Original Article

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The Efficacy of Low-Iodine Diet Instructional Media for the Preparation of Radioactive Iodine Therapy in Thyroid Patients

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Abstract:
Objective: To develop and evaluate a low-iodine diet (LID) instructional media for preparing radioactive iodine (RAI) therapy on LID practices, and knowledge in thyroid patients.
Material and Methods: This study was a randomized control trial (RCT), consisting of 120 thyroid participants; divided into 2 groups: a control group (original leaflet) and an intervention group (video and booklets). The efficacy of LID media was determined by measuring iodine intake, urine I/Cr ratio, knowledge tests, satisfaction surveys, and facilitators and barriers during the LID period.
Results: This study was conducted with 96 individuals. The energy and biggest nutrient intake changes were significantly lower than the baseline. The iodine intake levels of the intervention group were significantly lower than those of the control group. Conversely, the urine I/Cr ratio and proportion of participants that achieved the criteria of both groups showed no significant difference via inter-group. Participants evaluated "agreed" and "strongly agreed" for satisfaction assessment. Furthermore, both groups suggested the importance of social support and encouragement to attain their goal.
Conclusion: The results of the efficacy of LID instructional media were evidence-based for developing and evaluating LID multimedia for preparing RAI therapy in thyroid patients in Thailand. There are also good instruments for advice to thyroid patients in the hospital.

Keywords: low-iodine diet, multimedia, radioactive iodine, therapy, thyroid patient

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Introduction

Radioactive iodine (RAI) is an alternative therapy for benign thyroid disease and differentiated thyroid carcinoma (DTC) due to its beta-emission[1]. The main indications of RAI therapy are to decrease goiter and alleviate compressive signs and symptoms of benign thyroid disease. Furthermore, RAI therapy eradicates residual cancerous tissues after thyroidectomy and reduces thyroid cancer recurrence[2,3].

Moreover, RAI is accumulated in thyroid follicular cells through the membrane-based sodium-iodide symporter (NIS)[4]. The NIS is a protein membrane that actively transfers iodide ions into thyroid tissue, making RAI therapy highly effective. Therefore, thyroid patients should increase thyroid-stimulating hormone (TSH) concentrations and deplete the whole-body iodine pool to upregulate NIS expression. The elevated TSH levels could be accomplished by discontinuing thyroid hormone therapy (THW) or injecting recombinant human TSH (rhTSH)[1].

Moreover, a low-iodine diet (LID) before RAI therapy is used to deplete the whole-body iodine pool[4,5], which should be less than 50 mcg daily for 1-2 weeks prior to RAI therapy following ATA guidelines[3]. Many studies, including those by Prestwich et al. and Pluijmen et al., examined the benefit of LID for the efficacy of RAI therapy that gained RAI uptake and biological half-life[5,6]. Conversely, LID affects daily life and well-being[7]. Thus, nutrition education is crucial for improving LID adherence[7,8]. Currently, nutritional instruction is transmitted through multimedia, including visual and audio media[9] with examples of LID multimedia published online[10-12].

However, there is little research on the efficacy of LID instructional media, notably in Thailand. Therefore, this study aims to develop and evaluate the efficacy of LID multimedia on LID behaviors and comprehension of RAI therapy preparation.

Material and Methods

This study aimed to assess the efficacy of LID multimedia for preparing RAI therapy in thyroid patients regarding iodine intake, urine I/Cr ratio, knowledge, satisfaction, and facilitators/barriers during the LID period. This study had 3 phases. Phase I involved developing and evaluating LID media by five nutrition and health education experts, and phase II was the pilot study of 10 participants. Finally, Phase III examined the efficacy of LID media by studying participants from the selected hospital.

Phase I: Developing and evaluating the efficacy of the LID multimedia by experts

The contents of the LID recommendations were rearranged and constructed into videos and booklets. Microsoft Publisher and Adobe After Effects produced LID media. This multimedia consisted of instructions and the importance of preparing RAI therapy, LID recommendations, low-iodine seasoning, Thai LID tables, and sample low-iodine menus.

Afterward, five nutrition and health education experts investigated the appropriateness and relevance of the design and contents on a 4-point Likert scale. The acceptable scores were calculated using the content validity index for scale (S-CVI)[13]. An acceptable score was at least 0.9, and was adjusted as per the suggestions below.

Phase II: Evaluation of the LID Multimedia: pilot study

2.1 Reliability of the knowledge test

The knowledge test was assessed using the Kuder-Richard method, with 10 participants[14].

The formula $r_{tt} = \frac{K}{K-1}[1 - \frac{\Sigma pq}{s_t^2}]$

And $s_t^2 = \frac{(x_i - \bar{x})^2}{n}$

The evaluation criteria were as follows:

0.8-1.0 Very high reliability

0.6-0.79 High reliability

0.4-0.59 Medium reliability

0.2-0.39 Low reliability

0.01-0.19 Very low reliability

The reliability criteria were: "high reliability" to "very high reliability," then approved following the suggestions below.

2.2 Satisfaction questionnaires

Participant satisfaction questionnaires evaluated the appropriateness of the design and content of the developed LID media and comments. The acceptable scores were calculated using the content validity index for scale (S-CVI)[14].

Phase III: Evaluating the efficacy of the LID multimedia by study participants from the selected hospital

3.1 Participants and study design

The sample size was determined by the G*Power program, using an effect size of 0.58, a power of 0.80, and a two-tailed significance based on iodine consumption in previous research[15]. The sample size was 96 individuals, and we estimated a 20% loss to follow-up; therefore, a total of 120 individuals were recruited. Inclusion criteria included: those aged 20-65 that could cook or choose food that a caregiver had prepared; listen, read, and write Thai; and who met the criteria for RAI therapy[16]. The study excluded participants that received contrast agents within 2 months, alcoholics, had chronic kidney diseases (eGFR<45 mL/min/1.73 m^2), had uncontrolled psychiatric disorders, or conditions that affected learning and comprehension. Finally, 96 participants completed the pre-and post-intervention.

