ORIGINAL ARTICLE

Development and Validation of a Questionnaire on Knowledge and Attitude Toward Far-Infrared-Emitting Garments, Their Medical Applications and Health Benefits

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Keywords:
Far-infrared-emitting garments; Questionnaire; Knowledge; Attitude; Validity; Reliability

ABSTRACT

Introduction: Infrared radiation is a form of energy within the electromagnetic spectrum, categorized by its frequency and wavelength. Far-infrared (FIR)-emitting garments such as blankets, belts, clothing, and socks infused with bio-ceramic powder are commercially available and have been associated with various health benefits in scientific literature. However, no studies have yet explored the public's knowledge, attitude, and practice (KAP) regarding the use of FIR-emitting garments. This highlights the need for a valid and reliable instrument to assess these components. **Objective:** The primary objective of this study was to develop and validate a questionnaire to assess knowledge and attitudes toward FIR-emitting garments, including their medical applications and health benefits. **Methodology:** The development process included both validity and reliability assessments. Five experts conducted face and content validity evaluations based on item relevance, clarity, simplicity, and ambiguity. The Content Validity Index (CVI) was calculated using both the Item-level (I-CVI) and Scale-level (S-CVI) indices. A pilot test involving 51 respondents was carried out to determine internal consistency using Cronbach's Alpha. **Results:** The CVI scores for knowledge items averaged 0.88, with with I-CVI and S-CVI values averaging 0.88 across all evaluated criteria. For attitude items, the I-CVI and S-CVI values averaged 0.84 for relevance and 0.87 for clarity, simplicity, and ambiguity. The reliability analysis yielded Cronbach's Alpha values of 0.807 for knowledge items and 0.745 for attitude items. **Conclusion:** The developed questionnaire demonstrated strong content validity (CVI > 0.83) and acceptable internal consistency (Cronbach's Alpha > 0.73). Therefore, the instrument is considered valid and reliable for assessing knowledge and attitudes related to FIR-emitting garments and their potential health benefits. It is recommended for use in future population-based studies.

INTRODUCTION

Infrared (IR) radiation, also known as thermal radiation, is part of the electromagnetic spectrum and is classified according to frequency and wavelength (Bontemps et al., 2021). The International Commission on Illumination (CIE) classifies infrared radiation into three sub-bands based on wavelength: near-infrared (0.7–1.4 µm), mid-infrared (1.4–3.0 µm), and far-infrared (3.0–100 µm) (Vatansever & Hamblin, 2012). Far-infrared (FIR) radiation, while invisible to the naked eye, is perceived by human thermoreceptors in the skin as radiant heat. It can penetrate the body to a depth of approximately 2 to 3 centimetres into subcutaneous tissue without causing excessive surface heating (Hartel et al., 2006, as cited in Shui et al., 2015).

FIR-emitting garments typically contain bioceramic materials either embedded as fibres or powders within the fabric or affixed as disks or patches. These materials, composed of metallic oxides such as magnesium, silica, aluminium, and tourmaline, are capable of emitting infrared and far-infrared radiation when stimulated by body heat (Bontemps et al., 2021). Once heated, these garments absorb body heat, retain it, and re-emit it as FIR radiation back to the body. This interaction may result in physiological responses such as elevated skin temperature, vasodilation, and enhanced microcirculation in targeted areas (Mantegazza et al., 2018).

A range of FIR-emitting products is available commercially, including blankets, belts, clothing, and socks that incorporate bioceramic powders (Dyer, 2011, as cited in Bontemps et al., 2021). Research suggests these garments may offer multiple health benefits. Reported effects include reduction of skin temperature during exercise by promoting peripheral blood flow (Kenny & McGinn, 2017

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Journal homepage: https://journals.iium.edu.my/ijahs/index.php/IJAHS
EISSN NO 2600-8491

as cited in Bontemps et al., 2021), enhanced oxygen utilization, delayed onset of anaerobic metabolism, and prolonged physical endurance (Mantegazza et al., 2018). Additional findings indicate improvements in sleep quality (McCall et al., 2018) and reductions in body measurements such as weight (Conrado & Munin, 2011).

MATERIALS AND METHODS

Ethical Approval

This study received ethical clearance from the Kulliyyah Postgraduate and Research Committee (KPGRC), Kulliyyah of Allied Health Sciences, and the IIUM Research Ethics Committee (IREC). All data collected from participants were treated with strict confidentiality and used solely for research purposes, including analysis and reporting.

