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Changes in the Educational Effects and Radiation Risk Perception by Radiological Education for the Students of School of Health Sciences

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The aim of this study is to clarify changes in the educational effects and radiation risk perception of students enrolled in a health sciences school by radiological education after the March 2011 Fukushima nuclear power plant disaster. A questionnaire survey regarding radiation was given to 156 first-year students in 2010 and 129 first-year students in 2011. The survey was conducted before and after an 'Introduction to the Basic Radiation' class taught between April and June. Questions about radiation risk perception were based on the study of Kanda et al. and covered fear of radiation ('fear'), difficulty in understanding radiation ('difficult'), interest in radiation ('interest'), and understanding the effects of radiation on the human body ('effects on humans'). The 'fear' , 'difficulty', and 'interest' scores were decreased in the 2010 group more than in the 2011 group ($p<0.001$). The 'effects on humans' score was increased in the 2011 group compared with in the 2010 group ($p<0.001$). In the 2011 group, 'fear' and 'difficulty' showed a little decrease in score and the 'interest' score was stable. It is important to offer systematic radiological education to health science students and to execute the education by matching it to their readiness and social environment.

Key words: radiation, risk perception, radiological education, Fukushima accident

1. Introductions

The impact of the accident at the Fukushima Nuclear Power Plant (subsequently referred to as the Fukushima accident) is still ongoing, although one and half year have passed. Many Japanese people do not have even basic knowledge about radiation, but they watch the news, which includes daily references to difficult technical terms about radiation. Many Japanese people came to fear nuclear power and radiation after the Japan Nuclear Fuel Conversion Co. accident in Tokai-mura, Japan[1)], and the radiation risk perception of Japanese people seemed to be increased by the Fukushima accident. On the other hand, the acceptance of medical radiation among the people is relatively high, because the benefits of radiation exposure in medical field are clear[2)]. Nevertheless, many people are anxious about the effects of radiation or the risk of radiation

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Table 1. Contents of 'Introductiont to the Basic Radiation'

Lecture Number	Lecture Title	Contents
1	Pioneer of radiology	Outline concerning basic knowledge of radiation from the history of the discovery and applications of the radiation.
2	Radiation and Radioactivity	A natural radiation exposure, The nature of radiation, Types of ionizing radiation, A principle of radiation protection, The use of the radiation in the medical area
3	Detection of Radiation	Radiation measurement, Application of some detections, A principle of radiological detection of detection, The unit of a radiation.
4	Radiation exposure's modality and Influence on human body (1)	The cellular basis of pathology, Signs/symptoms in acute radiation syndromes.
5	Radiation exposure's modality and Influence on human body (2)	Signs/symptoms by radiation exposure, an acute radiation syndrome, Deterministic effects/Stochastic effects, A history of radiation accidents.
6	Mechanism of nuclear power plant and nuclear reprocessing, Security Precautio	Nuclear reactor schematics, Reactor accidents, Mechanisms for prevention of reactor accidents
7	Outline of Radiation Emergency Medicine	Radiation Emergency Medicine in Japan, Emergency protocol of radiation accident victim, JCO accidents and radiation emergency prevention system
8	Test	

Each lecture of this subjects has a 90-minute class.

exposure during medical examinations that require radiation[3]. Thus, it is important to evaluate the balance of the benefit and the risk of radiation adequately among medical staff members and to clarify the anxiety and causes of the anxiety[4]. Even medical staff members have anxiety about radiation exposure[5] and fear of radiation is highly communicable and can negatively affect patient care[6-9]. Specialists in radiology and radiation protection have pointed out that the curriculums of health science students in Japan do not have radiological issues which need for medical staff except for radiological technologists, although systematic radiological education is very important for medical care[10-12]. We started systematic radiological education for health science students and medical staff members at Hirosaki University in 2008. There are few studies related to the educational effects and change in risk perception by learning about radiation. A very important issue for risk communication is how to educate medical students about radiation after the Fukushima accident. However, no studies on the effects of systematic radiological education have so far been performed. Thus, the present study aimed to clarify changes in the educational effects and radiation risk perception on students enrolled in a school of health sciences by a systematic radiological education. In addition, the effects of the Fukushima accident on the differences in the educational effects and changes in risk perception were also analyzed.