Ethical Clearance Committee on Human Rights Related to Research Involving Human Subjects at the Faculty of Medicine, Ramathibodi Hospital, Mahidol University, approved this study. All participants signed a consent form after description of the study protocol.

This study was a two-armed randomized control trial (RCT) that used block randomized allocation to receive LID media. This research was conducted on thyroid patients at the Nuclear Medicine Outpatient Department, Ramathibodi Hospital. The participants received general RAI therapy education, then characteristic questionnaires, health questionnaires, 3-day dietary records, spot urine, anthropometric assessment and the LID knowledge test, which were collected at visit 1. Afterward, both groups assessed the questionnaires and spot urine on the RAI therapy day. In addition, the intervention group evaluated the media satisfaction questionnaires.

3.2 Anthropometric assessment

Pre- and post-intervention participants were assessed via height, weight, and their body mass index (BMI). The classification of BMI was for Asian adults, aged above 20 years[17].

3.3 EQ-5D-5L questionnaires

The EQ-5D-5L questionnaires were described and valued for their health outcomes[18]. These questionnaires contained 2 parts: an evaluation of utility score on a 5-point Likert scale, and a valuation of health conditions on a visual analog scale (VAS).

3.4 Amount of time the doctor spent with each participant

The researchers recorded the time the doctor spent with each participant. Accordingly, this duration was used to calculate the average duration of each group.

3.5 Dietary assessment

The dietary assessment used 3 days of a 24-hour dietary record;. After this, energy and nutrient intakes were calculated by INMUCAL-Nutrients V.4.0 software, database NB 4.0[19]. The iodine intakes were used in the food composition table of Thai foods in 2012 and 2018, and another database[20-22]. The borrowing of nutrients complied with the FAO/INFOODS principle[23]. According to the ATA recommendations, daily iodine consumption was less than 50 mcg[3].

3.6 Urine I/Cr ratio (UICR)

The UICR was collected via spot urine. The UICR was analyzed by inductively coupled plasma mass spectrometry (ICP-MS)[24]. The UICR target was less than 100 mcg/gCr[25].

3.7 Knowledge assessment

The knowledge test was a multiple-choice test, with 10 questions, and then experts and thyroid patients approved it. This knowledge test was analyzed as a mean score, and the proportion of participants who scored more than 80% of the total score.

3.8 Participant satisfaction questionnaires

The satisfaction questionnaire was utilized to evaluate the LID media and to investigate facilitators and barriers during the LID period in Visit 2. Five nutrition and health education experts assessed the satisfaction questionnaire, using the CVI[13].

Data analysis

Descriptive data such as mean, median, standard deviation, frequency, and percentage, were presented. The proportion of participants was compared across groups using the Pearson χ^2 test. The *t*-test, or Mann-Whitney U test, was used for comparing continuous variables between groups. A paired t-test or Wilcoxon matched-pairs signed-rank test was used to compare the mean for the intra-group. McNemar's χ^2 test was used to measure the proportion of participants for the intra-group. All statistical tests were two-sided, and a p-value of <0.05 was considered significant.

Results

Phase I: Developing and evaluating the efficacy of the LID multimedia by experts

The LID media were created as video and booklets (Figure 1). The experts evaluated the LID instructional media. An acceptable score was 0.97, upon which the media was further adjusted, based on their suggestions. Moreover, the acceptable scores on the knowledge test and satisfaction questionnaire were 1 and 0.98, respectively.

Phase II: Evaluation of the LID multimedia: pilot study

2.1 The reliability of the knowledge test

The calculation of the reliability of the knowledge test was shown in the following formula:

$$\text{Calculation; } r_{tt} = \frac{10}{9}\left[1 - \frac{1.12}{3.04}\right]$$

$$= 0.7$$

Consequently, the low-iodine knowledge test had a reliability score of 0.7, regarded as high reliability.

2.2 Participants' satisfaction with low-iodine instructional media

The acceptable score for the design and content of low-iodine instructional media was 0.98, with the average satisfaction rating being 3.77±0.14. After this, the researchers modified this multimedia, based on their recommendations.

Phase III: Evaluating the efficacy of the LID multimedia by study participants from the selected hospital

3.1 General characteristics of the participants

Ninety-six participants comprised 52 papillary thyroid cancer patients and 44 hyperthyroid/Graves' disease patients (16 males, 80 females, aged 43.68±12.98 years). Almost half of the participants (49.0%) had a bachelor's degree, with their monthly incomes exceeding 30,000 Bahts. Most participants were public workers or merchants. Two-thirds of the participants owned their own residences. Typically, some participants prepared their meals. Both groups' BMI was obese stage I. The mean duration time to advise preparation of RAI therapy for both groups was 13.72±5.30 and 12.99±5.92 minutes, respectively. There was no significant difference between both groups (Table 1).