Questionnaire Development

As there was no existing validated instrument assessing knowledge and attitudes regarding far-infrared (FIR)-emitting garments, a new questionnaire was developed based on a comprehensive review of scientific literature published between 1999 and 2021. Earlier studies, particularly those published before 2010, were included because a significant number of foundational experiments on the health effects of FIR-emitting garments involved animal models conducted during that period.

The questionnaire was divided into three sections:

- Section A: Sociodemographic information
- Section B: Knowledge-related items (12 items)
- Section C: Attitude-related items (11 items)

All items were close ended. To encourage thoughtful responses, a mixture of positively and negatively worded statements was used. Respondents were instructed to select only one answer per item.

The questionnaire was developed in English, and the estimated completion time was less than 15 minutes.

- In Section B (Knowledge), response options included *"True," "False,"* and *"Not Sure"*.
- In Section C (Attitude), a 5-point Likert scale was used, ranging from *"Strongly Agree" (1)* to *"Strongly Disagree" (5)*.

Scoring was conducted as follows: each correct answer in the knowledge section received one point, while incorrect or "Not Sure" responses received zero points. For attitude items, response distributions were reported in percentages for each Likert scale level.

Questionnaire Validation

Face Validity

Face validity was evaluated to ensure grammatical accuracy, logical item flow, and content appropriateness. This process followed guidance from DeVon et al. (2007), who suggested involving domain experts or laypeople to assess the instrument's clarity, structure, and relevance. A total of five experts participated in the face and content validation process. The panel consisted of academic staff from the Kulliyyah of Allied Health Sciences, specializing in:

- Anatomy and Physiology (1 expert)
- Physiology (1 expert)
- Epidemiology and Research Methodology (2 experts)
- Medical Imaging (1 expert)

A comment section was included in the validation form for each item to allow reviewers to provide feedback and suggestions for improvement.

Content Validity

Content validity refers to the extent to which the questionnaire items adequately reflect the theoretical constructs under investigation (Schultz & Whitney, 2005, as cited in Tsang et al., 2017). Experts rated each item on four criteria: relevance, clarity, simplicity, and ambiguity using a 4-point Likert scale. The Content Validity Index (CVI) was calculated, comprising:

- I-CVI (Item-Level Content Validity Index)
- S-CVI (Scale-Level Content Validity Index)

These indices quantified the proportion of agreement among the expert reviewers for each item and the overall scale.

The other calculation to determine the value of alpha (α) was measured by using:

$$\alpha = \frac{\kappa}{\kappa - 1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_x^2}\right)$$

x = a questionnaire
k = number of items
σ_i^2 = is the variance of item i
σ_x^2 = total variance of the questionnaire

Questionnaire Reliability

Reliability pertains to the consistency and repeatability of the instrument under similar conditions (Razavipour & Raji, 2022; Ofem & Mchi, 2023). Internal consistency was evaluated using Cronbach's Alpha (α), which measures the degree to which items within a scale are interrelated (Tsang et al., 2017). The reliability analysis was conducted using IBM SPSS Statistics version 26.0**.**

Before computing Cronbach's Alpha, all negatively worded items were reverse coded to ensure appropriate scoring:

- Knowledge items were scored as 1 for correct and 0 for incorrect/'Not Sure'. *Negatively phrased items were reverse-coded accordingly.*
- For attitude items, the reverse coding followed this logic:
    - *Strongly Agree (1)* → recoded as *Strongly Disagree (5)*
    - *Agree (2)* → recoded as *Disagree (4)*
    - *Neutral (3)* remained unchanged
    - *Disagree (4)* → recoded as *Agree (2)*
    - *Strongly Disagree (5)* → recoded as *Strongly Agree (1)*

According to Streiner (2003), reverse-coding is essential to prevent artificially low Cronbach's Alpha values resulting from negative item correlations. A pilot test involving 51 participants was conducted to calculate the reliability coefficients.

Interpretation of Correlation Coefficients

The interpretation of Cronbach's Alpha was guided by Mukaka (2012), as shown in **Table 1.**

Table 1: Interpretation of Correlation Coefficient Magnitudes (Mukaka, 2012)

Size of Correlation	Interpretation
0.90 to 1.00 (±)	Very high positive (negative)
0.70 to 0.90 (±)	High positive (negative)
0.50 to 0.70 (±)	Moderate positive (negative)
0.30 to 0.50 (±)	Low positive (negative)
0.00 to 0.30 (±)	Negligible correlation

Study Setting

Face and content validity evaluations were conducted remotely via email communication. Experts received a digital validation form containing clear instructions and the draft questionnaire for assessment.