2. Methods

2.1. Subjects

A questionnaire survey regarding radiation was given to 156 first-year students who entered the School of Health Sciences, Hirosaki University in 2010 (the 2010 group) and 129 first-year students who entered in 2011 (the 2011 group). They were majoring in nursing (N group), medical technology (T group), physical therapy (PT group), or occupational therapy (OT group).

2.2. Data collection

The questionnaire survey was administered before and after an 'Introduction to the Basic Radiation' class, which consisted of eight 90-minute lectures (Table 1). The class was designed to introduce basic knowledge of radiation protection and radiation emergency medicine to first-year students by the Co-medical Education Program in Radiation Emergency Medicine in 2010. The contents of this class included basic knowledge of radiation: the history of the discovery and applications of the radiation, natural radiation exposure, the nature of radiation, types of ionizing radiation, the principles of radiation protection, the cellular basis of pathology, signs/symptoms in acute radiation syndromes, nuclear reactor schematics, reactor accidents, mechanisms for prevention of reactor accidents, and radiation emergency medicine in Japan. We explained the purpose and method of the study to the subjects before or after each lecture and distributed the questionnaire to the students. We considered the students to have given approval to participate in the study when they submitted the completed questionnaire. These questionnaires were performed between April and June 2010 and between May and July 2011. The start of the class was delayed due to The Great Eastern Japan Earthquake in 2011.

Table 2. Questionnaire

Question 1 What comes mind when you hear the word "radiation" ? Please circle all number of the items that comes to mind. (There is no limit on number of choices.)

① X-ray and CT applications ② Hiroshima, Nagasaki (Nuclear Weapons) ③ Madam Curie ④ Food irradiation
⑤ Chernobyl ⑥ Cancer Treatment ⑦ Exposure ⑧ Leukemia ⑨ Waste ⑩ Breed improvement (agricultural produce)
⑪ Nuclear power generation ⑫ Other ( )

Question 2 What would you like to know more about as regards "radiation" ? Please circle three numbers corresponding to three choices. (Please limit your choices to three.)

① Amount of radiation not causing any harm ② How to control safety ③ Actions to be taken in the case of radiation accidents
④ Facilities utilizing radiation ⑤ How radiation is utilized in food ⑥ Breed improvement for agricultural produce
⑦ How radiation is utilized in industry ⑧ How radiation is utilized in medical science ⑨ Governmentalregulations
⑩ State-of-the-art research fields ⑪ Nothing in particular

Question 3 Of the following health hazards caused by radiation exposure, please select up to three items that concern you the most. Please circle the number of your choices.(Please limit your choices to three.)

① lifertility ② Cataracts ③ Ulcers, skin disorders, hair loss ④ life shortening
⑤ Effects on children (miscarriage, deformation, brain disorders)
⑥ Cancer and leukemia ⑦ Effects on descendents (genetic disorders) ⑧ Other ( )

Question 4 Please arrange the following ten items in order of your concern in terms of health risks. For example, if you think that riding a motorcycle is the most risky, please "1" in the relevant box. Similarly, please rank all the ten items by placing your corresponding numbers in the spaces provided.

☐ Riding a motorcycle	☐ Smoking (cigarettes)	☐ Drinking (alcoholoc beverages)	☐ Antibiotics
☐ HIV	☐ O-157	☐ Surgery	☐ Hepatic fever
☐ X-ray, CT applications	☐ Obesity (overweight)		

Question 5 We are constantly exposured to radiation in our daily life. Of the fellowing sources of radiation, how dengerous do you feel on your health by radiation or radioactive substances? Please evaluate items between zero (no dengerous) and ten (dangerous) respectively.