Figure 1 Low-iodine diet multimedia

Table 1 General characteristics of the participants

Characteristic	Total (N=96) n (%)	Control group (n=48) n (%)	Intervention group (n=48) n (%)
Type			
Cancer	52 (54.2)	29 (60.4)	23 (47.9)
Hyperthyroid/Graves' disease	44 (45.8)	19 (39.6)	25 (52.1)
Gender			
Male	16 (16.7)	7 (14.6)	9 (18.8)
Female	80 (83.3)	41 (85.4)	39 (81.3)
Age group (years)			
Mean±S.D.	43.68±12.98	43.88±13.68	43.48±12.39
20-30	19 (19.8)	11 (22.9)	8 (16.7)
31-40	22 (22.9)	9 (18.8)	13 (27.1)
41-50	25 (26.0)	11 (22.9)	14 (29.2)
51-60	15 (15.6)	9 (18.8)	6 (12.5)
≥61	15 (15.6)	8 (16.7)	7 (14.6)
Education			
Primary school	10 (10.4)	5 (10.4)	5 (10.4)
Junior high school	6 (6.3)	4 (8.3)	2 (4.2)
High school	13 (13.5)	7 (14.6)	6 (12.5)
Diploma	5 (5.2)	3 (6.3)	2 (4.2)
Bachelor's degree	47 (49)	22 (45.8)	25 (52.1)
Postgraduate	15 (15.6)	7 (14.6)	8 (16.7)
Occupation			
Agriculture/Fishing	1 (1)	0 (0)	1 (2.1)
Merchant/Business	17 (17.7)	10 (20.8)	7 (14.6)
Employee/Labor	2 (2.1)	1 (2.1)	1 (2.1)
Office worker	16 (16.7)	3 (6.3)	13 (27.1)
Public servant	26 (27.1)	13 (27.1)	13 (27.1)
Househusband/Housewife	14 (14.6)	8 (16.7)	6 (12.5)
Student	4 (4.2)	4 (8.3)	0 (0)
Other	16 (16.7)	9 (18.8)	7 (14.6)
Income (Baht)			
≤5,000	3 (3.1)	3 (6.3)	0 (0)
5,001-10,000	4 (4.2)	2 (4.2)	2 (4.2)
10,001-15,000	7 (7.3)	2 (4.2)	5 (10.4)
15,001-20,000	16 (16.7)	4 (8.3)	12 (25)
20,001-25,000	15 (15.6)	9 (18.8)	6 (12.5)
25,001-30,000	10 (10.4)	7 (14.6)	3 (6.3)
>30,000	41 (72.7)	21 (43.8)	20 (41.7)
Frequency of cooking			
Never	6 (6.3)	2 (4.2)	4 (8.3)
Seldom	23 (24)	11 (22.9)	12 (25)
Sometimes	22 (22.9)	12 (25)	10 (20.8)
Often	20 (20.8)	9 (18.8)	11 (22.9)
Usually	25 (26.0)	14 (29.2)	11 (22.9)
Weight (mean±S.D.)	62.23±13.46	63.75±12.78	60.71±14.08
Male	66.78±15.97	78.13±7.77	75.31±20.81
Female	59.36±10.92	61.29±11.85	57.34±9.59
Height (mean±S.D.)	160.69±7.38	160.92±7.46	160.46±7.36
Male	163.8±10.80	172.57±6.35	169.4±8.51
Female	158.67±5.45	158.93±5.62	158.4±5.33
BMI (kg/m^2) [mean±S.D.]	24.02±4.43	24.58±4.54	23.45±4.29
Underweight	9 (9.38)	5 (10.4)	4 (8.3)
Normal weight	34 (35.42)	14 (29.2)	20 (41.7)
Overweight	17 (17.71)	7 (14.6)	10 (20.8)
Obese stage I	26 (27.08)	16 (33.3)	10 (20.8)
Obese stage II	10 (10.42)	6 (12.5)	4 (8.3)
Time (mean±S.D.)	13.36±5.60	13.72±5.30	12.99±5.92

S.D.=standard deviation, BMI=body mass index

3.2 Anthropometric assessment

The intervention group's body weight and BMI grew from baseline, but the control group's body weight and BMI reduced. The mean and changes in both groups' weight and BMI showed no significant differences.

3.3 Dietary intake

Food consumption, by food group and changes, are represented in Table 2. The control group's intake of legumes, vegetables, fruits, freshwater fish, and products was significantly greater than that of the intervention group at baseline. Furthermore, the mean energy and nutrient intake are reported in Table 3. The energy consumption of the control group was higher than that of the intervention group. The intakes of calcium, phosphorus, magnesium, iron, zinc, selenium, and vitamins A, B_2, B_3, B_6, and B_{12} were below the Thai DRI[26] for both groups. The mean nutrients met by Thai DRI included vitamins B_1 and C in the control group and vitamin E in the intervention group. Moreover, the level of vitamin A in the control group was significantly greater than in the intervention group. Accordingly, there was no significant difference in energy and other nutrient intakes between groups.

Subsequently, the intervention group consumed significantly more legumes, vegetables, fruits, and meat than the baseline and the control group. Conversely, they significantly reduced their intake of seafood, processed foods, and salty vegetables compared to the baseline and the control group.

Furthermore, the energy changes of the control group decreased significantly more than those of the intervention group. The carbohydrate distribution in the control group grew significantly from baseline, but the fat distribution and consumption declined significantly. Likewise, the protein distribution in the intervention group grew significantly from the baseline. The nutrient intakes were significantly lowered from baseline in the control group: cholesterol, calcium, phosphorus, iron, and magnesium. The intervention group's carbohydrate, calcium, and sodium intakes decreased significantly from baseline, although potassium and vitamin B_1 increased significantly.

Moreover, the mean nutritional intakes achieved the criteria for vitamin C in both groups and vitamin E and B1 in the intervention group; due to the gain in vegetable, fruit, and meat consumption. Lastly, the potassium and vitamin A consumption in the intervention group decreased significantly more than in the control group. Additionally, the sodium intake changes in the intervention group decreased significantly compared to the control group.