The pilot test was administered to undergraduate students from the Kulliyyah of Allied Health Sciences (KAHS). The

questionnaire link was distributed via WhatsApp, both through personal messages and student group chats. The primary aim of the pilot was to determine the internal consistency and reliability of the developed instrument measuring knowledge and attitudes toward FIR-emitting garments and their health-related applications.

RESULTS

Face Validity

Knowledge Domain

Expert evaluation was conducted to assess the face validity of the initial 15 items in the knowledge domain. Feedback highlighted issues related to wording, clarity, and redundancy. Following the review, three items were removed, and several items were revised to improve clarity and comprehension. This process resulted in a reduction to 13 finalized items. For instance, technical terms were clarified with lay explanations, and grammatical structures were standardized to enhance readability. A summary of the changes, including original and revised items as well as the rationale for modification, is presented in Table 2.

Attitude Domain

Similarly, 15 initial items assessing attitude were reviewed. Expert feedback identified issues of redundancy, irrelevance, and inappropriate phrasing. As a result, four items were removed, and the remaining were revised for content clarity and relevance, leading to a final total of 11 attitude items. Notable adjustments included rephrasing items for consistency in tone (e.g., positively or negatively worded statements), removal of knowledge-based content, and correction of grammatical inconsistencies. The revised attitude items and corresponding changes are summarized in Table 3.

Content Validity Index (CVI)

Table 4 shows the relevance of items based on knowledge domain. Content validity was assessed quantitatively using the Item-Level Content Validity Index (I-CVI), Scale-Level Content Validity Index based on average agreement (S-CVI/Ave), and Universal Agreement (S-CVI/UA), as described by Roy & Sahu (2024). Five experts independently rated each item on a 4-point scale in terms of relevance, clarity, simplicity, and ambiguity.

Ratings of 3 or 4 were recoded as "1" (valid), while ratings of 1 or 2 were recoded as "0" (not valid). The I-CVI for each item was computed by dividing the number of experts rating an item as 3 or 4 by the total number of experts. For example, if all five experts rated an item as relevant (score 3 or 4), the I-CVI was 1.00. S-CVI/Ave was derived by averaging the I-CVI scores across all items, while S-CVI/UA reflected the proportion of items that achieved full agreement across all experts.

For knowledge items, the S-CVI/Ave was 0.88, indicating strong overall content validity, while the S-CVI/UA was 0.67. A summary of CVI values for relevance, clarity, simplicity, and ambiguity for knowledge items is presented in Table 5.0.

For attitude items, the S-CVI/Ave values were 0.84 for relevance and 0.87 for clarity, simplicity, and ambiguity. The S-CVI/UA for attitude items was 0.67 (see **Table 6.0**). Two attitude items were excluded due to conceptual overlap with knowledge items or low relevance scores.

Tables summarizing the CVI calculations for relevance (Table 4.0), and comprehensive breakdowns for each item's CVI dimensions (Tables 5.0 and 6.0), are provided.

Table 2: The List of Updated Items for Development of Questionnaire on Knowledge on Far-Infrared-Emitting Garments, Their Medical Applications and Health Benefits

Draft of Items	Updated Items	Action for Improvement Based on Feedbacks
(Q1) Infrared radiation is one of the region in electromagnetic spectrum	Thermal radiation (infrared) is one of the regions of the electromagnetic spectrum (range of all types of electromagnetic radiation)	Add some definition and use layman term (put in bracket after the original term) to make sure the respondents understood the question
(Q2) Infrared radiation can be divided into 3 groups which are near infrared, mid infrared and far infrared	Infrared radiation can be divided into near-infrared, mid-infrared and far-infrared	Change the structure of item
(Q3) Far infrared radiation is visible #	Far-infrared radiation is visible #	-
(Q4) The wavelength of far infrared radiation is 3.0 µm to 100 µm	The wavelength of far-infrared radiation is 3.0 µm to 100 µm	Correct the grammatical error
(Q5) Far infrared cannot penetrate the skin #	Far-infrared cannot penetrate the skin #	-
(Q6) Far infrared radiation can cause dilation of capillary	Far-infrared radiation can promote dilation of blood capillaries	Change the structure of item
(Q7) Far infrared emitting garments are type of items made of bio ceramic fibres	Garments that emit far-infrared are made up of bioceramic fibres	Correct the grammatical errors
(Q8) The materials of bio ceramic fibres can radiate far infrared when heated to body temperature	When heated to body temperature, bioceramic fibres can emit far-infrared	Change the structure of the item
(Q9) Far infrared emitting garments cannot reduce skin temperature during exercise #	Far-infrared-emitting garments can reduce skin temperature during exercise	Putting as positively worded item
(Q10) Far infrared emitting socks act as cooling agent during long distance running exercise	-	Delete the item because contradict with item number 9
(Q11) Far infrared emitting garments enhancing oxygen production	Far-infrared-emitting garments can enhance oxygen production	Correct the grammatical errors
(Q12) Far infrared emitting garments can delay anaerobic metabolism during exercise	Far-infrared-emitting garments can delay the onset of fatigue during exercise	Change the structure of the item
(Q13) Far infrared bedsheet can promote sleep induction	Far-infrared-emitting bedsheets can reduce sleep quality #	Change to negative worded item and change the structure of the item