Not dangerous 0 10 dangerous

1. Rocks & Soils
2. Cosmic rays
3. Radon spring
4. Chest X-ray
5. CT
6. Radiation Therapy
7. Airport baggage inspection
8. Air travel
9. Nuclear testing
10. Living near nuclear power plant

Question 6 How do you fear the radiation?.
1. Not at all 2. Slightly 3. Moderate 4. Strong

Question 7 How difficult is the knowledge of radiation?
1. Not at all 2. Slightly 3. Moderate 4. Strong

Question 8 How much influence on the human body of the radiation do you know?
1. Not at all 2. Slightly 3. Moderate 4. Strong

Question 9 How much are you interested about radiation?
1. Not at all 2. Slightly 3. Moderate 4. Strong

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To conclude this questionnaire, please provide the following personal information below. Please circle the appropriate number.

＊Sex 1. Male 2. Female
＊Age ( ) years old
＊Grade 1. Freshman 2. Sophomore 3. Junior 4. Senior
＊Which did you take elective Subjects of Science in high school?
1. Physics 2. Chemistry 3. Biology 4. Geography

＊Have any of your family members undergone radiological treatment? 1. Yes 2. No
＊Have any of your family members engaged in occupation related to radiation? 1. Yes 2. No
＊Did you grow up in the prefecture where the nuclear plant existed ? 1. Yes 2. No
＊What is your resourse about radiation? There is no limit on number of choices.
1. lecture at School 2. family acquaintance 3.public relations facilities for nuclear power
4.newspaper magazine 5. Television 6.Internet

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Table 3. Background data of subjects

		2011 (n=156)	2012 (n=129)	χ^2	*P*
Sex	Male	43 (27.9)	30 (23.3)	0.9	n.s.
	Female	111 (72.1)	99 (76.7)		
Majoring	N	76 (48.7)	69 (53.5)	0.9	n.s.
	T	39 (25.3)	29 (22.5)		
	PT	21 (13.5)	14 (10.9)		
	OT	20 (13.5)	17 (13.2)		
Elective Subjects of Science in high school	Physics	60 (39.0)	52 (40.3)	0.1	n.s.
	Chemistry	150 (97.4)	128 (99.2)	1.3	n.s.
	Biology	102 (66.2)	86 (66.7)	0	n.s.
	EarthSciences	0 (0)	1 (0.4)	1.2	n.s.
Nuclear power plant in prefecture grew up	exist	99 (63)	74 (57.4)	0.8	n.s.
	notexist	57 (37)	53 (41.1)		
	uncertain	0 (0)	2 (1.5)		
knowing a family person who has a job related to radiation	exist	18 (11.4)	14 (10.8)	0.04	n.s.
	notexist	130 (83.3)	110 (85.3)		
	uncertain	6 (3.8)	5 (3.9)		
	blank	1 (0.6)	0 (0)		
knowing afamily person who underwent radiotherapy	exist	26 (16.9)	26 (20.1)	3.1	n.s.
	notexist	75 (48.0)	71 (55)		
	uncertain	53 (33.9)	32 (24.9)		
	blank	1 (0.6)	0 (0)		

Values are numbers of response and values in brackets are percentage.
Majors of students are showed by nursing (N), medical technology (T), physical therapy (PT), and occupational therapy (OT) .
Statistical Analysis was used by Chi-Square test.
Statistical significance was defined as P<0.05. N.S. was meaning of not siginificant.

