

Associations between Sensitivity to Cold, Menstruation-Related Symptoms and Handgrip Strength in Female University Students in Japan

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Abstract

Sensitivity to cold, which is a popular symptom in Japanese women, is associated with various symptoms such as shoulder stiffness and general fatigue. However, an association of sensitivity to cold with muscle strength has not been reported. The aim of the study was to clarify the associations of sensitivity to cold with handgrip strength and with menstruation-related symptoms in female university students in Japan. We recruited 278 female university students in Japan. Sensitivity to cold and menstruation-related symptoms including physical and psychological symptoms were assessed by using a self-administered questionnaire that we designed. Handgrip strength was measured by using a handgrip strength dynamometer. We received responses from 269 students. The prevalence rate of sensitivity to cold in the subjects was 54.3%. The students who had sensitivity to cold had a lower handgrip strength level (25.5 ± 3.8 kg) than did the students who did not have sensitivity to cold (26.7 ± 3.9 kg) ($p = 0.017$). Sensitivity to cold was associated with low body mass index. In addition, the students who had sensitivity to cold tended to have low back pain and constipation during menstruation. In conclusion, sensitivity to cold is an important symptom associated with muscle strength as well as menstruation-related symptoms for young women.

Keywords

Sensitivity to Cold, Menstruation-Related Symptoms, Handgrip Strength, Menstrual Phase, Young Women

1. Introduction

Autonomic thermoregulation in response to cold exposure differs in healthy individuals [1]. It has been suggested that cold hypersensitivity in the hands and feet is a symptom of sensation of cold in the extremities under conditions that would not typically evoke such a sensation [2]. In Japan, sensitivity to cold is defined as a state in which there exists a temperature range from core temperature to temperature of the extremities and there is slow recovery of the tip body temperature in a warm environment with the person usually having an awareness of cold sensation [3]. It has been reported that cold hypersensitivity in the hands and feet is common in East Asians, especially women [4]. Traditional herbal medicine has been used as an alternative approach for treatment of peripheral coldness, and improvement in peripheral coldness has been reported [5]. Peripheral coldness is thought to be a result of circulation failure caused by constriction of peripheral blood vessels. Various symptoms associated with sensitivity to cold, including shoulder stiffness, fatigue, neck stiffness, eyestrain, depressed mood and menstrual pain, have been reported [6]. Several studies have demonstrated that perceived sensitivity to cold in young students was associated with premenstrual symptoms [7] [8] and premenstrual dysphoric disorder [9]. Menstruation-related symptoms include not only physical symptoms but also psychological symptoms before and during menstruation. However, there have been few studies on the association of sensitivity to cold in young women with menstruation-related symptoms including physical and psychological symptoms during menstruation.

A decrease in heat production due to a loss of muscle volume and/or decrease in basal metabolism is considered to be one of the causes of sensitivity to cold [6]. It has been reported that sensitivity to cold was negatively correlated with amount of exercise and that amount of exercise had a positive correlation with handgrip strength level for children [10]. On the other hand, many studies have shown that handgrip strength level was associated with various diseases such as cardiovascular diseases, respiratory diseases and cancer [11] [12]. It has also been reported that lower handgrip strength was associated with psychological symptoms such as depression and anxiety [13] [14]. In a previous study, we showed that handgrip strength was associated with degree of depression and anxiety during menstruation in female university students in Japan [15]. However, the relationship between sensitivity to cold and handgrip strength has not been elucidated. Sensitivity to cold in young women may be associated with handgrip strength, which is one of the factors in the criteria for diagnosis of sarcopenia.

We aimed to clarify the associations of sensitivity to cold with handgrip strength and with menstruation-related symptoms in female university students in Japan.

2. Methods

This study was designed as a cross-sectional study.

2.1. Procedure

First, we conducted a preliminary study in July 2019 to determine whether there are differences in the proportion of the subjects with sensitivity to cold and in levels of handgrip strength depending on the three phases of the menstrual cycle: luteal phase, menstrual phase and follicular phase. For preliminary study, the students completed a questionnaire for assessment of sensitivity to cold and measured their handgrip strength in the three menstrual phases over a period of one month. Among 19 female nursing students in Japan recruited, data for 8 students were eligible for analysis. It was found that the proportion of the subjects with sensitivity to cold and the levels of handgrip strength in these students were not significantly different depending on the menstrual cycle phase. Therefore, we decided to recruit subjects regardless of the phase of the menstrual cycle. We recruited 278 female university students from July to August in 2019. At the end of a lecture, we asked the students to complete a questionnaire and to measure their handgrip strength with guidance from researchers. The questionnaires were collected on the same day. Informed consent was obtained prior to participation in the study and the preliminary study. The study received approval from the Ethics Committee of Tokushima University Hospital (approval number: 3483).