3.4 Iodine intake and urine iodine excretion

The mean iodine intake in both groups were significantly lower than at baseline; furthermore, they attained the ATA recommendation. In addition, the mean iodine intake in the intervention group was significantly lower than in the control group (64±32.71 vs. 99.11±54.99, respectively). Moreover, the proportion of people in the intervention group whose iodine intake met the recommendations was significantly higher than in the control group. Nevertheless, the UICR and the proportion of those who achieved the target did not differ significantly between the two groups on visit 2. These results are shown in Table 4.

3.5 Knowledge test

Table 5 compares the intra-group and inter-group mean scores and the percentage of participants who attained goal scores on the LID knowledge exam. The mean scores and the proportion of participants on the LID knowledge exam grew significantly compared to the baseline. At visit 1, there were no significant differences between the groups. However, the intervention group's mean scores were significantly higher than those of the control group at visit 2.

Table 2 Food consumption (mean±S.D.) from food groups and changes

Food group	No. of participants reporting consumption				Food consumption (g/day)					
	Control gr.		Intervention gr.		Control gr.			Intervention gr.		
	Visit 1	Visit 2	Visit1	Visit 2	Visit 1	Visit 2	Δg/day	Visit 1	Visit 2	Δg/day
Grains	48	48	47	48	293.34±110.5	282.95±112.77	−10.39±110.63	286..69±120.47	265.27 ±102.35	−21.42±110.41
Legumes	19	14	16	11	103.24±132.43*	87.39±78.45**	−15.85±105.4⁋	15.53 ±13.56*♣	55.45 ±45.32**♣	39.92±98.41⁋
Vegetables	45	46	48	48	134.35±126.12*	146.83±106.58	12.48±116.35⁋	97.96 ±86.37*♣	141.84 ±110.46♣	43.88±97.45⁋
Salted vegetables	6	1	1	2	22.33±25.21	17.8±10.2	−4.53±17.82⁋	36.82 ±26.34♣	12.33±12.45♣	−24.49±18.29⁋
Fruits	37	43	43	44	236.06±121.65*$^{+}$	256.09±134.62**$^{+}$	20.03±128.14⁋	174.28±147.32*♣	201.17±171.35**♣	26.89±167.95⁋
Meats	44	47	45	46	100.28±106.78	109.11±109.12	8.83±107.84	71.80 ±58.36♣	100.50±105.48♣	28.70±80.9
Eggs	33	34	45	31	66.68±32.04	66.94±40.06	0.26±36.05	63.06 ±40.58	63.76±38.96	0.70±39.70
Milk and dairy products	25	18	39	13	124.46±42.35	121.91±64.07	−2.55±33.21	127.86±56.87	110.41±48.26	−17.45±52.50
Oils	39	41	20	40	70.67±56.8	51.59±35.29	−19.08±46.04	61.75±48.79	53.7±40.15	−8.05±44.47
Freshwater fish and products	27	22	41	19	70.39±42.63*	50.75±36.52	−19.64±39.58	38.5±25.76*	47.94±26.39	9.44±25.12
Seafood and products	25^{+}	6^{+}	25♣	3♣	20.20±11.54	25.56±12.36	5.36±11.95⁋	39.99±18.72♣	13.36±10.4♣	−26.63±72.5⁋
Beverages	25	23	27	23	210.36±120.98	186.85±115.23	−23.51±118.11	210.26±136.42	215.99±106.7	5.73±71.82
Seasonings	48	48	27	48	52.22±34.56	37.51±26.75	−14.71±30.66	56.20±36.89	39.76±28.65	−16.44±32.05
Processed foods	26^{+}	11^{+}	48	17	26.09 ±32.01^{+}	71.73 ±56.10^{+}	45.64 ±44.05⁋	54.40 ±35.41♣	18.27 ±8.37♣	−36.13±111.41⁋

*, **, ⁋ denotes food consumption that differs significantly between the group at the 0.05 level.
+, ♣ denotes food consumption that differs significantly from the baseline at the 0.05 level.
gr.=group