2.3. Questionnaire

We asked questions about background data of the subjects as well as the radiation risk perception. Background data included age, sex, elective science subjects in high school, knowing a relative who had undergone radiotherapy, knowing a relative who has a job related to radiation, having a nuclear power plant in the prefecture where they grew up, and knowing how to get information about radiation. Questions about radiation risk perception were based on the study of Kanda et al[4] and covered items including radiological knowledge that students wanted to obtain and risk of damage to one's health by radiation or radioactive substances (health risk of radiation) (Table 2). Both of the words associated with radiation and the things that students would like to know about radiation were limited to three items. The questions about health risk of radiation were evaluated using an 11-point scale, from 0 to 10. Higher scores indicate a greater radiation risk perception. Survey questions also assessed what factors influenced risk perception, including fear of radiation ('fear'), difficulty in understanding radiation ('difficulty'), understanding the effect of the radiation on the human body ('effects on humans'), and interest in radiation ('interest'). These items were assessed using a 4-point Likert scale ranging from no impact at all to a strong impact.

2.4. Statistical analysis

Data were analyzed using SPSS software (version 19.0) for Windows (SPSS Inc., Chicago, IL). Statistical significance was defined as P<0.05. Differences in Background data among the groups were determined by the chi-square test. For the analysis of health risk of radiation and the scores of items involved in risk perception consisting of fear, difficulty, interest, and effects on humans between groups before and after the class, a two-way repeated-measures analysis of variance was applied. The intra-group comparison between before data and after data was done by the Bonferroni correction for multiple comparisons.

2.5. Ethical issues

All study protocols were approved by the Committee for Medical Ethics of the School of Medicine, Hirosaki University, and informed consent was obtained from each participant prior to the study.

3. Results

3.1. Background data of the subjects

A total of 285 health science students included 74 males (26%) and 211 females (74%). The background data of the subjects were summarized in Table 3. The mean age of the subjects was 18 years (± 1.7; range, 18 to 31 years). Students of the N group were half of the subjects, and students in the T group and sum of the PT and OT groups were one-quarter of the subjects. There were no significant differences between years in almost variables of background

Table 4. Sources of knowledge concerning radiation

	2010 (n=156)	2011 (n=129)	χ^2	P
lecture atschool	78 (50.0)	44 (34.1)	7.3	$P < 0.01$
family acquaintance	24 (15.4)	27 (29.9)	1.5	n.s.
public relations facilities for nuclear power	32 (20.5)	27 (20.9)	2.7	n.s.
newspaper magazine	62 (39.7)	52 (40.3)	0.009	n.s.
Television	133 (85.3)	115 (89.1)	0.95	n.s.
Internet	23 (14.7)	34 (26.4)	6.0	$P < 0.05$
Other	6 (0.4)	6 (0.5)	0.1	n.s.
Only media	51 (32.7)	54 (41.9)	3.0	$P < 0.1$
education & media	82 (52.6)	55 (42.6)		

Values are numbers of response and values in brackets are percentage.
Statistical Analysis was used by Chi-Square test.
Statistical significance was defined as P<0.05. N.S. was meaning of not siginificant.

Table 5. Radiological knowledge that students wanted to obtain

	2010 (n=155)				χ^2	2010 Total	2011 (n=129)				χ^2	2011 Total	Compare with2010 and 2011
	N	T	PT	OT			N	T	PT	OT			
① Amount of radiation not causing any harm	40	12	8	11	6.1	71 (45.8)	26	13	3	8	2.7	50 (38.6)	n.s.
② How to control safety	31	15	4	7	3.4	57 (36.8)	28	7	8	6	4.8	49 (38.0)	n.s.
③ Actions to be taken in the case of rasiation accidents	54	23	11	16	5.2	104 (67.1)	53	26	9	15	5	103 (79.8)	2010<2011*
④ Facilities utilizing radiation	8	3	4	3	3.7	18 (11.6)	8	4	2	1	0.7	15 (11.6)	n.s.
⑤ How radiation is utilized in food	4	5	7	1	14.2**	17 (11.0)	14	1	1	3	5.4	19 (14.7)	n.s.
⑥ Breed improvement for agricultural prodice	2	0	1	0	2.3	3 (2.0)	4	1	0	0	1.9	5 (3.9)	n.s.
⑦ How radiation is utilized in industry	0	2	0	0	6.1△	2 (1.2)	4	0	1	0	2.9	5 (3.9)	n.s.
⑧ How radiation is utilized in medical science	61	33	16	15	1	125 (80.6)	49	21	9	14	1.4	93 (72.1)	n.s.
⑨ Government regulation	4	1	0	0	2.4	5 (3.2)	3	0	0	1	2.2	4 (3.1)	n.s.
⑩ State-of-art research fields	13	12	4	4	3	33 (21.3)	21	13	9	3	9.3*	46 (35.7)	2010<2011**