Note. Negative items are identified with (#)

Table 3: The List of Updated Items for Development of Questionnaire on Attitude on Far-Infrared-Emitting Garments, Their Medical Applications and Health Benefits

Draft of items	Updated items	Action for improvement based on feedbacks
(Q1) I believe far infrared emitting garments can provide many health benefits	I believe that far-infrared-emitting garments can provide many health benefits	Correct the grammatical error
(Q2) I think far infrared emitting garments can cause burn injury to skin **#**	I fear far-infrared-emitting garments can burn the skin #	Correct the grammatical error
(Q3) I feel far infrared radiation cannot penetrate the skin due to its wavelength #	-	Delete the item because repetition in Q5 in knowledge domain
(Q4) I am aware with the manufactured of far infrared emitting garments can be found in clothes	I am aware of the manufacturing of far-infrared-emitting clothes	Correct the grammatical error and the structure of the item
(Q5) I think far infrared emitting garments cannot reduce skin temperature during exercise #	-	Delete the item because repetition in Q9 in knowledge domain
(Q6) I believed far infrared emitting garments can longer the duration of exercise	I do not believe far-infrared-emitting garments can reduce fatigue during exercise #	Change the structure of item and putting as negative worded item
(Q7) I am aware with far infrared emitting socks can reduce unpleasant smells during exercise	I believe that far-infrared-emitting socks can reduce unpleasant smells during exercise	Correct the grammatical error
(Q8) I feel the usage of far infrared emitting garments can reduce comfort during exercise #	I feel wearing far-infrared-emitting garments can be uncomfortable #	Change the structure of item
(Q9) I am aware the manufacturer of far infrared emitting garments can be found in belts	-	Delete the item because sound like question on knowledge
(Q10) I believe far infrared belts can be used for weight reduction	I believe that far-infrared-emitting belts can be used for weight reduction	Correct the grammatical error
(Q11) I am aware far infrared emitting garments can reduce menstrual pain	I believe that far-infrared-emitting garments can help reduce menstrual pain	Correct the grammatical error
(Q12) I think far infrared bed sheet can improve sleep quality	I think far-infrared-emitting bedsheets can be used to treat insomnia	Change the structure of item
(Q13) I believe the manufacturer of far infrared in sportswear can improve performance in athletes	I believe far-infrared-emitting sportswear can improve performance in athletes	Change the structure of item
(Q14) I believe far infrared emitting garments can prevent hyperthermia during hot temperature	I believe far-infrared-emitting garments can cause heat stroke during hot weather #	Change the structure of item and putting as negative worded item
(Q15) I think far infrared emitting garments can optimise the recovery process in athletes	-	Delete the item because the question sound like knowledge

Note. Negative items are identified with (#)

Internal Consistency Reliability

Knowledge Domain

Internal consistency reliability for the knowledge domain was assessed using Cronbach's Alpha. Table 7 shows the mean score of each item on knowledge domain. Total of 12 items were initially analysed using data from 51 respondents. The inter-item correlation matrix revealed weak correlations ($r < 0.3$) for several item pairs (Table 8), and item-total statistics (Table 9) showed that the removal of item K1 improved the internal consistency. After removing this item, the Cronbach's Alpha increased from 0.795 to 0.807 (Table 10), indicating good internal consistency. The final knowledge domain contained 11 items.

Attitude Domain

Table 11 shows mean score of each item for attitude domain. There was no item with mean higher than range from 2.61 to 3.29. Table 12 shows the value of inter-item correlation matrix and Table 13 shows the value of corrected items and value of Cronbach's Alpha if item deleted.

