valid among university student populations in the United States, and has been used widely in other studies (15,28). Moreover, it covers a wide range of difficulty items, based on a comprehensive review of currently available instruments used to determine heart disease knowledge, as means to improving the HDKQ items. However, the value of its psychometric properties has not been properly tested in Malaysian undergraduate students. Thus, it is possible that the results obtained in this study would differ to those obtained in studies conducted in the United States.

Therefore, the aim of this study was to evaluate the psychometric properties of the English version of the adapted HDKQ, designed to measure knowledge related to heart disease in Malaysian undergraduate students. Specifically, the intention was to examine each individual item included in the HDKQ by item analysis and then to determine the factor structure of HDKQ via confirmatory factor analysis (CFA).

Methods

Study design and procedures

A cross-sectional, survey design was used in this study conducted at Universiti Sains Malaysia (USM) from November 2014 to January 2015. The questionnaire was reviewed by cardiologist, physician, psychometric and psychology experts to ensure that the contents were appropriate to Malaysian culture. This study involved the psychometric testing of an inventory based on item level (item analysis) and scale level (CFA) in a Malaysian population.

Participants were briefed on the purpose of the study, the procedures and the confidentiality of their responses. They were informed that their participation in the study was voluntary, and had the opportunity of reviewing the questionnaire before agreeing to participate in the study. The completed surveys were collected immediately prior to the students leaving the lecture hall.

Participants

This research recruited Malaysian undergraduate university students as research participants. The participants were recruited from the three campuses (Health, Main and Engineering) at USM. A cluster sampling technique, with probability proportional to the cluster size, was applied. The schools were treated as a cluster. Eight schools were randomly selected from 24 schools at USM. A higher proportion of study participants was drawn from schools with a higher number of registered students than that from schools with a lower number.

Due to the restricted information from Registrar Office of USM and the availability of students in class are dynamic, not all students were selected from each cluster. The weightage was given to each school, based on the population of students enrolled in the year 2014. Thereafter, first- to third-year undergraduate students were purposively selected from the selected eight schools from the final school cluster. Eight hundred and thirty-seven students were invited to participate in the study. The completed questionnaire was returned to the researcher by 788 students, and the response rate was 94%.

Heart Disease Knowledge Questionnaire (HDKQ) instrument

The self-administered English version of the HDKQ comprises 30 items as follows: dietary (6 items), epidemiology (4 items), medical (7 items), risk factor (9 items) and heart attack symptom (4 items). There were three possible answers to each statement of "True", "False" and "Don't know" (24).

The response of the participants was coded as 0 for an incorrect answer or "Don't know" answer, and as 1 for the correct answer. Total subscales score were calculated. A higher score indicated a higher level of knowledge. The average time taken to complete the questionnaire was 15 minutes.

Bergman et al. (24) examined the validity of the questionnaire using CFA, and found that the items were reduced from 82 items to a final 30 items, reflecting a five-factor model. Comparative fit index (CFI) = 0.82, Tucker-Lewis index (TLI) = 0.88, and root mean square error of approximation (RMSEA) = 0.03 were reported for the CFA model. Thus, the five-factor model demonstrated a good-fit model based on RMSEA.

In the present study, two items did not reach a content validity index of 0.78. These were questions pertaining to statement Q13 – *"Heart disease is the leading cause of death in the United States"* and Q25 – *"Margarine with liquid safflower oil is healthier than margarine with hydrogenated soy oil"*. Thus, the wording of the two items was revised to be more culturally appropriate, and altered accordingly to suit the Malaysian context. The wordings of items Q13 and Q25 were changed to *"Heart disease is the leading cause of death in Malaysia"* and *"Margarine with liquid olive oil is healthier than margarine with hydrogenated palm oil"* respectively. The adapted HDKQ was utilised in the present study.

Ethical considerations

Approval for the study was obtained from the Human Research Ethics Committee, USM. Participants were guaranteed anonymity and confidentiality for participating in the study, and were fully informed about its purpose. Implied consent was deemed to have given once the participants completed and returned the survey form.

