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Levels of Awareness among School Teachers Regarding Female Athletes and Nutritional Science

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Abstract Given the concerns about the adverse physical effects of overtraining and energy intake deficiency in pubescent girls, teachers providing them with sports instructions must have accurate knowledge about and complete understanding of their physical and mental conditions as well as knowledge about nutritional science. In this study, we surveyed 60 registered dietitians (G1), 131 health and physical education teachers (G2), and 116 teachers teaching other subjects (G3) to find differences in the levels of knowledge about the female athlete triad (FAT) and nutritional science among the three groups. The participants were requested to answer 30 questions regarding six factors associated with FAT and nutrition: obesity and thinness, dietary behavior, menstruation, energy, bone, and nutritional science. The total scores for the respective factors were evaluated. There were no differences in the menstruation factor score between G1 and G2. The scores for the other factors in G2 were significantly lower than those in G1. The scores for the following four factors in G3 were significantly lower than those in G1 and G2: obesity and thinness, nutritional science, bone, and menstruation. The scores for the remaining two factors, i.e., dietary behavior and energy, were significantly lower in G3 than those in G1. In conclusion, only G3 had a lower level of awareness about the menstruation factor, whereas G2 and G3 had lower levels of awareness about the other factors.

Keywords: *FAT, obesity, thinness, nutrition, menstruation, bone*

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1. Introduction

In Western countries, children's sports activities are implemented by local sporting clubs [1]. In recent years, Japan has attempted to introduce its own counterparts in the form of community-integrated sports clubs. Meanwhile, Japanese schools have club activities as part of extracurricular programs, and many students participate in sporting activities as club members [2]. Such activities are supervised by specialized instructors in community-integrated sports clubs and by school teachers in school club activities. In principle, school club activities aim to not only improve physical strength and skills but also nurture constructive human relationships, thereby helping students grow both physically and mentally and experience a meaningful school life [3]. However, in schools with powerhouse sports clubs eying to enter national competitions or winning awards, it is feared that excessive practice may result in overtraining in which the minds and bodies of the students become exhausted or result in sports-related disorders such as fatigue fractures [4]. In particular, overtraining is a factor that causes menstrual irregularities among girl athletes in puberty. Accordingly, it is critical for trainers instructing the girl athletes to have an accurate understanding of their physical and mental states and developmental stages.

The American College of Sports Medicine (ACSM) cited the following conditions as health issues specific for female athletes: "low energy availability (lack of available energy)," "hypothalamic amenorrhea," and "osteoporosis." The ACSM defined them as the female athlete triad (FAT) [5]. When compared with non-athletic women, female athletes reportedly tend to have menarche later and are susceptible to amenorrhea [6,7,8]. In fact, approximately 30% of middle school female athletes [9] and approximately 20% of high school female athletes participating in national competitions are reportedly amenorrheic [10]. Hence, amenorrhea is not a symptom limited to top athletes. When amenorrhea-derived state of low estrogen persists for an extended period, bone salt content decreases and the risk of osteoporosis increases. In Japan, middle-to-high school female students often retire from sporting competitions after incurring sports disorders. Therefore, athletes themselves, their guardians, and instructors must evaluate the levels of growth and development from the late years of elementary school and determine whether the athletes are leading a detrimental lifestyle [10]. Instead of "low energy availability," "eating

disorder" has been one of the conditions associated with FAT until it was replaced in 2007 with a new concept of "energy insufficiency not accompanied by eating disorder [11]." Nevertheless, it does not mean that no one suffers from eating disorder anymore. Athletes are more susceptible to eating disorder than non-athletes [12]. Among the former, athletes competing in events in which light bodyweight is preferred (e.g. aesthetic, endurance, and weight-category sports) are more predisposed to eating disorder [6,12]. Nonetheless, the risk is no less in any other sporting events. As long as one remains an athlete, development of eating disorder is likely to happen; hence, it is essential to detect the early signs. Specifically, the instructors need to not only give practical instructions to female athletes but also provide guidance on their dietary habits, thereby helping to prevent FAT.