Values are numbers of response and values in brackets are percentage.
Majors of students are showed by nursing (N), medical technology (T), physical therapy (PT), and occupational therapy (OT). Statistical analysis was used by Chi-Square test. Statistical significance was defined as P<0.05.
**P<0.01, *P<0.05, △P<0.1, N.S. was meaning of not siginificant.

Table 6. Ranking of scores regarding health risk of radiation

	2010 (n=155)		Bonferroni correction ※2	2011 (n=129)		Bonferroni correction ※2	F ※1	P
	before	after		before	after			
1 Living near a nuclear power plant	7.7 (2.3)	6.8 (2.4)	pre>post***	7.2 (2.3)	6.9 (2.7)	n.s.	3	n.s.
2 Nuclear testing in other country	7.5 (2.5)	6.8 (2.5)	pre>post**	6.7 (2.5)	6.5 (2.5)	n.s.	2.4	n.s.
3 Cosmic rays	6.5 (7.9)	5.1 (3.1)	pre>post**	5.1 (3)	3.9 (3)	n.s.	0.09	n.s.
4 Radiological treatment	4.3 (2.5)	4.8 (2.3)	pre<post*	3.9 (2.3)	4 (2.3)	n.s.	1.4	n.s.
5 Radium/radon hot spring	3 (2.4)	3.3 (2.5)	pre<post***	2.7 (2.6)	3 (2.4)	n.s.	0.01	n.s.
6 Air travels	2.6 (1.7)	3.5 (2.1)	pre<post**	2.6 (1.5)	3.1 (2.1)	n.s.	1.7	n.s.
7 Rocks and soil	3.5 (2.8)	2.8 (3.0)	pre>post**	2.2 (2.4)	2.4 (2.7)	pre<post***	6.6	P<0.05
8 CT scan	2.3 (2.1)	3.4 (2.5)	pre<post***	1.9 (1.9)	2.9 (2.2)	pre<post***	0.2	n.s.
9 Chest X-ray photograms	2.3 (2.1)	3.2 (2.3)	pre<post***	1.9 (1.9)	2.8 (2.2)	pre<post***	0.3	n.s.
10 Airport baggage inspection	1.3 (1.7)	2.5 (2.1)	pre<post**	1.2 (1.5)	2.3 (2.1)	n.s.	0.03	n.s.

※1 Statistical analysis was used by 2 way repeated measure ANOVA.
※2 The intra-group comparison between pre and post was done by the Bonferroni correction for multiple comparisons.
Statistical significance was defined as p<0.05.
***P<0.001, **P<0.01, *P<0.05 N.S. was meaning of not siginificant.