Table 3 Dietary intake (mean ± S.D.) of participants and changes

Energy & nutrients	Control gr.			Intervention gr.		
	Visit 1	Visit 2	Δ	Visit 1	Visit 2	Δ
Energy (kcal)	1789.61±640.11+	1498.46±462.97+	−291.15±606.60**	1746.48±616.05♣	1568.18±541.50♣	−178.3±462.10**
Carbohydrate (g)	170.60±62.18	160.72±54.18	−9.87±46.63	179.47±59.29♣	158.07±51.79♣	−21.4±41.80
Protein (g)	57.32±22.79	50.08±21.19	−7.24±23.71	54.56±21.14	55.22±27.30	0.66±19.40
Fat (g)	97.55±57.66+	72.81±35.92+	−24.74±57.75	90.04±45.82	79.45±42.43	−10.59±42.92
Calcium (mg)	316.17±166.87+	229.75±123.93+	−86.42±154.09	291.61±148.90♣	232.62±132.48♣	−58.99±155.62
Phosphorus (mg)	609.38±246.83+	519.13±220.68+	−90.25±248.31**	556.35±215.45	558.28±263.28	1.93±219.61**
Iron (mg)	9.09±4.18+	7.47±3.43+	−1.62±3.84	8.48±3.43	7.59±3.51	−0.89±4.09
Zinc (mg)	4.07±1.53	3.79±1.55	−0.28±1.43	4.01±2.24	3.93±1.82	−0.08±1.43
Selenium (mcg)	38.23±23.28	34.80±19.39	−3.43±29.23	37.02±21.05	34.49±21.52	−2.53±24.15
Copper (mg)	0.66±0.34	0.59±0.23	−0.67±0.26	0.60±0.42	0.58±0.21	−0.02±0.37
Magnesium (mg)	64.62±44.10+	45.68±26.81+	−18.94±39.15	57.03±26.28	55.83±36.53	−1.2±39.12
Sodium (mg)	3429.24±1849.54	3050.45±1425.94	−378.79±2169.86**	3795.64±1942.45♣	2917.58±1154.10♣	−878.06±1938.35**
Potassium (mg)	1403.58±692.27	1402.13±553.68	−1.45±458.50**	1259.16±435.68♣	1528.69±657.47♣	269.53±617.43**
Vitamin A (µgRE)	551.94±718.80*	505.18±1652.30	−46.76±1150.65**	270.01±212.21*	329.92±487.62	59.91±350.21**
Vitamin E (mg)	4.18±4.02	4.46±3.76	0.28±3.89	13.66±36.68	11.93±30.28	−1.73±33.48
Thiamin (mg)	1.64±3.99	1.00±0.52	−0.63±4.02	0.87±0.42♣	1.19±0.78♣	0.32±0.70
Riboflavin (mg)	0.91±0.41	0.86±0.39	−0.05±0.30	0.87±0.40	0.94±0.39	0.07±0.46
Niacin (mg)	12.90±6.92	12.63±7.52	−0.03±7.32	11.26±5.56	12.96±7.53	1.7±5.62
Vitamin C (mg)	100.27±124.50	113.37±106.21	13.1±87.99**	77.56±90.29	114.04±138.55	36.48±152.19**
Cholesterol (mg)	304.81±202.50+	230.91±175.50+	−73.9±224.75	300.64±184.58	229.75±179.70	−71.21±203.33
Energy (%)						
1) Carbohydrate	39.65±12.14+	43.88±11.26+	4.24±12.81	42.31±8.46	41.84±11.86	−0.47±11.12
2) Protein	13.23±3.85	13.88±4.90	0.65±5.04	12.94±3.72♣	14.58±5.80♣	1.65±5.21
3) Fat	47.13±12.86+	42.23±12.11+	−4.89±15.79	44.75±9.53	43.59±12.87	−1.16±12.86

*, **, ⁋ denotes food consumption that differs significantly between the group at the 0.05 level.
+, ♣ denotes food consumption that differs significantly from the baseline at the 0.05 level.
gr.=group

Table 4 Comparison of iodine intake and urinary iodine excretion (intra– and inter–group)

Iodine	Control (n=48)			Intervention (n=48)			Difference visit 2 (inter–group)	95% CI
	Visit 1	Visit 2	$\Delta v_2 v_1$	Visit 1	Visit 2	$\Delta v_2 v_1$		
Iodine intake								
Mean±S.D. (µg)	171.70±126.84^{+}	99.11±54.99^{+}	−72.59±92.82*	164.24±91.96♣	64±32.71♣	−100.24±43.53*	35.11**	(15.47, 54.75)
Iodine levels, n (proportion)								
≤50 µg	1 (0.02)$^{+}$	7 (0.15)$^{+}$	6 (0.13)*	0 (0.0)♣	19 (0.40)♣	19 (0.40)*	13 (0.27)**	(−0.42, −0.08)
51–100 µg	8 (0.17)$^{+}$	17 (0.35)$^{+}$	9 (0.19)	10 (0.21)♣	23 (0.48)♣	13 (0.27)	4 (0.08)	(−0.33, 0.07)
>100 µg	39 (0.81)$^{+}$	24 (0.50)$^{+}$	−15 (0.31)	38 (0.79)♣	6 (0.13)♣	−32 (0.67)	−18 (0.36)**	(0.2, 0.54)
Urine I/Cr ratio (µg/gCr)								
Mean±S.D. (µg/gCr)	224.12±120.16^{+}	99.68±93.14^{+}	−124.44±28.06	219.92±104.43♣	89.80±94.15♣	−130.12±130.62	4.73	(−39.89, 49.36)
Iodine levels, n (proportion)								
≤100 µg/gCr	6 (0.13^{+}	30 (0.63)$^{+}$	24 (0.5)	5 (0.10)♣	33 (0.69)♣	28 (0.58)	3 (0.06)	(−0.25, 0.13)
>100 µg/gCr	42 (0.88)$^{+}$	18 (0.38)$^{+}$	−24 (0.5)	43 (0.90)♣	15 (0.31)♣	−28 (0.58)	3 (0.07)	(−0.12, 0.26)

*, ** denotes nutrient intakes that differ significantly between the group at the 0.05 level.
+, ♣ denotes nutrient intakes that differ significantly from baseline at the 0.05 level.
CI=confidence interval, S.D.=standard deviation, Cr=creatinine

Table 5 Mean scores and proportion of participants in the low-iodine diet knowledge test

Knowledge scores	Control gr. (n=48)	Intervention gr. (n=48)
Pre-test		
Mean±S.D.	7.21±1.85^{+}	7.62±1.73$^{♣}$
Pre-test: score ≥80% (people)	24$^{₵}$	31^{Ω}
Post-test		
Mean±S.D.	8.65±1.31$^{*,+}$	9.17±1.06$^{*,♣}$
Post-test: score ≥80% (people)	39$^{₵}$	44^{Ω}

*, **denotes nutrient intakes that differ significantly between the group at the 0.05 level.
+, ₵, ♣, Ω denotes nutrient intakes that differ significantly from baseline at the 0.05 level.
S.D.=standard deviation, gr.=group

Table 6 Mean of health status dimension in the EQ-5D-5L assessment

Dimension	Visit 1		Visit 2	
	Control (n=48)	Intervention (n=48)	Control (n=48)	Intervention (n=48)
Health utility (mean±S.D.)	0.91±0.14	0.97±0.07	0.91±0.1	0.97±0.09
VAS (mean±S.D.)	75.05±15.03*	78.64±12.03**	80.07±13.91*	83.05±10.53**