The internal consistency of the attitude domain was similarly assessed using Cronbach's Alpha. Initial analysis of 11 items revealed two problematic items: A3 and A11. These items demonstrated low item-total correlations and negatively affected the overall reliability. After their removal, the Cronbach's Alpha increased to 0.729, confirming acceptable internal consistency (Table 14). The final attitude scale consisted of 9 items.

Summary of Modifications and Psychometric Properties

- Total items in the knowledge domain were reduced from 15 to 11 after revisions based on expert feedback and reliability analysis.
- Total items in the attitude domain were reduced from 15 to 9.
- All retained items demonstrated acceptable to excellent CVI values.
- Cronbach's Alpha values indicated satisfactory internal consistency for both domains (knowledge = 0.807; attitude = 0.729).

Table 4: The Calculation of Content Validity Index for Relevance on Knowledge Items

Domain : Knowledge	Relevance							
Items	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert in agreement	I-CVI	UA
1	1	1	1	1	1	5	1	1
2	1	1	1	1	1	5	1	1
3	1	1	1	1	1	5	1	1
4	1	1	1	1	1	5	1	1
5	1	1	1	1	1	5	1	1
6	1	1	1	1	1	5	1	1
7	1	1	1	1	1	5	1	1
8	1	1	1	1	1	5	1	1
9	1	0	1	1	1	4	0.8	0
10	1	0	1	1	1	4	0.8	0
11	1	1	1	1	1	5	1	1
12	0	1	1	1	1	4	0.8	0
13	1	1	1	1	1	5	1	1
14	0	0	1	0	0	1	0.2	0
15	0	0	1	1	1	3	0.6	0
Proportion relevance =	0.8	0.73	1	0.93	0.93	S-CVI Ave =	0.88	
						S-CVI/UA =		0.67
Average proportion of item judged as relevance across the 5 experts =				0.88				

Table 5: The Summary of Content Validity Index (CVI) based on Knowledge Items for Relevance, Clarity, Simplicity and Ambiguity

Items	Relevance	Clarity	Simplicity	Ambiguity
(Q1) Infrared radiation is one of the region in electromagnetic spectrum	1.0	0.8	0.8	0.8
(Q2) Infrared radiation can be divided into 3 groups which are near infrared, mid infrared and far infrared	1.0	1.0	0.8	1.0
(Q3) Far infrared radiation is visible	1.0	1.0	1.0	1.0
(Q4) The wavelength of far infrared radiation is 3.0 µm to 100 µm	1.0	1.0	1.0	1.0
(Q5) Far infrared cannot penetrate the skin	1.0	1.0	1.0	1.0
(Q6) Far infrared radiation can cause dilation of capillary	1.0	1.0	1.0	1.0
(Q7) Far infrared emitting garments are type of items made of bio ceramic fibres	1.0	0.8	1.0	0.8
(Q8) The materials of bio ceramic fibres can radiate far infrared when heated to body temperature	1.0	1.0	1.0	1.0

(Q9) Far infrared emitting garments cannot reduce skin temperature during exercise	0.8	1.0	1.0	1.0
(Q10) Far infrared emitting socks act as cooling agent during long distance running exercise	0.8	1.0	1.0	1.0
(Q11) Far infrared emitting garments enhancing oxygen production	1.0	0.6	0.8	0.6
(Q12) Far infrared emitting garments can delay anaerobic metabolism during exercise	0.8	0.8	0.8	0.8
(Q13) Far infrared bedsheet can promote sleep induction	1.0	1.0	0.8	1.0
(Q14) The factors of sleepiness are depending on the accumulation of extracellular adenosine	0.2	0.4	0.4	0.4
(Q15) Far infrared bedsheet cannot decline the accumulation of extracellular adenosine level	0.6	0.8	0.8	0.8
(S-CVI/Ave) based on (I-CVI)	0.88	0.88	0.88	0.88
(S-CVI/UA)	0.67	0.6	0.53	0.6
(S-CVI/Ave) based on proportion	0.88	0.88	0.88	0.88

Table 6: The Summary of Content Validity Index (CVI) based on Attitude Items for Relevance, Clarity, Simplicity and Ambiguity