Regarding consultation and medical care for menstruation-related problems, levels of awareness among female students in puberty are low. which could be partly attributed to the scarcity of descriptions related to health issues specific for females in the current Education Ministry guidelines and physical education (PE) textbooks [13]. Therefore, it is probable that even PE teachers (who had likely taken courses on nutritional science in college) lack a proper understanding of FAT. Moreover, teachers supervising club activities are not necessarily specialized PE teachers, and some of them have no playing experience of the sports they supervise (45.9% for middle schools; 40.9% for high schools) [14]. Naturally, the teachers who lack such an experience are likely to be less knowledgeable about FAT. As stated above, even the perception commonly recognized in the field of nutritional science may not be fully acknowledged in the school setting. Hence, it is feared that teachers with incorrect knowledge may endanger the lives of female students.

This study aimed to compare the levels of awareness among nutritional experts and school teachers regarding female athletes and nutritional science.

2. Method

2.1. Subjects

This web-based study involved nationally certified dieticians and teachers in middle schools, high schools, and special-needs schools. After the submitted questionnaire sheets were checked (for omissions, different answers to identical questions, etc.), data from three persons were excluded. Consequently, the data from 60 certified dieticians (G1, years since certification: 6.5 ± 6.3 years), 131 PE teachers (G2, years of instruction experience: 15.0 ± 9.7 years), and 116 other teachers (G3, years of instruction experience: 13.9 ± 10.9 years) were judged as valid. By affiliation, there were 75 middle school teachers (30.4%), 162 high school teachers (65.6%), and 10 special-needs school teachers (4.0%). The research plan for this study was approved by the Ethical Review Board for Human Experimentation of the Fukui University of Technology (Human-2020-07).

2.2. Survey Content

The survey consisted of four items related to obesity and thinness, 10 items related to nutritional science, and 16 items related to the FAT (Table 1). Each item was based on middle school and high school textbooks and books/documents supervised by the Japan Sport Association (JSPO) and was assessed by one certified dietician (years since certification: 3.0 years) for its content validity. Thereby, the items were screened. Regarding FAT, the following four factors were established: dietary behavior, menstruation, energy, and bone . The participants were asked to answer each item on a 3-point scale (true, false, or uncertain); for correct answers and incorrect/unclear answers, 1 and 0 points were added, respectively. The total score was calculated for each factor, with higher scores corresponding to higher awareness.

2.3. Statistical Analysis

One-factor analysis of variance without matching was performed to compare intergroup differences in the scores of each factor. When significant differences were noted, Tukey's honestly significant difference test was used for multiple comparison analysis. To assess the size of the differences in mean values, effective doses (η^2) were calculated. Additionally, intergroup differences in the percentage of correct answers were analyzed by ratio differential tests. When significant differences were observed, multiple comparison analysis was performed.

To assess the size of the differences, Cramer's coefficient of association was calculated. In this study, the level of significance in statistical hypothesis testing was set at 5%, which was controlled by Bonferroni's method.

3. Results

Table 2 lists the differences in the basic statistics and mean values of each factor score. All variables were found to be significant: the scores for obesity and thinness, nutritional science, and bone were largest in G1, followed by G2 and then G3. The scores for dietary behavior and energy were significantly higher in G1 than in the other two groups, whereas the scores for menstruation were significantly higher in G1 and G2 than in G3. Additionally, the effective dose for dietary behavior was small ($\eta^2 = 0.05$); however, the effective doses for the other factors were moderate (η^2: 0.07–0.38).

Table 3 lists the percentage of correct answers for each item in each group and the differential test results. Except for items 6,7,13,14,15,23,24, and 28, all variables were determined to be significant. For items 3, 4, 5, 8, and 10, G1 recorded the highest percentage of correct answers, followed by G2 and then G3. For items 1, 2, 9, 11, 18, 29, and 30, the percentage was significantly higher in G1 than in the other two groups. For items 17, 19, 20, 21, 22, 25, and 27, the percentage was significantly higher in G1 and G2 than in G3. For items 16, and 26, the percentage was significantly higher in G1 than in G3. For items 12 was significantly higher in G2 than in G3. Additionally, the effective doses were moderate or high for items 1, 3, 4, 8, 9, 10, 11, and 29 (V: 0.30-0.53), whereas they were small for the other items (V: 0.01-0.29).