*, ** denotes nutrient intakes differ significantly from baseline at the 0.05 level.
S.D.=standard deviation, VAS=visual analogue scale

3.6 EQ-5D-5L questionnaires

The participants had no problems in the health dimensions of movement, self-care, and usual activities at baseline; conversely, almost half had mild pain/discomfort and anxiety. At visit 2, movement, self-care, and anxiety in both groups reported fewer problems; in contrast, pain/discomfort and usual activities rose marginally. The means EQ-VAS of both groups were significantly increased than the baseline. Consequently, the mean utility score and EQ-VAS were not statistically different between the two groups. The EQ-5D-5L questionnaires are presented in Table 6.

3.7 Satisfaction assessment of the LID media

Most participants strongly agreed with consistent and explicit content (81.3%, 3.81±0.39). They also strongly agreed with appropriate designs that were easy to understand. Two-thirds of the participants strongly agreed that household-level measurement units might be utilized in daily life and had practical implementation (62.5%). Most participants agreed that media help expands their knowledge and assist with meal planning. In addition, they had satisfactory LID media, and preferred to share these media with other thyroid patients.

The facilitators and barriers to LID practices are analyzed and ranked in Table 7. The first facilitator of LID practices for the intervention group was the LID multimedia, which provided knowledge to promote their understanding and aid in creating their meal plans. Moreover, independent meal preparation encouraged them to regulate their iodine intake readily. Concurrently, the healthcare provider's counseling was the most effective facilitator in the control group. Furthermore, they suggested Internet searching and self-empowerment as supporting LID practices. Family

Table 7 Facilitators and barriers to LID practices

Facilitators	Barriers
Control group	
1. Recommendation of healthcare provider	1. Eating out at the restaurant
2. Encouragement of family	2. Small amount of low-iodine food list
3. Distance from market	3. Few free times for preparing LID
4. Goal for recovery from disease	4. Taste and appetite
5. Internet search	5. Difficulty adaptation
Intervention group	
1. LID instructional media	1. Eating out at the restaurant
2. Encouragement of family	2. Difficulty adaptation
3. Recommendation of healthcare provider	3. Less appetite
4. Cooking foods on their own	4. Anxiety in measuring dietary intakes to avoid exceeding the recommended amount of iodine
5. Distance from market	5. Pain/discomfort

LID=low-iodine diet

support and closeness to fresh food markets for both groups assisted efficacy practices and increased access to LID sources.

Barriers to LID practices in both groups included:eating out at restaurants, challenging adaptation, and reduced taste and appetite. The intervention group was nervous that excessive iodine avoidance might result in inadequate energy and utrient intake. Pain and discomfort, due to preparation and treatment, might be obstacles to controlling an iodine-containing diet. On the contrary, the control group's obstacles were a need for more information regarding low-iodine foods and less time to prepare meals. Therefore, patients would purchase meals with iodine seasoning from restaurants, hindering iodine management.

Discussion

The LID media consisted of video and booklets. The multimedia were a combination of visual and audio that improved efficient cognitive processing during education, without overwhelming the cognitive systems of the participants[27]. Several studies have investigated the impact of multimedia on enhancing nutrition knowledge and practices[28-30]. Hence, this LID multimedia might assist thyroid patients in obtaining sufficient information on LID practices, adapting, and decreasing the risk of insufficient energy and nutrients. Ninety-six thyroid patients; including 52 papillary thyroid cancer and 44 hyperthyroid/Graves' disease patients, completed the study.

The changes in iodine consumption in the intervention group decreased significantly more than in the control group, because of the intervention group's reduced seafood, processed foods, and salted vegetable consumption. Nonetheless, the mean iodine intake of the intervention group failed to meet the ATA's guidelines. In addition, the UICR of both groups significantly decreased from baseline, and both attained a reduction acceptable as in prior research[31]. The UICR between the two groups did not differ significantly at visit 2. Since, 3-day dietary records were self-administered, the iodine intakes might be underestimated. Therefore, the results of significant statistics between iodine intake and the UICR were inconsistent. Despite this, the intervention group had lower iodine intake and urinary iodine excretion than the control group. As a result, according to prior research[32,33], this LID multimedia may increase adherence and promote LID knowledge.

The energy changes in the intervention group were significantly reduced compared to the baseline. Most nutrient intake changes decreased significantly below the Thai DRI 2020[26], because of restricted LID practices. On the contrary, the intervention group had higher vitamin E, B_1, and C levels within the criteria because the intervention group consumed significantly more legumes, vegetables, fruits, and meats than the baseline. Moreover, potassium and vitamin A intakes in the intervention group were significantly higher than in the control group. The intervention group's sodium intake changes dropped significantly compared to the control group. These results were the same as those of the Ju DL et al. study; in which the energy and nutrient intakes were compared between pre-and post-intervention[15]. Accordingly, LID media were one of the variables that assisted patients in enhancing their knowledge of choosing healthy foods during LID. However, the changes in some nutrients did not differ significantly due to short-term LID and the side effects of preparing for RAI therapy.

Because of the avoidance of high-iodine foods, the participants reduced energy and nutrient intake. Likewise, the control group had lower weight and BMI. This outcome was similar to previous research findings that presented weight and BMI reductions were associated with iodine evasion[15]. Conversely, the intervention group gained weight, which could be related to hypothyroidism caused by THW[3]. Furthermore, they commented that they could easily prepare meals using the LID media. However, the weight and BMI changes were not statistically different between the two groups, because of the short-term duration of 1-2 weeks of LID.