Items	**Relevance**	**Clarity**	**Simplicity**	**Ambiguity**
(Q1) I believe far infrared emitting garments can provide many health benefits	1.0	1.0	1.0	1.0
(Q2) I think far infrared emitting garments can cause burn injury to skin	0.8	1.0	1.0	1.0
(Q3) I feel far infrared radiation cannot penetrate the skin due to its wavelength	0.4	0.8	0.8	0.6
(Q4) I am aware with the manufactured of far infrared emitting garments can be found in clothes	0.8	0.4	0.4	0.4
(Q5) I think far infrared emitting garments cannot reduce skin temperature during exercise	0.4	1.0	1.0	1.0
(Q6) I believed far infrared emitting garments can longer the duration of exercise	1.0	1.0	1.0	1.0
(Q7) I am aware with far infrared emitting socks can reduce unpleasant smells during exercise	1.0	1.0	1.0	1.0
(Q8) I feel the usage of far infrared emitting garments can reduce comfort during exercise	0.8	0.8	0.8	0.8
(Q9) I am aware the manufacturer of far infrared emitting garments can be found in belts	0.4	0.2	0.2	0.4
(Q10) I believe far infrared belts can be used for weight reduction	1.0	1.0	1.0	1.0
(Q11) I am aware far infrared emitting garments can reduce menstrual pain	1.0	1.0	1.0	1.0
(Q12) I think far infrared bed sheet can improve sleep quality	1.0	1.0	1.0	1.0
(Q13) I believe the manufacturer of far infrared in sportswear can improve performance in athletes	1.0	0.8	0.8	0.8
(Q14) I believe far infrared emitting garments can prevent hyperthermia during hot temperature	1.0	1.0	1.0	1.0
(Q15) I think far infrared emitting garments can optimise the recovery process in athletes	1.0	1.0	1.0	1.0
(S-CVI/Ave) based on (I-CVI)	0.84	0.87	0.87	0.87
(S-CVI/UA)	0.67	0.67	0.67	0.67
(S-CVI/Ave) based on proportion	0.84	0.87	0.87	0.87

Table 7: The Value of Means of Each Items on Knowledge Items.

Item Statistics			
	Mean	Std. Deviation	N
K1	.86	.348	51
K2	.63	.488	51
K3#	.24	.428	51
K4	.16	.367	51
K5#	.27	.451	51
K6	.37	.488	51
K7	.27	.451	51
K8	.25	.440	51
K9	.20	.401	51
K10	.20	.401	51
K11	.31	.469	51
K12#	.12	.325	51

Table 8: The Value of Inter-Item Correlation Matrix on Knowledge Items

Inter-Item Correlation Matrix												
	K1	K2	K3#	K4	K5#	K6	K7	K8	K9	K10	K11	K12#
K1	1.000	.164	.087	.172	-.010	.072	-.010	-.028	-.090	-.090	.024	.146
K2		1.000	.236	.109	.110	.174	.201	.172	.176	.074	.259	.030
K3#			1.000	-.112	.073	.242	.177	.100	.192	.075	.123	.228
K4				1.000	.339	.225	.218	.243	.194	.330	.289	-.157
K5#					1.000	.344	.212	.245	.028	.028	.152	.048
K6						1.000	.526	.573	.539	.641	.440	.096
K7							1.000	.648	.471	.582	.626	.321
K8								1.000	.391	.504	.671	.205
K9									1.000	.751	.518	-.027
K10										1.000	.518	-.027
K11											1.000	.409
K12#												1.000

Table 9: The Value of Corrected Item and Cronbach's Alpha if Item Deleted on Knowledge Items

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
K1	3.02	7.660	.065	.172	.807
K2	3.25	6.954	.277	.180	.796
K3#	3.65	7.193	.230	.196	.797
K4	3.73	7.163	.309	.382	.789
K5#	3.61	7.083	.258	.341	.796
K6	3.51	6.055	.671	.619	.750
K7	3.61	6.163	.688	.588	.750
K8	3.63	6.278	.650	.610	.755
K9	3.69	6.620	.545	.640	.767
K10	3.69	6.540	.588	.746	.763
K11	3.57	6.090	.690	.679	.749
K12#	3.76	7.424	.212	.429	.795

Table 10: The Value of Cronbach's Alpha after Item Number 1 Deleted on Knowledge Items

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.807	.801	11

Table 11: The Value of Means of each Items on Attitude Items.