Table 1. Question items and correct answers

Factor		Question	Correct answer
Obesity and thinness		1. Criteria for body mass index (BMI) differ between men and women.	F
		2. To improve obesity, it is necessary to decrease fat volume while maintaining muscle quantity.	T
		3. A BMI of ≤16.5 is judged as "thin."	F
		4. A BMI of ≥25 is judged as "obese."	T
Nutritional science		5. The five essential nutrients are carbohydrates, proteins, fats, vitamins, and dietary fiber.	F
		6. Glucides present in rice and bread function as an energy source to move the body.	T
		7. As protein intake increases, muscle quantity increases proportionately.	F
		8. Vitamin B_1 helps convert the glucide into energy.	T
		9. A "balanced diet" means a diet containing all three elements: a staple dish, main dish, and dairy product.	F
		10. Bone-related nutrients mainly include calcium and vitamin D.	T
		11. To efficiently ingest iron, it is better to consume iron contained in green vegetables rather than that contained in red meat.	F
		12. Exercising while hungry helps burn only fat.	F
		13. To recover from fatigue, it is recommended to mainly ingest protein after training.	F
		14. In most sporting events, a diet primarily consisting of carbohydrates is recommended as a breakfast on the day of a match.	T
FAT	**Dietary behavior**	15. Being concerned too much about one's weight and physique may lead to eating disorder and abnormal dietary behavior.	T
		16. Generally, female athletes are more aware of abnormal dietary behavior than ordinary female students.	F
		17. Female athletes are more susceptible to eating disorder than ordinary female students.	T
		18. Intentionally increasing the amount of exercise to expend energy is also a form of eating disorder.	T
	Menstruation	19. Amenorrhea is defined as a state without menstruation for at least 3 months.	T
		20. Athletes competing in events that do not prefer light bodyweight may also experience menstrual abnormalities.	T
		21. Regardless of the age group, menstrual abnormalities increase the risk of osteoporosis.	T
		22. When concerned about menstrual pain or physical condition during menstruation during matches, one can delay the menstrual cycle by consuming a low-dose pill.	T
	Energy	23. In puberty, body height and weight continue to increase even when energy is lacking.	F
		24. In puberty, a state of energy insufficiency is diagnosed when one's weight falls below 85% of the ideal weight.	T
		25. Even when one does not appear to be thin, amenorrhea can occur when energy intake is insufficient.	T
		26. Even when large quantities of iron are consumed, anemia can occur when energy intake is insufficient.	T
	Bone	27. Since osteoporosis is a problem specific for middle-aged to elderly patients, female athletes in their growing stage are not at risk.	F
		28. A lack of muscular strength is a factor for fatigue fracture.	F
		29. Male hormones are more relevant to bone mass than female hormones.	F
		30. To strengthen (harden) bones, exposure to sunlight is important.	T

Table 2. Differences in the basic statistics and mean values of each factor score

		M±SD (range)						
		G1	G2	G3	F	p	η^2	post-hoc
Obesity and thinness		3.8±0.5 (2-4)	2.0±1.2 (0-4)	1.5±1.1 (0-4)	94.3*	0.00	0.38	G3 < G2 < G1
Nutritional science		8.2±1.3 (5-10)	6.5±1.8 (2-10)	5.2±1.9 (0-9)	58.2*	0.00	0.28	G3 < G2 < G1
FAT	Dietary behavior	2.8±0.9 (1-4)	2.4±0.9 (0-4)	2.2±1.0 (1-4)	8.48†	0.00	0.05	G2,G3<G1
	Menstruation	3.4±0.7 (2-4)	3.1±0.9 (1-4)	2.3±1.2 (0-4)	28.2†	0.00	0.16	G3<G1,G2
	Energy	2.8±0.9 (0-4)	2.3±1.0 (0-4)	2.0±1.2 (0-4)	12.7†	0.00	0.07	G2,G3<G1
	Bone	3.0±0.7 (1-4)	2.4±0.9 (0-4)	1.9±0.9 (0-4)	28.8†	0.00	0.16	G3 < G2 < G1

NOTE) *: $p < 0.05$, †: $p < 0.05/4 = 0.0125$.