Data analysis

Several type of software were used for the data analysis. Microsoft Excel (2013), IBM SPSS version 22 and Mplus version 7.3 (29) were used to conduct item analysis, descriptive analysis and CFA, respectively. There were no missing data values.

Descriptive statistics were calculated to describe the characteristics of the sample and the item analysis (the index of difficulty and item discrimination) of the scale. The validation of the factor structure of HDKQ was tested via CFA and construct validity. A P-value < 0.050 (two-tailed) was regarded as statistically significant.

Item analysis

Item analysis involved statistical analysis, based on item level in a scale. It was used to identify which items could be retained or discarded (30). Item analysis was performed using the difficulty and discrimination indices.

The difficulty index was defined as the proportion of participants answering the item correctly, and was calculated by the number of correct responses over the total number of responses. Thus, the smaller the index, the more difficult the item is (30). An item within the range of 0.20–0.80 was deemed to be acceptable (31).

The discrimination index was defined as the ability of the item to discriminate between students with high achievement and low achievement (32). It was calculated by dividing the participants into three groups according to their scores obtained on the knowledge measure as a whole: an upper group, consisting of 27% who answered the item correctly, a lower group, consisting of the 27% who answered the item correctly and a middle group consisting of the remaining 46%, after the students had been ranked (32–34).

Scoring for the discrimination index was as follows: > 0.40 = very good items; 0.30–0.39 = reasonably good, but possibly subject to improvement; 0.20–0.29 = marginal items, and subject to improvement; and < 0.19 = poor items, to be rejected or improved by revision (33). Items that did not fulfil the criteria of the difficulty and discrimination indices were still included in the CFA analysis, but were cautiously viewed as potentially problematic.

Confirmatory Factor Analysis

The weighted least squares mean and variance adjusted (WLSMV) estimator was used in the analysis. The WLSMV is a robust estimator of the weighted least squares in Mplus with regard to modelling categorical outcome (29).

To determine the factor structure of the adapted HDKQ, a number of fit indices were recommended: CFI ≥ 0.95, TLI ≥ 0.95, the weighted root mean square residual (WRMR) ≤ 1.00, the RMSEA < 0.05, or at most 0.08 and a non-significant WLSMV scaled chi-square difference test (Δ χ^2 WLSMV) with degree of freedom (df) for the nested model (35–39). The CFA model was modified based on a modification index (MI) > 10 of the additional specification of error covariance (40). Specifically, all deletions and modifications of item were carried out iteratively, based on insignificant factor loadings and poor item analysis until the model fit indices met the established criteria.

Discriminant validity was examined using the correlation among constructs (r ≤ 0.85). The discriminant validity could be established when items from the different constructs did not correlate with one another (41), or when a construct did not correlate with other constructs in a scale (35).

Results

Socio-demographical characteristics

Seven hundred and eighty-eight students were recruited. The socio-demographic characteristics of the undergraduate students are shown in Table 1. The sample was primarily female (71%) with mean [standard deviation (SD)] age of 20.2 (1.02) years, and ranging from 19–27 years.

Heart Disease Knowledge Questionnaire responses

As seen in Table 2, 30 questions were assessed, and the correct response to each item in the subscales presented as frequency and percentage. The mean (SD) score of the correct responses was 15.0 (3.79) over a total number of 30 questions.

Item analysis

The psychometric properties of the HDKQ by item level are given in Table 3. The difficulty index for most items was satisfactory (ranging from 0.12–0.91). Some items did not fall within the range of 0.20–0.80 (Q8, Q10, Q11, Q17, Q20, Q24, and Q30). However, they were retained for further deletion during the CFA stage. According to the discrimination index, some items scored poorly and needed further improvement (Q8, Q10, Q14, Q17, Q20, Q22, and Q24). All items that did not meet the acceptable levels of difficulty and discrimination indices were retained in the subsequent CFA analyses but were view as potentially problematic.

Confirmatory factor analysis

CFA was subsequently applied to the data in order to determine how well the hypothesised five-factor model fit the data obtained. The initial model displayed a poor fit of data for a five-factor model, with 30 items. The CFI (0.71), TLI (0.68) and WRMR (1.30) were not within the acceptable threshold. The only exception in this regard was RMSEA (0.032) [90% confidence interval (CI): 0.03, 0.04 and close-fit P-value = > 0.950].