2.2. Questionnaire

A self-administered questionnaire was designed by the researchers and it took about 10 minutes to complete. The first part consisted of questions about age, body height and weight, length and present phase of the menstrual cycle. Phases of the menstrual cycle include the luteal phase (21 to 25 days after the start of the last menstruation), menstrual phase (during menstruation) and follicular phase (2 to 4 days after the start of the last menstruation). The second part of the questionnaire consisted of questions about self-assessment of menstruation-related symptoms during menstruation including physical symptoms such as abdominal pain, headache, low back pain, nausea, abdominal distension, constipation, diarrhea, getting tired easily, edema, sleepiness, rough skin, thirst and psychological symptoms such as increase in appetite, irritation, depression, loss of motivation and anxiety. The severity of each symptom was assessed using the following five degrees: no symptom, unrecognizable, bearable, unrecognizable if taking medication and affecting daily life. The third part of the questionnaire consisted of questions on self-assessment of sensitivity to cold. Based on Sakaguchi's criteria of sensitivity to cold [16] in a 24-item questionnaire, we used the following 22 statements: 1) I do not think that I am sensitive to cold, 2) I tend to be more sensitive than other people to cold, 3) I sometimes suffer because my entire body is cold, 4) I suffer because my back, hands and feet or some part of my body is cold, 5) I wear thick socks even in summer because my feet are cold, 6) Due to cold weather in winter, I always use an electric blanket, mattress or pocket warmer, 7) I suffer in air-conditioned rooms because my body feels cold, 8) I have

been suffering from the cold for the last several years, 9) In winter, I use an electric blanket or mattress, 10) I do not like air conditioning, 11) Compared to others, my hands and feet are cold, 12) Even in summer, I prefer wearing thick socks, 13) I like to dress warmly, 14) Especially in winter, I tend to sleep curled up, 15) In winter and on cold days, I urinate more frequently, 16) Even in summer, I like hot drinks, 17) Compared to others, my face is more pale, 18) My body temperature does not normally go above 36°C, 19) On cold days, my joints become stiff or painful, 20) Even in summer, my hands and feet get cold, 21) My body sometimes suddenly becomes too warm or cold, and 22) My hands and feet always feel cold. A response of “Yes” or “No” was given to each of them. Participants were “sensitive to cold” if they answered “Yes” to more than two statements from the five important statements 2), 4), 7), 11), and 20) or if they answered “Yes” to one of the important statements and to more than two of the 7 reference statements 3), 5), 6), 8), 15), 17), and 22).

2.3. Instrument for Measuring Handgrip Strength

We used a handgrip strength dynamometer (GRIP-D, Takei Scientific Instruments Co., Ltd., Japan, Product No. T.K.K.5401) for measurement of handgrip strength according to the instructions for the instrument. Measurements were performed twice each with the left and right hands alternately. The mean value of the highest values of the forces of both hands was indicated on the display of the handgrip strength dynamometer.

2.4. Statistical Analysis

By using the criteria of sensitivity to cold that was based on the previous report [16], the subjects were divided into a sensitivity to cold group and a non-sensitivity group. Background characteristics of the participants including age, height, weight, body mass index (BMI) and handgrip strength were expressed as means and standard deviation (SD). Each categorized variable is expressed as number with percentage. The answers for self-assessment of menstruation-related symptoms during menstruation were divided into three groups depending on the degree of each symptom: no symptoms, mild symptoms (unrecognizable and bearable) and severe symptoms (unrecognizable if taking medication and affecting daily life). The Mann-Whitney U test was used for analysis of differences in age, height, weight, BMI and handgrip strength between the two groups (sensitivity to cold group and non-sensitivity to cold group). Comparisons of menstrual cycle, present phases of the menstrual cycle and intensity of each menstruation-related symptom between the two groups were performed by the chi-square test. All p values less than 0.05 were considered statistically significant. Statistical analyses were conducted using SPSS version 24 for Windows.