Table 3. Percentage of correct answers for each item in each group and the differential test results

		G1		G2		G3					
		n	%	n	%	n	%	χ^2	p	V	post-hoc
Obesity and thinness	ID 1	55	91.7	45	34.4	24	20.7	86.2†	0.000	0.53	G2, G3 < G1
	ID 2	59	98.3	109	83.2	87	75.0	15.3†	0.000	0.22	G2, G3 < G1
	ID 3	53	88.3	47	35.9	25	21.6	75.3†	0.000	0.50	G3 < G2 < G1
	ID 4	58	96.7	62	47.3	35	30.2	70.9†	0.000	0.48	G3 < G2 < G1
Nutrition science	ID 5	51	85.0	87	66.4	57	49.1	22.8‡	0.000	0.27	G3 < G2 < G1
	ID 6	57	95.0	130	99.2	107	92.2	7.53	0.023	0.16	
	ID 7	54	90.0	102	77.9	83	71.6	7.81	0.020	0.16	
	ID 8	56	93.3	71	54.2	37	31.9	60.0‡	0.000	0.44	G3 < G2 < G1
	ID 9	57	95.0	88	67.2	65	56.0	27.9‡	0.000	0.30	G2, G3 < G1
	ID 10	58	96.7	99	75.6	69	59.5	28.6‡	0.000	0.31	G3 < G2 < G1
	ID 11	55	91.7	45	34.4	28	24.1	79.2‡	0.000	0.51	G2, G3 < G1
	ID 12	50	83.3	114	87.0	81	69.8	11.9‡	0.003	0.20	G3 < G2
	ID 13	27	45.0	36	27.5	30	25.9	7.72	0.021	0.16	
	ID 14	29	48.3	76	58.0	45	38.8	9.11	0.011	0.17	
Dietary behavior	ID 15	59	98.3	129	98.5	114	98.3	0.02	0.992	0.01	
	ID 16	54	91.7	102	77.9	82	70.7	10.1†	0.006	0.18	G3 < G1
	ID 17	27	45.0	58	44.3	31	26.7	9.71†	0.008	0.18	G3 < G1, G2
	ID 18	26	43.3	29	22.1	26	22.4	11.0†	0.004	0.19	G2, G3 < G1
Menstruation	ID 19	42	70.0	73	55.7	39	33.6	23.7†	0.000	0.28	G3 < G1, G2
	ID 20	59	98.3	130	99.2	98	84.5	24.9†	0.000	0.29	G3 < G1, G2
	ID 21	50	83.3	99	75.6	60	51.7	24.1†	0.000	0.28	G3 < G1, G2
	ID 22	50	83.3	99	75.6	71	60.3	12.2†	0.002	0.20	G3 < G1, G2
Energy	ID 23	48	80.0	84	64.1	71	61.2	6.64	0.036	0.15	
	ID 24	19	31.7	29	22.1	21	18.1	4.20	0.123	0.12	
	ID 25	49	81.7	93	71.0	65	56.0	13.2†	0.001	0.21	G3 < G1, G2
	ID 26	52	86.7	96	72.5	75	64.7	9.56†	0.008	0.18	G3 < G1
Bone	ID 27	59	98.3	123	93.9	97	83.6	12.8†	0.002	0.20	G3 < G1, G2
	ID 28	17	28.3	44	33.6	21	18.1	7.64	0.022	0.16	
	ID 29	42	70.0	30	22.9	16	13.8	64.8†	0.000	0.50	G2, G3 < G1
	ID 30	60	100	112	85.5	89	76.7	16.9†	0.000	0.23	G2, G3 < G1

NOTE) †: $p < 0.05/4 = 0.0125$, ‡: $p < 0.05/10 = 0.005$.

4. Discussion

The secondary sexual characteristics of girls start developing at around 9–11 years of age and include various physical changes, such as the development of the uterus and rounded body shape along with increases in body weight and fat. In particular, many respondents knew that obesity should be managed because obesity often leads to cardiac and cerebrovascular diseases. Accordingly, we hypothesized that the level of obesity-related knowledge among school teachers, particularly those teaching health and PE, would be as high as that among registered dietitians. However, the results of this study showed that the awareness of obesity in registered dietitians was significantly higher than that in the other two groups. Approximately 90% of the registered dietitians answered questions related to body mass index (BMI; Items 1 and 4) correctly, whereas <50% of teachers in the two groups could answer these questions correctly. Meanwhile, the rates of awareness for the item related to how to ameliorate obesity (Item 2) in the two teacher groups were approximately 80%; however, the intergroup differences were not significant. These results revealed that the levels of awareness on obesity, particularly about the BMI criteria for categorization, in the two teacher groups were low. In Japan, the rate of obesity among girls is relatively low compared with that in other countries [15]; this is partly because they are served a nutritionally balanced school lunch [16]. However, as the overall awareness of obesity among school teachers was not found to be high, registered dietitians, including teachers teaching nutrition, should share information with school teachers.