It was found on examination of each item's standardised factor loading that three items (Q8, Q10 and Q14) had a very low negative loadings ranging from −0.13 to −0.03 while four items (Q11, Q22, Q17 and Q24) did not produce significant estimates (P-value > 0.050) of their respective factors. Previously, these items Q8, Q10, Q11, Q17, Q20, Q24 and Q30 did not meet the difficulty index criteria, while items Q8, Q10, Q14, Q17, Q20, Q22 and Q24 did not meet the discrimination index criteria. Adequate theoretical support was applied to investigate these items, and a decision taken to remove them iteratively. Item Q20 and Q30 were not removed from the model because the factor loadings were found to be significant.

Table 1: Demographical data (n = 788)

Demographic variables	Frequency (n)	Percentage (%)
Gender		
Female	557	70.7
Male	231	29.3
Ethnicity		
Malay	375	47.6
Chinese	338	42.9
Indian	48	6.1
Others	27	3.4
Living arrangement		
On campus	707	89.7
Off campus	81	10.3
School/Faculty		
Health Sciences	133	16.9
Medical Sciences	83	10.5
Music	4	0.5
Management	161	20.4
Electric and Electronic Engineering	73	9.1
Mechanical Engineering	49	6.2
Pharmaceutical Sciences	184	23.4
Computer Science	102	12.9
Fields of study		
Arts	165	20.9
Sciences	401	50.9
Technical	222	28.2
Year of study		
First	421	53.4
Second	234	29.7
Third	133	16.9

Furthermore, an improvement in the fit indices was not observed when both items were removed iteratively. The subsequent modified model of knowledge consisted of a five-factor model with 23 items with fit indices: Δ χ^2 WLSMV (df) = 13.79 (4), P-value = 0.008, CFI = 0.86, TLI = 0.84, WRMR = 1.14, RMSEA = 0.03 (90% CI: 0.03, 0.04 and close-fit P-value = > 0.950). Thus, a better fit improvement was demonstrated with the subsequent modified model compared to the initial model. However, modification based on MI was not performed because a remarkable improvement in the fit indices was not observed.

The factors correlations for the modified five-factor model are presented in Table 4. Owing to high correlation between factors (risk factor and epidemiology), the model was revised to a four-factor model by combining the risk factor and epidemiology subscales. The four-factor model had factor correlations r, ranging from 0.43–0.97. The correlation between the factors was still high, and all the remaining 23 items were combined into a single-factor structure.

The single-factor structure CFA model fitted the data well based on several fit indices: Δ χ^2 WLSMV (df) = 1.22 (2), P-value = 0.544 and RMSEA = 0.03 (90% CI: 0.03, 0.04 and close-fit P-value = > 0.950). A summary of the fit indices of the CFA models of HDKQ are shown in Table 5. The final model consisted of 23 items with significant factor loadings, ranging from 0.15–0.66 (Table 6).

Table 2: The responses with correct answers (in bold) given to items on HDKQ (n = 788)