3. Results

The questionnaire was distributed to 278 students, and we received responses

from 269 students (96.8%), which were used for analysis. The mean age (\pm standard deviation: SD) of the participants was 20.0 (\pm 2.7) years.

3.1. Background Characteristics of the Subjects According to the Presence of Sensitivity to Cold

Among the 269 students, the proportion of students who had sensitivity to cold (sensitivity to cold group) and the proportion of students who did not have sensitivity to cold (non-sensitivity to cold group) were 146 (54.3%) and 123 (45.7%), respectively. As shown in **Table 1**, there were significant differences between the two groups in body weight ($p = 0.003$) and BMI ($p < 0.001$). There was a significant difference in the proportions of women with and those without sensitivity to cold among the three groups ($p = 0.024$) according to BMI (<18.5, 18.5 - 24.9, \geq 25). There was no association of sensitivity to cold with the menstrual cycle length or menstrual cycle phase.

3.2. Difference in Handgrip Strength between the Sensitivity to Cold Group and Non-Sensitivity to Cold Group

Mean (\pm SD) handgrip strength in the sensitivity to cold group was 25.5 (\pm 3.8)

Table 1. Background characteristics and handgrip strength of the subjects according to the presence of sensitivity to cold.

		Sensitivity to cold group (n = 146)		Non-sensitivity to cold group (n = 123)		P-value
Age (years) ^a		20.1 \pm 2.8		19.9 \pm 2.5		0.451
Height (cm) ^a		158.0 \pm 5.2		158.0 \pm 4.3		0.971
Weight (kg) ^a		49.9 \pm 5.8		52.3 \pm 6.3		0.003
BMI (kg/m ²) ^a		20.0 \pm 1.9		20.9 \pm 2.2		<0.001
BMI (kg/m ²) ^b	<18.5	31	(22.5)	11	(9.7)	0.024
	18.5 - 24.9	104	(75.4)	98	(86.7)	
	\geq 25	3	(2.2)	4	(3.5)	
	missing	8		10		
Menstrual cycle length ^b	<24 day	10	(6.9)	5	(4.1)	0.146
	25 - 31 day	85	(59.0)	89	(72.4)	
	32 - 38 day	39	(27.1)	24	(19.5)	
	>39 day	10	(6.9)	5	(4.1)	
	missing	2		0		
Menstrual cycle phase ^b	Luteal phase	65	(50.8)	57	(53.8)	0.814
	Menstrual phase	32	(25.0)	27	(25.5)	
	Follicular phase	31	(24.2)	22	(20.8)	
	don't know/missing	18/0		16/1		
Handgrip strength ^a		25.5 \pm 3.8		26.7 \pm 3.9		0.017

^aNumbers are means \pm standard deviation, and the Mann-Whitney U test was used for statistical analysis.

^bNumber (%), statistical analysis by the chi-square test.

kg and that in the non-sensitivity to cold group was 26.7 (± 3.9) kg (**Table 1**). The handgrip strength level in the sensitivity to cold group was significantly lower than that in the non-sensitivity to cold group ($p = 0.017$).

3.3. Associations of Sensitivity to Cold with Menstruation-Related Symptoms

There were significant associations between sensitivity to cold and physical menstruation-related symptoms including constipation ($p = 0.021$) and low back pain ($p = 0.004$), and there was a tendency for an association between sensitivity to cold and abdominal pain ($p = 0.057$) (**Table 2**). Regarding psychological symptoms, only anxiety tended to be associated with sensitivity to cold ($p = 0.085$) (**Table 3**).

Table 2. Associations of sensitivity to cold with degrees of physical symptoms in menstruation-related symptoms.