Item Statistics

	Mean	Std. Deviation	N
A1	2.61	.918	51
A2#	3.08	.913	51
A3	3.29	1.137	51
A4#	2.78	.673	51
A5	2.75	.891	51
A6#	3.06	.835	51
A7	3.08	.771	51
A8	3.00	.800	51

A9	2.90	.855	51
A10	2.90	.831	51
A11#	3.08	.845	51

Table 12: The Value of Inter-Item Correlation Matrix on Attitude Items

Inter-Item Correlation Matrix

	A1	A2#	A3	A4#	A5	A6#	A7	A8	A9	A10	A11#
A1	1.000	-.153	.055	.216	.413	-.021	.384	.572	.485	.552	-.243
A2#		1.000	.074	-.037	-.098	.073	.020	.137	-.041	.221	.070
A3			1.000	.215	.174	-.103	.064	.286	-.031	-.011	-.025
A4#				1.000	.374	.023	.342	.297	.206	.391	-.005
A5					1.000	-.168	.292	.196	.334	.344	-.159
A6#						1.000	-.007	-.030	-.048	-.107	.334
A7							1.000	.616	.498	.606	-.225
A8								1.000	.497	.602	-.118
A9									1.000	.578	-.543
A10										1.000	-.359
A11#											1.000

Table 13: The Value of Corrected Item and The Value of Cronbach's Alpha If Item Deleted on Attitude Items

Item-Total Statistic

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
A1	29.92	15.074	.474	.558	.563
A2#	29.45	18.053	.053	.269	.653
A3	29.24	16.744	.135	.282	.647
A4#	29.75	16.474	.434	.316	.583
A5	29.78	15.973	.355	.373	.590
A6#	29.47	18.734	-.019	.208	.661
A7	29.45	15.373	.551	.523	.556
A8	29.53	14.454	.690	.680	.524

A9	29.63	15.878	.394	.591	.583
A10	29.63	14.758	.602	.676	.540
A11#	29.45	20.413	-.240	.477	.699

Table 14: The Value of Cronbach's Alpha after Item Number 11 Deleted on Attitude Items

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.729	.737	9

DISCUSSION

Analysis of Face Validity and Content Validity Index (CVI) for Relevance, Clarity, Simplicity, and Ambiguity on Knowledge Items

Table 5 summarizes CVI values for relevance, clarity, simplicity, and ambiguity of items within the knowledge domain. All items scored above 0.8 for item-level CVI (I-CVI), except for item 11 (clarity = 0.6, ambiguity = 0.6), item 14 (relevance = 0.2, clarity = 0.4, simplicity = 0.4, ambiguity = 0.4), and item 15 (relevance = 0.6). According to Polit & Beck (2006), items evaluated by five or fewer experts must achieve a CVI of at least 0.83 to be considered valid. Thus, items scoring below 0.83 did not meet the threshold for content validity.

Based on expert feedback from face validity assessments, item 14 ("The factors of sleepiness are depending on the accumulation of extracellular adenosine") was removed as it did not reflect the knowledge of far-infrared-emitting garments, their medical applications, or health benefits. Item 15 ("Far-infrared bedsheets cannot decline the accumulation of extracellular adenosine level") was also deleted due to redundancy and contradiction with item 14.

Item 11 was retained but revised for grammatical clarity. The phrase "Far infrared emitting garments" was corrected to "Far-infrared-emitting garments," and "enhancing" was revised to "can enhance" oxygen production. As stated by Polit & Beck (2006), items should be revised or eliminated if they do not meet the minimum agreement among experts.

The average S-CVI/Ave (scale-level CVI based on averaging I-CVI scores across items) for relevance, clarity, simplicity, and ambiguity was 0.88, exceeding the 0.83 threshold required for acceptable content validity (Lynn, 1986). However, the S-CVI/UA (scale-level CVI based on universal agreement) values were lower: relevance (0.67), clarity (0.6), simplicity (0.53), and ambiguity (0.6). These scores did not meet the 100% agreement criterion for universal agreement. Polit and Beck (2006) noted that as the number of experts increases, the likelihood of total agreement tends to decrease.

Analysis of Face Validity and Content Validity Index (CVI) for Relevance, Clarity, Simplicity, and Ambiguity on Attitude Items

Table 6 displays CVI values for the attitude items. Items with I-CVI values below 0.8 included item 3 (relevance = 0.4, ambiguity = 0.6), item 4 (clarity = 0.4, simplicity = 0.4, ambiguity = 0.4), item 5 (relevance = 0.4), and item 9 (relevance = 0.4, clarity = 0.2, simplicity = 0.2, ambiguity = 0.4). These values did not meet the minimum required I-CVI of 0.83 (Shen et al. 2024).