Item number	Description	Responses		
		True (%)	False (%)	Don't know (%)
Dietary knowledge				
Q1	Polyunsaturated fats are healthier for the heart than saturated fats.	**394 (50)**	92 (11.7)	302 (38.3)
Q6	Trans-fats are healthier for the heart than most other kinds of fats.	212 (26.9)	**262 (33.1)**	315 (40)
Q9	Most of the cholesterol in an egg is in the white part of the egg.	115 (14.6)	**585 (74.2)**	88 (11.2)
Q12	Dietary fiber lowers blood cholesterol.	**514 (65.2)**	71 (9.0)	203 (25.8)
Q25	Margarine with liquid olive oil is healthier than margarine with hydrogenated palm oil.	**486 (61.7)**	77 (9.8)	225 (28.6)
Q30	Many vegetables are high in cholesterol.	35 (4.4)	**683 (86.7)**	70 (8.9)
Epidemiology knowledge				
Q2	Women are less likely to get heart disease after menopause than before.	151 (19.2)	**270 (34.3)**	367 (46.6)
Q13	Heart disease is the leading cause of death in Malaysia.	**623 (79.1)**	74 (9.4)	91 (11.5)
Q24	Most women are more likely to die from breast cancer than heart disease.	443 (56.2)	**148 (18.8)**	197 (25.0)
Q29	Heart disease is better defined as a short-term illness than a chronic, long-term illness.	139 (17.6)	**464 (58.9)**	185 (23.5)
Risk factor knowledge				
Q3	Having had chicken pox increases the risk of getting heart disease.	51 (6.5)	**413 (52.4)**	324 (41.1)
Q4	Eating a lot of red meat increases heart disease risk.	**551 (69.9)**	110 (14.0)	127 (16.1)
Q7	The most important cause of heart attack is stress.	436 (55.3)	**268 (34.0)**	84 (10.7)
Q8	Walking and gardening are considered types of exercise that can lower heart disease risk.	**720 (91.4)**	35 (4.4)	33 (4.2)
Q10	Smokers are more likely to die of lung cancer than heart disease.	606 (76.9)	**95 (12.1)**	87 (11.0)
Q11	Taking an aspirin each decreases the risk of getting heart disease.	**146 (18.5)**	355 (45.1)	287 (36.4)
Q22	Taller people are more at risk for getting heart disease.	74 (9.4)	**456 (57.9)**	258 (32.7)
Q26	People who have diabetes are at higher risk of getting heart disease.	**533 (67.6)**	102 (12.9)	153 (19.4)
Q28	Eating a high fiber diet increases the risk of getting heart disease.	99 (12.6)	**572 (72.6)**	117 (14.8)
Medical knowledge				
Q5	Most people can tell whether or not they have high blood pressure.	357 (45.3)	**299 (37.9)**	132 (16.8)
Q14	The healthiest exercise for the heart involves rapid breathing for a sustained period of time.	**313 (39.7)**	200 (25.4)	275 (34.9)
Q16	A healthiest person's pulse should return to normal within 15 minutes after exercise.	**414 (52.5)**	71 (9.0)	303 (38.5)
Q18	Cardiopulmonary resuscitation (CPR) helps to clear clogged blood vessels.	174 (22.1)	**395 (50.1)**	219 (27.8)
Q19	HDL refers to "good" cholesterol, and LDL refers to "bad" cholesterol.	**376 (47.7)**	115 (14.6)	297 (37.7)

(*continued on next page*)

Table 2: (*continued*)

Item number	Description	Responses		
		True (%)	False (%)	Don't know (%)
Q20	Atrial defibrillation is a procedure where hardened arteries are opened to increase blood flow.	280 (35.5)	**81 (10.3)**	427 (54.2)
Q23	"High" blood pressure is defined as 110/80 (systolic/diastolic) or higher.	192 (24.4)	**386 (49.0)**	210 (26.6)
Symptoms knowledge				
Q15	Turning pale or gray is a symptom of having a heart attack.	**330 (41.9)**	151 (19.2)	307 (39.0)
Q17	Sudden trouble seeing in one eye is a common symptom of having a heart attack.	191 (24.2)	**149 (18.9)**	448 (56.9)
Q21	Feeling weak, lightheaded, or faint is a common symptom of having a heart attack.	**439 (55.7)**	177 (22.5)	172 (21.8)
Q27	Men and women experience many of the same symptom of a heart attack.	**463 (58.8)**	128 (16.2)	197 (25.0)

Q = Question number.