Symptoms	Degree*	Sensitivity to cold group (n = 146)		Non-sensitivity to cold group (n = 123)		P-value
Abdominal pain	no symptoms	10	(6.9)	17	(14.0)	0.057
	mild	62	(43.1)	58	(47.9)	
	severe	72	(50.0)	46	(38.0)	
	missing	2		2		
Headache	no symptoms	67	(46.9)	68	(55.7)	0.318
	mild	52	(36.4)	39	(32.0)	
	severe	24	(16.8)	15	(12.3)	
	missing	3		1		
Low back pain	no symptoms	31	(21.2)	48	(39.3)	0.004
	mild	66	(45.2)	38	(31.1)	
	severe	49	(33.6)	36	(29.5)	
	missing	0		1		
Nausea	no symptoms	115	(79.3)	104	(85.2)	0.162
	mild	19	(13.1)	15	(12.3)	
	severe	11	(7.6)	3	(2.5)	
	missing	1		1		
Abdominal distension	no symptoms	51	(34.9)	49	(40.5)	0.633
	mild	79	(54.1)	59	(48.8)	
	severe	16	(11.0)	13	(10.7)	
	missing	0		2		
Constipation	no symptoms	69	(47.3)	77	(63.6)	0.021
	mild	67	(45.9)	36	(29.8)	
	severe	10	(6.8)	8	(6.6)	
	missing	0		2		

Continued

Diarrhea	no symptoms	77	(52.7)	70	(57.9)	0.575
	mild	55	(37.7)	43	(35.5)	
	severe	14	(9.6)	8	(6.6)	
	missing	0		2		
Getting tired easily	no symptoms	31	(21.4)	25	(20.7)	0.239
	mild	84	(57.9)	80	(66.1)	
	severe	30	(20.7)	16	(13.2)	
	missing	1		2		
Edema	no symptoms	55	(37.9)	57	(46.7)	0.307
	mild	80	(55.2)	56	(45.9)	
	severe	10	(6.9)	9	(7.4)	
	missing	1		1		
Sleepiness	no symptoms	19	(13.1)	27	(22.1)	0.100
	mild	90	(62.1)	73	(59.8)	
	severe	36	(24.8)	22	(18.0)	
	missing	1		1		
Rough skin	no symptoms	46	(31.5)	39	(32.0)	0.863
	mild	86	(58.9)	69	(56.6)	
	severe	14	(9.6)	14	(11.5)	
	missing	0		1		
Thirst	no symptoms	122	(83.6)	97	(80.2)	0.645
	mild	22	(15.1)	23	(19.0)	
	severe	2	(1.4)	1	(0.8)	
	missing	0		2		

Number (%), statistical analysis by the chi-square test. *Mild: unrecognizable and bearable, Severe: unrecognizable if taking medication and affecting daily life.

Table 3. Associations of sensitivity to cold with degrees of psychological symptoms in menstruation-related symptoms.

Symptoms	Degree*	Sensitivity to cold group (n = 146)		Non-sensitivity to cold group (n = 123)		P-value
Increase in appetite	no symptoms	40	(27.4)	37	(30.3)	0.656
	mild	84	(57.5)	71	(58.2)	
	severe	22	(15.1)	14	(11.5)	
	missing	0		1		
Irritation	no symptoms	31	(21.2)	25	(20.5)	0.131
	mild	87	(59.6)	84	(68.9)	
	severe	28	(19.2)	13	(10.7)	
	missing	0		1		

Continued

Depression	no symptoms	41	(28.1)	37	(30.3)	0.176
	mild	79	(54.1)	73	(59.8)	
	severe	26	(17.8)	12	(9.8)	
	missing	0		1		
Loss of motivation	no symptoms	34	(23.3)	36	(29.5)	0.297
	mild	93	(63.7)	76	(62.3)	
	severe	19	(13.0)	10	(8.2)	
	missing	0		1		
Anxiety	no symptoms	68	(46.6)	69	(56.6)	0.085
	mild	63	(43.2)	48	(39.3)	
	severe	15	(10.3)	5	(4.1)	
	missing	0		1		

Number (%), statistical analysis by the chi-square test. *Mild: unrecognizable and bearable, Severe: unrecognizable if taking medication and affecting daily life.

4. Discussion

In our survey, the prevalence rate of sensitivity to cold for female university students was 54%. The prevalence rates for female university students in previous studies were 42.3% [17], 69.1% [18] and 68.9% [8]. It has been reported that mild sensitivity to cold in hands and feet occurs in 49% and severe sensitivity occurs in 35% of Japanese women respectively [19]. Since the definition of sensitivity to cold has not been well established, there is variation in the reported prevalences.