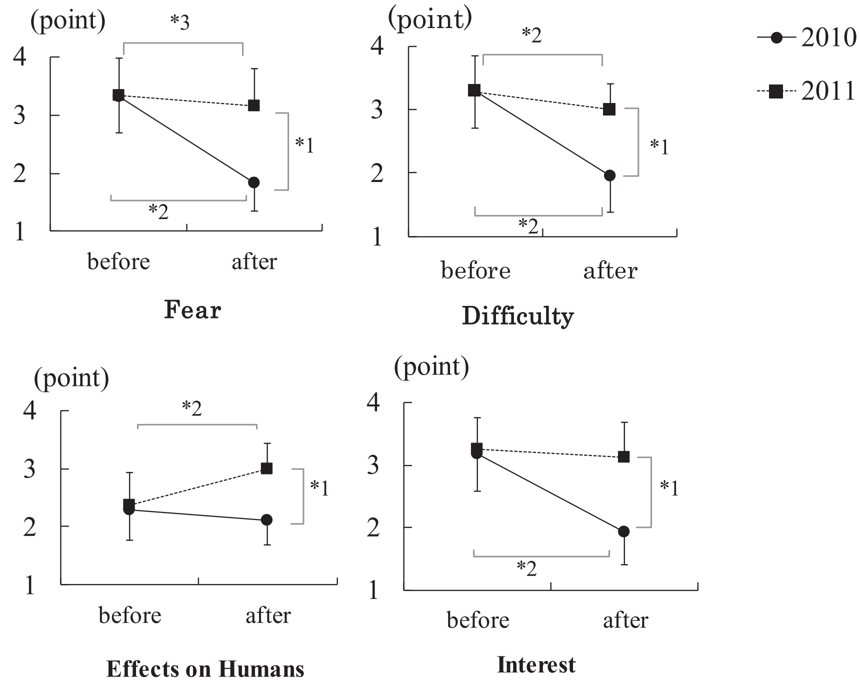

Fig. 1. Changes in risk perception and factors influencing risk perception regarding radiation
Statistical analysis: 2-way repeated measure ANOVA and the intra-group comparison between before and after data was done by the Bonferroni correction for multiple comparisons.
*1: P<0.001, 2-way repeated measure ANOVA
*2: P<0.001, for comparison between before data and after data
*3: P<0.05, for comparison between before data and after data
Statistical significance was defined as P<0.05.

data. The rates of obtained knowledge concerning radiation in 2010 and 2011 were as follow; 85% and 90% in lectures on television; 34% and 50% in school, 40% in newspapers and magazines, 21% in public relations facilities for nuclear power plants, 15% and 26% in the Internet and 15% and 30% in family or acquaintances, respectively (Table 4). Subjects in the 2011 group obtaining information from only mass media accounted for a likely higher percentage than those in the 2010 group. The number of subjects in the 2011 group who obtained some information about radiation from a lecture at school was significantly lower than that in the 2010 group (p < 0.01), whereas the number of subjects in the 2011 group who obtained some information from the Internet was significantly higher than that in the 2010 group (P <0.05).

3.2. Radiological knowledge that students wanted to obtain (up to three items)

Radiological knowledge that students wanted to obtain are shown in Table 5. The rates of contents which subjects wanted to learn in 2010 and 2011 were as follow; 72% and 81% in 'how radiation is utilized in medical science', 67% and 80% in 'actions to be taken in the case of radiation accidents' and 39% and 46% in 'amount of radiation that does not cause any harm'. Subjects in the 2011 group were significantly more likely to select 'actions to be taken in the case of radiation accidents' (P<0.05) and 'how radiation is utilized in medical science' (P<0.01) compared with students in the 2010 group. There were no significant differences between groups in interests except 'how radiation is utilized in food' and 'how radiation is utilized in industry'.

3.3. Health risks of radiation

The survey contained questions associated with radiation itself and 10 questions about the health risks of radiation. The items scored as high-risk were 'living near a nuclear power plant', 'nuclear testing', 'cosmic rays' and 'radiation therapy' (Table 6). The score of 'rocks and soil' was significantly decreased in the 2010 group, whereas it was increased in the 2011 group (P<0.05). For intra-group analysis, 'living near a nuclear power plant', 'nuclear testing in other countries', 'cosmic rays', and 'rocks and soil' were perceived as being significantly lower risks after the class than before the class in the 2010 group. The other six items were perceived as being significantly higher risks after the class compared with before the class in the 2010 group. The scores for 'rocks and soil', 'CT scan', and 'chest X-ray photograms' indicated significantly higher risk after the class than before the class in the 2011 group.