Table 3: Psychometric properties of HDKQ by item level (*n* = 788)

Item	Difficulty index	Discrimination index
Q1	0.50	0.49
Q2	0.34	0.41
Q3	0.52	0.29
Q4	0.70	0.29
Q5	0.38	0.36
Q6	0.33	0.43
Q7	0.34	0.29
Q8	0.91	0.03
Q9	0.74	0.41
Q10	0.12	0.05
Q11	0.19	0.15
Q12	0.65	0.38
Q13	0.79	0.24
Q14	0.40	0.11
Q15	0.42	0.37

(*continued*)

Table 3: (*continued*)

Item	Difficulty index	Discrimination index
Q16	0.53	0.36
Q17	0.19	0.13
Q18	0.50	0.47
Q19	0.48	0.52
Q20	0.10	0.11
Q21	0.56	0.33
Q22	0.58	0.16
Q23	0.49	0.46
Q24	0.19	0.10
Q25	0.62	0.46
Q26	0.68	0.30
Q27	0.59	0.37
Q28	0.73	0.50
Q29	0.59	0.41
Q30	0.87	0.24

Q = Question number

Table 4: Model fit indices of the HDKQ measurement models

Model	ΔChi-square[a]			CFI	TLI	WRMR	RMSEA (90% CI)	Clfit *P*-value
	Δ χ2 WLSMV	df	*P*-value					
Initial	-	-	-	0.708	0.679	1.299	0.032(0.028, 0.036)	> 0.950
5-factor modified	13.793	4	0.008	0.857	0.836	1.140	0.031(0.026, 0.036)	> 0.950
4-factor	7.299	3	0.063	0.858	0.840	1.145	0.031(0.025, 0.036)	> 0.950
1-factor	1.219	2	0.544	0.848	0.833	1.173	0.031(0.026, 0.036)	> 0.950

[a] WLSMV scaled difference chi-square test, df = degree of freedom, CFI = Comparative fit index, TLI = Tucker-Lewis index, WRMR = Weighted root mean square residual, RMSEA = Root mean square error of approximation, Clfit = Close fit P-value for RMSEA.

Table 5: Standardised factor loadings (λ) and probability value of the final model of HDKQ

Item number	Standardised factor loadings (95% CI)	*P*-value
Q1	0.401 (0.302, 0.484)	< 0.001
Q2	0.349 (0.247, 0.435)	< 0.001
Q3	0.153 (0.048, 0.241)	0.004
Q4	0.256 (0.153, 0.342)	< 0.001
Q5	0.255 (0.149, 0.344)	< 0.001
Q6	0.445 (0.345, 0.528)	< 0.001
Q7	0.208 (0.103, 0.296)	< 0.001
Q9	0.496 (0.399, 0.578)	< 0.001
Q12	0.414 (0.314, 0.497)	< 0.001
Q13	0.249 (0.137, 0.343)	< 0.001
Q15	0.229 (0.117, 0.309)	< 0.001
Q16	0.216 (0.113, 0.302)	< 0.001
Q18	0.439 (0.346, 0.518)	< 0.001
Q19	0.547 (0.459, 0.621)	< 0.001
Q20	0.242 (0.086, 0.373)	0.002
Q21	0.208 (0.105, 0.294)	< 0.001
Q23	0.391 (0.290, 0.475)	< 0.001
Q25	0.458 (0.364, 0.536)	< 0.001
Q26	0.221 (0.115, 0.311)	< 0.001
Q27	0.282 (0.180, 0.367)	< 0.001
Q28	0.658 (0.573, 0.730)	< 0.001
Q29	0.400 (0.304, 0.481)	< 0.001
Q30	0.538 (0.425, 0.634)	< 0.001

Q = Question number, CI = Confidence Interval.

Table 6: Factor correlations for the modified five-factor model

Factor pairs	Correlations, *r*	*P*-value
Dietary-Risk Factor	0.937	< 0.001
Epidemiology-Risk Factor	1.062	< 0.001
Epidemiology - Dietary	0.884	< 0.001
Medical -Risk Factor	0.910	< 0.001
Medical - Epidemiology	1.130	< 0.001
Medical - Dietary	0.940	< 0.001
Symptoms - Risk Factor	0.543	< 0.001
Symptoms - Dietary	0.484	< 0.001
Symptoms - Epidemiology	0.737	< 0.001
Symptoms - Medical	0.439	< 0.001

Discussion

This study illustrated the application of two approaches in determining the psychometric properties of the adapted HDKQ, namely item analysis and the CFA. The study findings provided evidence that the adapted HDKQ inventory have adequate levels of psychometric properties based on item and scale levels to measure the knowledge of heart disease among Malaysian undergraduate students.