In this study, we found that the students who have sensitivity to cold tended to have weak handgrip strength. This result is similar with the results that handgrip strength was correlated with amount of exercise and negatively correlated with sensitivity to cold [10]. Therefore, an appropriate amount of physical activity for increasing muscle strength might be needed to prevent sensitivity to cold. Transient receptor potential melastatin 8 (TRPM8) is widely distributed in the human body [20]. In skeletal muscle, detection of 10 different TRP channels has been reported [21]. Further study regarding the association of sensitivity of TRP channels for sensitivity to cold with skeletal muscle strength may be needed.

We showed that BMI and body weight, but not body height, in students with sensitivity to cold were lower than those in students without sensitivity to cold. Our results are consistent with the results of a previous study in young women in Japan [18]. Decrease in body weight may lead to decreases in subcutaneous and perivascular adipose tissues and subsequently increase the susceptibility to vasospastic events. It has been shown that perivascular adipose tissue altered the balance between endothelium-dependent vasodilator and vasoconstrictor substances [22], which further underlies the importance of BMI in the occurrence of

Raynaud's phenomenon characterized by an episodic discoloration of the extremities in response to cold exposure. Blood circulatory failure due to abnormal balance in vessels may induce sensitivity to cold. However, in healthy female Libyans, it was reported that there were no correlations of body weight and BMI with cold pressor pain responses [23]. The reason for the difference in results is not clear. It has been reported that cold hypersensitivity in the hands and feet was associated with an increase in circulating adiponectin level, which affects thermogenesis during cold stress in women [24]. Further study on adipokines including adiponectin and leptin may be important.

In our study, sensitivity to cold was associated with menstruation-related symptoms including low back pain and constipation during menstruation and tended to have an association with abdominal pain. A previous study showed that women with sensitivity to cold have menstrual pain [6], but another study showed that women with sensitivity to cold did not have menstrual pain [18]. The difference in the results might be due to different criteria for sensitivity to cold. It was reported that sensitivity to cold was associated with back pain [18] [19] and constipation [6] regardless of menstruation. Since a number of TRP channels are expressed in nociceptive sensory neurons, pain might be closely related to sensitivity to cold. Associations of TRP channels with various diseases have been reported [25]. The difference in sensitivity of TRP channels may be related to the difference in symptoms in response to cold exposure. Sensitivity to cold may be associated with constipation since bowel movement is poor due to circulating blood flow failure. Sensitivity to cold may be associated with back pain and constipation regardless of the presence of menstruation. It has been reported that senior high school students who perceived sensitivity to cold had a higher odds ratio to have anxiety during menstruation than did students who did not perceive sensitivity to cold in an irregular menstruation group [7]. The reason for the associations of sensitivity to cold with psychological symptoms is not clear.

There was no association between sensitivity to cold and length of the menstrual cycle in this study, being in agreement with the results of previous studies [18]. Circulating gonadal hormones have been reported to mediate adaptation to cold pressor pain [26]. Estrogen deficiency might be related to sensitivity to cold since menopausal status was shown to be significantly related to sensitivity to cold [27]. In young women with regular menstruation, there has been no report regarding an association between sensitivity to cold and estrogen. Given that basal body temperature in women increases in the mid-luteal phase, we speculated that the proportion of the subjects with sensitivity to cold may differ depending on the phase of the menstrual cycle. However, no difference in the proportions of subjects with sensitivity to cold was found among the three menstrual cycle phases. Sensitivity to exogenous cold exposure may be different from endogenous body temperature in the subjects.

Sensitivity to cold in young women may influence their reproductive health in

the future since female infertility [28], abnormalities of delivery [29] and menopausal symptoms [30] have been reported in women who had sensitivity to cold. Low handgrip strength related to sensitivity to cold may lead to sarcopenia and dynapenia in the future. Improvement of sensitivity to cold is important for young women to solve lifelong problems.

This study has several limitations. There was not sufficient evidence for a causal relationship since this study was a cross-sectional design. We used questions to clarify the presence of sensitivity to cold based on the criteria of Sakaguchi. Further study using objective assessment of sensitivity to cold is needed. The study subjects were limited to nursing students at a university in Japan. Thus, a future study needs to target various kinds of women at various ages.

5. Conclusion

More than half of the university female students in this study had sensitivity to cold, which was associated with low back pain and constipation during menstruation and with handgrip strength level. Sensitivity to cold is an important symptom associated with muscle strength as well as menstruation-related symptoms for young women.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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