3.4. Fear, Difficulty, Effects on Humans and Interest

The scores for 'fear' and 'difficulty' were decreased in the 2010 group compared with in the 2011 group (P<0.001, Fig. 1). These scores were significantly decreased after the class compared with before the class in both groups. The score for 'interest' was also decreased in the 2010 group compared with in the 2011 group (P<0.001, Fig. 1). Score for 'interest' was significantly decreased after the class compared with before the class in the 2010 group (P<0.001). The score for 'effects on humans' was increased in the 2011 group compared with in the 2010 group (P<0.001). It was also increased after the class compared with before the class in the 2011 group (P<0.001).

4. Discussion

In the present study, the educational effects and radiation risk perception following systematic radiological education for students enrolled in a school of health sciences were analyzed. Additionally, the differences in the educational effects and risk perception of students were also evaluated. The score for 'fear' was decreased by systematic radiological education in both the 2010 and 2011 groups (Fig. 1). It has been reported that people with poor knowledge about radiation have high anxiety[13, 14]. Slovic reported that factors contributing to risk perception include risk of dread and unknown risk[15]. Thus, radiation risk perception was decreased after the class because students gained some knowledge about radiation in limited categories of radiology. However, the systematic radiological education caused only slight changes in 'fear' in the 2011 group (Fig. 1). There were no significant differences in background data between the groups. These results suggest that students in the 2011 group continued to have fear of radiation even after the class because of the ongoing concerns regarding the Fukushima accident at that time. Additionally, after the disaster, the 2011 group gained much information from mass media every day concerning basic information of radiation, circumstances of the disaster and radiation exposure. The anxiety or the fear about radiation is generally exacerbated by insufficient knowledge regarding the true effects of radiation, an inability to recognize radiation injuries, or lack of appropriate clinical experience with patients involved in radiological incident[9]. The relationship between learning about radiation and risk perception has several implications. For example, radiological knowledge had a positive correlation with a positive attitude toward nuclear power[16]. A previous study reported that there was no significant correlation between knowledge and a radiation risk perception[17]. People who had much or little knowledge still had a high risk perception of radiation[18] and gaining knowledge influenced the degree of anxiety[13]. The relationship between knowledge and radiation risk perception was not expected to have a significant correlation after the Fukushima accident; however, the impression of the accident was too strong to improve high risk perceptions as the students gained radiological knowledge over the class of eight lectures. The level of understanding or readiness to learn seemed to have more influence on high risk perception because 'effects on humans' increased and 'interest' was stable in the 2011 group (Fig. 1). This result suggests that educational effects were very high because there was high level of needs for studying radiology. Our previous study reported that nursing students achieved an adequate level of radiation risk perception by learning issues related radiation and radiotherapy or care in the radiotherapy[19]. Systematic radiological education involved in radiological hazard is also very important for students majoring in health sciences because teaching REM to medical staff members according to the magnitude of radiological hazards allow them to provide the required patient care[20]. Furthermore, we suggest that higher interest in radiation by providing copious information about radiation lead to the sufficient understanding of 'effects on humans'.

There are some limitations to the present approaches. The sample population consisted of students who were enrolled in one university in Japan. The class consisted of only eight lectures and each lecture was relatively short. Additionally, the contents of this class consisted of several radiological fields and the level of contents were fundamental. Thus, our findings need to be carefully interpreted with these limitations in mind. Studies of the long-term effects of this education and the educational effects of specialized subjects are still needed. Despite these limitations, our findings suggest that it is important to offer systematic radiological education to medical students and to execute the education by matching it to their readiness and social environment.

5. Conclusions

It is important to decrease the risk perception regarding radiation and the difficulty of understanding about radiation by systematic radiological education. However, these decreases were difficult to produce by systematic education soon after the Fukushima accident occurred. The social environment also contributes to the readiness of students for radiological education and interest in radiological knowledge. Thus, it is important to examine the educational content and the method for promoting the continued interest in radiation after learning about radiation according to changes in the social environment.

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