The findings of both the difficulty and discrimination indices indicated that the adapted HDKQ inventory was satisfactory. The wide scatter of item discrimination values for items with a similar level of difficulty may reflect that, to some extent, undergraduate students guessed when answering question on heart disease knowledge. Poor scores for the discrimination and difficulty indices were obtained for Q20 and a poor difficulty index score for Q30. Nevertheless, a decision to retain these items after the CFA stage was taken because the procedure of atrial defibrillation in medical knowledge (Q20) and the importance of vegetable consumption for heart disease prevention (Q30) constitute core information on heart disease.

Perhaps, in addition to poor medical knowledge of heart disease, the low score obtained for Q20 related to vocabulary skills. However, it must be recognised other factors need to be taken into account when using discrimination indices to categorise HDKQ inventory as either “good” or “bad”, especially when dealing with a multidisciplinary undergraduate students. For example, students’ performance with respect to HDKQ items on nutrition knowledge of heart disease may not be accurately predictive of their performance of with respect to HDKQ items on another domain e.g. medical knowledge, or with regard to their overall performance in the total HDKQ test score.

The advantage of performing item analysis was the ability to flag the poor performing item. It is also used to ensure determine the quality of the item (42) for further analysis. Interestingly, a wide scatter of difficulty index scores was obtained in our study. Seven items were either ≤ 0.20 or ≥ 0.80, when compared to the scores obtained in the study by Bergman et al. (24), in which only one item have poor difficulty index of ≤ 0.20. This may be owing to the sample characteristics of the present study, which included university students of differing backgrounds and different field of studies.

WLSMV was used in our study because the HDKQ has a binary categorical outcome. WLSMV provides the identical parameter estimate and standard error like those of the maximum likehood estimator, a common estimator in CFA analysis (39,43). Furthermore, minimal assumptions about the distribution of the observed variable are required using the WLS method, and it also produces accurate chi-square statistics and standard errors if the sample size is sufficiently large (38).

A five-factor model with 30 items was cited in the original HDKQ inventory (24). However, this was not supported, based on the present findings. The CFA result revealed a final 23-item, one-factor model of HDKQ inventory, with the elimination of other poor performing items (Q8, Q10, Q11, Q14, Q17, Q22 and Q24) in the CFA stage. The poor items were revisited in the CFA stage for further deletion to ensure that the inventory demonstrated coherence between the data and the structure based on the fit indices criteria.

An adequate model fit was shown in the final CFA model and can presently be considered to be the best validated scale. The five-factor model was relapsed and combined as a single factor model, which fit the data well, based on the $\Delta\chi^2$ WLSMV and RMSEA indices. The single-factor model was more logically sound, informative and meaningful than a five- or four-factor model as the other indices, i.e., TLI, CFI and WRMR, demonstrated weak support for model fitness. Furthermore, the TLI and CFI values in the present findings were also similar to those obtained in the study by Bergman et al. (24), with TLI and CFI falling below the recommended criteria.

With respect to discriminant validity, six pairs of factors demonstrated high correlation (r > 0.85), i.e., diet-risk factor, epidemiology-risk factor, epidemiology-diet, medical-risk factor, medical-epidemiology and medical-diet (Table 4). According to Brown (41), when factors overlap to this degree (r > 0.85), it may be possible to combine the factors to acquire a more parsimonious solution. As shown in Table 6, the standardised factor loadings were found to be lower than those suggested by Ford et al. (44) but the factor loading the range was higher than that reported by Bergman et al. (24). A factor loading of ≥ 0.40 was found for 10 of the 23 items in the present study. Thus, the final CFA model was revised to a single-factor model with an improvement in the $\Delta\chi^2$ WLSMV and RMSEA indices.

Limitations

There were a number of potential limitations to this study. While the sample was randomly selected, selection bias was possible owing to the unequal proportion of students in different fields of study and their gender (mostly females). These confounding variables should have been controlled during the baseline comparison.

Furthermore, the study population derived mainly from one university. Therefore, it can only be generalised to undergraduate students studying in USM until further cross-cultural validation study are conducted at other universities in Malaysia to confirm these findings. The students may have not been familiar with the contents of the HDKQ, and this might have led them to response bias as the participants came from different fields of study. However, young adults should always be targeted when promoting cardiovascular health as they are our future assets.