Thinness is another physical health issue, and the FAT is considered particularly problematic for pubescent female athletes. Elite athletes as well as individuals performing a high volume of exercise [17]. Thus, female students participating in sporting activities are also at risk for thinness. Despite this, approximately 90% of female athletes are unaware of the FAT [18,19]. Therefore, the

complete understanding of FAT-related knowledge by teachers instructing female students will be beneficial for not only maintaining the health of these students but also for improving their awareness of the FAT.

Registered dietitians and health and PE teachers were more knowledgeable regarding the menstruation factor of the FAT than the other teachers. Conventionally, education regarding the reproductive system, including menstruation, has been a part of health and PE as per the official curriculum guidelines. This is presumably why the level of knowledge among health and PE teachers was similar to that among registered dietitians. However, the contents and hours of education regarding menstruation in schools are insufficient, and insufficient "understanding of how to treat menstruation" and "availability of occasions for health consultation" have been pointed out [13]. This suggests that health and PE teachers have inadequate knowledge about how to treat menstruation disorders, whereas their menstruation-related knowledge may be interpreted as being equivalent to that of registered dietitians. The levels of awareness of menstruation disorders among school teachers should be investigated in future studies.

Meanwhile, the rates of awareness for the bone, dietary behavior, and energy factors among registered dietitians tended to be higher than those among health and PE teachers. Although all registered dietitians were aware of the item "bone is strengthened by exposing the body to sunlight (Item 30)", the rate of awareness for the same item was approximately 80% in the two teacher groups. For the item "relationship between bone and female hormones (Item 29)", the rates of awareness in the two teacher groups were approximately 20%, compared with 70% among registered dietitians. For the item "relationship between overexercise and eating disorder (Item 18)", the rate of awareness among registered dietitians was approximately 40%, whereas the rates in the two teacher groups were approximately 20%. Although these factors and items are crucial for maintaining the health of female students, the levels of awareness in the two teacher groups were not necessarily high, suggesting gaps in information awareness in terms of education and nutrition. The nutrition professionals should actively intervene and provide education.

It is important to continue having balanced meals with sufficient energy intake to prevent the FAT. An interventional study on nutritional guidance in amenorrheic athletes has reported that improved EA contributed to the improvement in luteinizing hormone levels [20], suggesting that reviewing the energy consumption and the meal size as soon as menstruation disorders are detected is conducive to preventing the FAT. In this study, the rates of awareness about nutritional science among health and PE teachers were significantly lower than those among registered dietitians. An adequate level of knowledge about nutritional science may be necessary not only to provide female students with dietary advice and help resolve the energy insufficiency, which is a factor contributing to the FAT, but also to help prevent menstruation irregularities, such as amenorrhea, and fatigue fractures, as well as the rectification of unbalanced dietary habits. In this study, the rates of awareness about the basic nutritional knowledge ["five major nutrients (Item 5)" and "balanced diet (Item 9)"] among health and PE and other teachers were not very high (approximately 65% and 50%, respectively). In light of these results, registered dietitians are expected to actively provide teachers with essential knowledge of nutritional science (e.g., how to ensure sufficient energy intake). Since school sport club activities are anticipated to be replaced by community-integrated sports club activities, knowledge about the FAT and nutritional science should be disseminated to not only school teachers instructing female students in club activities but also to other people involved in providing instructions regarding sports, such as sports club coaches. Registered dietitians and certified sports dietitians should encourage local governments and organizations supervising community club activities to take action in this regard.

5. Conclusion

Knowledge regarding menstruation among health and PE teachers was comparable with that among registered dietitians. However, school teachers, including those of health and PE, have poorer levels of knowledge regarding obesity and thinness, nutritional science, dietary behavior, energy, and bone than registered dietitians.

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Conflict of Interest Statement

The authors declare no conflicts of interest associated with this manuscript.

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