Both groups significantly increased their mean knowledge scores and the proportion of patients who passed the criteria from baseline. The intervention group significantly gained higher mean scores than the control group; however, the proportion of patients who achieved target scores did not significantly differ from that of the control group. These findings suggested that LID multimedia could improve limited LID foods and seasoning confusion in previous studies[7,8].

As to the general quality of life assessment by EQ-5D-5L questionnaires, the participants had fewer difficulties with mobility, self-care, and anxiety, among other health dimensions. Conversely, pain, discomfort, and usual activities increased slightly compared to the baseline. Surgery and thyroid drug withdrawal could have an impact on these outcomes[34-36]. In addition, the mean EQ-VAS of both groups significantly increased from the baseline.

Furthermore, most participants rated "agreed" to "strongly agreed" with LID media's design, language, usefulness, and distribution to other thyroid patients. The participants recommended that LID media should include even more food products. Besides, facilitators during LID practices of both groups provided social support by reminding, planning, and monitoring diet compliance to achieve successful LID recommendations. Previous research has shown that family support enhances diet and health outcomes[37,38]. Fresh food market's closeness improved iodine intake control and accessibility to LID food sources and seasonings. In contrast, eating in restaurants, challenging adaptation, and diminished taste and appetite were obstacles to LID for both groups.

This study had some limitations. First, the nutrient intake was determined by a 3-day dietary record; furthermore, we had limited time to describe household measurements. Therefore, iodine and other nutrient intakes might be undervalued. Second, the Thai iodine database does not cover many food items; therefore, this study had to borrow from and comply with the FAO/INFOODS principle[23]. Third, this study measured spot urine iodine, which would be less accurate than 24-hour urine iodine. However, it was necessary to facilitate and reduce the burden on the participants, who had to adapt their lifestyles and deal with the side effects of preparation for RAI therapy; such as THW, LID control, and dietary records. Finally, the

COVID-19 situation affected a declining number of thyroid patients. Therefore, this study included thyroid cancer and thyroid toxicosis patients that might have had variable-interfered primary outcomes.

Conclusion

This study offered evidence for constructing and examining the efficacy of LID multimedia for preparing RAI treatment in Thai thyroid patients. These media might assist thyroid patients in enhancing their comprehension, knowledge, and quality of life during the LID time preceding RAI therapy. Additionally, several individuals attained LID compliance by reducing their iodine intakes and achieving the UCIR target to meet the criteria. In the hospital, there were additional, helpful instruments for advising thyroid patients.

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Conflict of interest

The authors have declared no actual or potential conflicts of interest.

References

1. Dietlein M. Radioiodine therapy for benign thyroid disease. In: Ahmadzadehfar H, Biersack H-J, Freeman LM, Zuckier LS, editors. Clinical nuclear medicine. Cham: Springer International; 2020;p.815-29.
2. Stokkel MPM, Handkiewicz Junak D, Lassmann M, Dietlein M, Luster M. EANM procedure guidelines for therapy of benign thyroid disease. Eur J Nucl Med Mol Imaging 2010;37:2218-28.
3. Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, et al. 2015 American thyroid association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer. Thyroid 2016;26:1-133.
4. Carvalho DP, Ferreira AC. The importance of sodium/iodide symporter (NIS) for thyroid cancer management. Arq Bras Endocrinol Metabol 2007;51:672-82.
5. Prestwich RJ, Gerrard GE. Chapter 99 – a low-iodine diet prior to radioiodine administration in the management of differentiated thyroid cancer. London: Elsevier; 2009.
6. Pluijmen MJ, Eustatia-Rutten C, Goslings BM, Stokkel MP, Arias AM, Diamant M, et al. Effects of low-iodide diet on postsurgical radioiodide ablation therapy in patients with differentiated thyroid carcinoma. Clin Endocrinol (Oxf) 2003;58:428-35.
7. Prestwich RJ, Gerrard GE. Low-iodine diet before radioiodine uptake scans or therapy flawed advice to U.K. patients. Clin Oncol (R Coll Radiol) 2005;17:73-4.
8. Herbert G, Searle A, England CY, Ness A, Beasley M, Haupt-Schott I, et al. Experiences of low iodine diets in the treatment of differentiated thyroid cancer with radioactive iodine ablation therapy. Clin Nutr ESPEN 2020;39:190-7.
9. Mayer RE. Cognitive theory of multimedia learning. In: Mayer RE, editor. The Cambridge handbook of multimedia learning. Cambridge Handbooks in Psychology. 2nd ed. Cambridge: Cambridge University Press; 2014;p.43-71.
10. Lim CY, Kim JY, Yoon MJ, Chang HS, Park CS, Chung WY. Effect of a low iodine diet vs. restricted iodine diet on postsurgical preparation for radioiodine ablation therapy in thyroid carcinoma patients. Yonsei Med J 2015;56:1021-7.
11. Thyroid Cancer Canada. A short-term diet to prepare for radioactive iodine treatment or scan: low iodine diet. Toronto: The Canadian Association Nuclear Medicine; 2017;p.1-16.
12. ChRYs. Low iodine diet, 2019 [homepage on the Internet]. Bangkok: Wongnai; 2019 [cited 2021 Apr 20]. Available from: https://www.wongnai.com/cooking/users/90a3359d98d8405e84d0b097d449fe8
13. Tiansawad S. Content validity index: critique and recommendation for computation. Nurs J CMU 2007;34:1-9.
14. Meehanpong P, Chatdokmaiprai K. Assessing quality of research instrument in nursing research. J Royal Thai Nurse 8;1:9-15.