Conclusion

It was shown in the present study that the 23-item, single-factor model of the HDKQ inventory has adequate levels of psychometric properties. It is a refined measure of heart disease knowledge that covers a wide range of knowledge concepts, and is presently considered to be the best validated scale among Malaysian undergraduate students.

In practice, this instrument may be used to assess knowledge about heart disease among young adults, and provide useful insight for professional healthcare providers, nursing educators, policy-makers and lecturers who are promoting cardiovascular health in university for early preventive behaviours among young adults. More emphasis should be placed on ensuring that young adults effectively improve their knowledge about heart disease and engaging healthier lifestyle activities during their university years.

The present study could have been improved via the application of the item response theory (IRT). According to Wilson et al. (45), IRT is a behaviour change assessment that utilises a model-based approach to a measurement for each item as a probability of a correct response in participants' latent trait e.g. true heart disease knowledge.

Future studies should also include samples from other universities for cross-cultural validation studies via multi-group CFA test such as gender (e.g. male or female), fields of study (e.g. arts or science or technical) and student groupings (e.g. undergraduate or postgraduate) and to examine the stability properties of the adapted HDKQ instrument through the test-retest method. Ultimately, there is a need for a qualitative study to examine how well this measure assesses all relevant facets of the construct of HDKQ inventory among undergraduate students.

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Conflict of Interest

No

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No

Authors' Contributions

Conception and design, provision of study materials, collection and assembly of the data, statistical expertise, administrative, technical, or logistics, analysis and interpretation of the data, and drafting of the article,

final approval of the article: BCL
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Appendix

Description of the questionnaire

Item number	Description
Dietary knowledge	
Q1	Polyunsaturated fats are healthier for the heart than saturated fats.
Q6	Trans-fats are healthier for the heart than most other kinds of fats.
Q9	Most of the cholesterol in an egg is in the white part of the egg.
Q12	Dietary fiber lowers blood cholesterol.
Q25	Margarine with liquid olive oil is healthier than margarine with hydrogenated palm oil.
Q30	Many vegetables are high in cholesterol.
Epidemiology knowledge	
Q2	Women are less likely to get heart disease after menopause than before.
Q13	Heart disease is the leading cause of death in Malaysia.
Q24	Most women are more likely to die from breast cancer than heart disease.
Q29	Heart disease is better defined as a short-term illness than a chronic, long-term illness.
Risk factor knowledge	
Q3	Having had chicken pox increases the risk of getting heart disease.
Q4	Eating a lot of red meat increases heart disease risk.
Q7	The most important cause of heart attack is stress.
Q8	Walking and gardening are considered types of exercise that can lower heart disease risk.
Q10	Smokers are more likely to die of lung cancer than heart disease.
Q11	Taking an aspirin each decreases the risk of getting heart disease.
Q22	Taller people are more at risk for getting heart disease.
Q26	People who have diabetes are at higher risk of getting heart disease.
Q28	Eating a high fiber diet increases the risk of getting heart disease.
Medical knowledge	
Q5	Most people can tell whether or not they have high blood pressure.
Q14	The healthiest exercise for the heart involves rapid breathing for a sustained period of time.
Q16	A healthiest person's pulse should return to normal within 15 minutes after exercise.
Q18	Cardiopulmonary resuscitation (CPR) helps to clear clogged blood vessels.
Q19	HDL refers to "good" cholesterol, and LDL refers to "bad" cholesterol.
Q20	Atrial defibrillation is a procedure where hardened arteries are opened to increase blood flow.
Q23	"High" blood pressure is defined as 110/80 (systolic/diastolic) or higher.
Symptoms knowledge	
Q15	Turning pale or gray is a symptom of having a heart attack.
Q17	Sudden trouble seeing in one eye is a common symptom of having a heart attack.
Q21	Feeling weak, lightheaded, or faint is a common symptom of having a heart attack.
Q27	Men and women experience many of the same symptom of a heart attack.

Q = Question number.