Item 3 ("I feel far infrared radiation cannot penetrate the skin due to its wavelength") was deleted due to redundancy with item 5. Likewise, item 5 was deleted due to overlap with item 9. Item 9 ("I am aware the manufacturer of far infrared emitting garments can be found in belts") was also removed as it resembled a knowledge-based question. Item 4 was revised for grammar and clarity, changing from "I am aware with the manufactured of far infrared emitting garments can be found in clothes" to "I am aware of the manufacturing of far-infrared-emitting clothes."

The S-CVI/Ave across all attitude items was 0.87, except for relevance which scored 0.84—both above the minimum threshold of 0.83 for five or fewer experts (Ma et al. 2022). The S-CVI/UA values were 0.67 for clarity, simplicity, and ambiguity, and 0.6 for relevance, all below the required 1.0 (100%) agreement. This reflects the challenge of achieving

full agreement among all experts due to different background of experts.

Analysis of Questionnaire Reliability Based on Cronbach's Alpha for Knowledge Items

Table 7 shows the mean scores for each knowledge item, which ranged from 0.20 to 0.37, indicating consistency among items. However, items 1 (mean = 0.86) and 2 (mean = 0.63) were outliers.

Table 8 indicates that item 1 had negligible correlations (below 0.3) with other items, along with five negative inter-item correlations. According to Mukaka (2012), such low correlation suggests the item does not measure the same construct and should be considered for removal. Item 1 was therefore removed.

Table 9 shows that item 1 had the lowest corrected item-total correlation (0.065) and the highest increase in Cronbach's Alpha when deleted (0.807). Experts also suggested improving clarity by using layman's terms. The item was revised from "Infrared radiation is one of the regions in the electromagnetic spectrum" to "Thermal radiation (infrared) is one of the regions of the electromagnetic spectrum (range of all types of electromagnetic radiation)."

After item 1 was deleted, the Cronbach's Alpha increased to 0.807 (Table 10.0), which is within the acceptable range of 0.70–0.90 for high reliability (Mukaka, 2012). The number of knowledge items was reduced from 12 to 11.

Analysis of Questionnaire Reliability Based on Cronbach's Alpha for Attitude Items

Table 11 indicates that the mean scores of attitude items ranged from 2.61 to 3.29, with no extreme outliers. Table 12.0 reveals that items 6 and 11 had the most negative inter-item correlations, likely due to being reverse-coded. Their mixed correlations suggested these items were problematic.

Table 13 shows that deleting item 11 would increase Cronbach's Alpha to 0.699, followed by items 6 (0.661), 2 (0.653), and 3 (0.647). Although Taber (2018) recommends a minimum alpha of 0.70, item 3 was deleted based on both expert feedback and low CVI values (relevance = 0.8, clarity = 0.4, simplicity = 0.4, ambiguity = 0.4).

After deleting item 3, Cronbach's Alpha was 0.647, so item 11 was also removed to achieve an acceptable reliability level. The final Cronbach's Alpha (Table 14) met the threshold of ≥0.70, and the number of attitude items was reduced to 9. Item 11 was revised from "I believe far infrared emitting garments can prevent hyperthermia during hot temperature" to "I believe far-infrared-emitting garments can cause heat stroke during hot weather," as recommended by experts for improved clarity.

CONCLUSION

This study demonstrated that the developed questionnaire is a valid and reliable tool for assessing knowledge and attitudes towards far-infrared-emitting garments, their medical applications, and health benefits. Both the CVI and Cronbach's Alpha values met the required thresholds for five or fewer experts and internal consistency, respectively.

However, some limitations were identified. The presence of negatively worded or reverse-coded items in the knowledge and attitude sections may have reduced reliability. This contradicts item development guidelines, which recommend avoiding negative formulations (Haladyna, Downing & Rodríguez, 2002; Haladyna & Rodríguez, 2013; Lane, Raymond & Haladyna, 2016; Moreno et al., 2004, 2006, 2015).

Additionally, the use of a 5-point Likert scale may have affected Cronbach's Alpha. Polit and Beck (2006) suggest using a 4-point scale to eliminate neutral or ambivalent midpoints. Future studies should consider developing a revised questionnaire using only positively worded items and a 4-point scale to further improve reliability and validity.

ACKNOWLEDGEMENT

This research was not funded by any grant. The author would like to express sincere gratitude to the lecturers of the Kulliyyah of Allied Health Sciences for their support and contributions of expertise throughout this study. Special thanks also go to the respondents for their time and willingness to participate in the survey.

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