15. Ju DL, Park YJ, Paik HY, Kim MJ, Park S, Jung KY, et al. Dietary evaluation of a low-iodine diet in Korean thyroid cancer patients preparing for radioactive iodine therapy in an iodine-rich region. Nutr Res Pract 2016;10:167-74.
16. Wattana-Narong K. Innovation and technical education technology. Bangkok: King Mongkut's University of Technology North Bangkok; 2014;p.1-10.
17. Pan WH, Yeh WT. How to define obesity? Evidence-based multiple action points for public awareness, screening, and treatment: an extension of Asian-Pacific recommendations. Asia Pac J Clin Nutr 2008; 17:370-4.
18. Pattanaphesaj J. Health-related quality of life measure (EQ-5D-5L): measurement property testing and its preference-based score in Thai population [Doctoral dissertation]: Mahidol University; 2014.
19. Institute of Nutrition, Mahidol University. INMUCAL-Nutrients V.4.0 database NB4.0. Nakhon Pathom: Mahidol University; 2018.
20. United States Department of Agriculture Agricultural Research Service (USDA). USDA food composition databases, release 1 (2020) [homepage on the Internet]. Beltsville: USDA; 2020 [cited 2022 May 22]. Available from: https://ndb.nal.usda.gov/ndb/
21. Public Health England. McCance and Widdowson's The Composition of Foods Integrated Dataset 2021 [homepage on the Internet]. London: Public Health England; 2021 [cited 2022 May 22]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/971018/McCance_Widdowsons_Composition_of_Foods_Integrated_Dataset_2021.xlsx
22. Ministry of Education, Culture, Sports, Science and Technology. Standard Tables of Food Composition in Japan-2015 (7th Revised Edition) [monograph on the Internet]. Tokyo: Policy Division Science and Technology Policy Bureau; 2015 [cited 2022 May 22]. Available from: https://www.mext.go.jp/en/policy/science_technology/policy/title01/detail01/1374030.htm
23. Charrondiere UR. Recipe and other calculations [monograph on the Internet]. Rome: The Food and Agriculture Organization; 2011 [cited 2022 May 23]. Available from: ftp://ftp.fao.org/ag/agn/infoods/
24. Wallborn T, Vogel M, Kneuer A, Thamm M, Dittrich K, Kiess W, et al. Spot urine iodine levels below the WHO recommendation are not related to impaired thyroid function in healthy children and adolescents. Eur J Nutr 2021;60:493-502.
25. Li JH, He ZH, Bansal V, Hennessey JV. Low iodine diet in differentiated thyroid cancer: a review. Clin Endocrinol 2016; 84:3-12.
26. Chaengbamrung S, Mosuwan L, Nachiangmai B, Suthutvoravut U, Udomkesmalee, E, Chongviriyaphan, N, et al. Dietary reference intake for Thais 2020. Bangkok: Bureau of Nutrition; 2020;p.437-42.
27. Mayer RE. Multimedia learning [press release]. Cambridge: Cambridge University; 2001.
28. Park J, Zuniga J. Effectiveness of using picture-based health education for people with low health literacy: An integrative review. Cogent Med 2016;3:1264679.
29. Bravo BJ, Tamò M, Dannon AE, Pittendrigh BR. An assessment of learning gains from educational animated videos versus traditional extension presentations among farmers in Benin. Inf Technol Dev 2018;24:224-44.
30. Lara TR, Munoz Torres VA, Salmerón GM, Vela ZD, Bravo PM, García IR, et al. La educación con una plataforma multimedia en web mejora conocimientosy la HbA1c de pacientes mexicanos con diabetes tipo 2. Ensayo clínico abierto. Endocrinol Diabetes Nutr 2020;67:530-9.
31. Tomoda C, Uruno T, Takamura Y, Ito Y, Miya A, Kobayashi K, et al. Reevaluation of stringent low iodine diet in outpatient preparation for radioiodine examination and therapy. Endocrine J 2005;52:237-40.
32. Choi JH, Kim HI, Park JW, Song EH, Ko BJ, Cheon GJ, Kim BI. Analysis of urine iodine excretion decrease by two-week stringent low iodine diet for remnant thyroid ablation with radioactive iodine in Korean patients with thyroid cancer; prospective study. Nucl Med Mol Imaging 2008;42:375-82.
33. Dobrenic M, Huic D, Zuvic M, Grosev D, Petrovic R, Samardzic T. Usefulness of low iodine diet in managing patients with differentiated thyroid cancer-initial results. Radiol Oncol 2011; 45:189-95.
34. Cheah WK, Arici C, Ituarte PH, Siperstein AE, Duh QY, Clark OH. Complications of neck dissection for thyroid cancer. World J Surg 2002;26:1013-6.
35. Duntas LH, Biondi B. Short-term hypothyroidism after levothyroxine-withdrawal in patients with differentiated thyroid cancer: clinical and quality of life consequences. Eur J Endocrinol 2007;156:13–9.
36. Lee J, Yun MJ, Nam KH, Chung WY, Soh EY, Park CS. Quality of life and effectiveness comparisons of thyroxine withdrawal,

triiodothyronine withdrawal, and recombinant thyroid-stimulating hormone administration for low-dose radioiodine remnant ablation of differentiated thyroid carcinoma. Thyroid 2010;20:173-9.

37. Rieger E, Sellbom M, Murray K, Caterson I. Measuring social support for healthy eating and physical activity in obesity. Br J Health Psychol 2018;23:1021-39.

38. Watanabe K, Kurose T, Kitatani N, Yabe D, Hishizawa M, Hyo T, et al. The role of family nutritional support in japanese patients with type 2 diabetes mellitus. Int Med 2010;49:983-9.