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Analysis of Cold Hypersensitivity in Female University Students Using Subjective and Objective Indicators

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Abstract

Background: Cold hypersensitivity (CH), often referred to as *hiesho* in Japan, is a common but poorly understood condition characterized by pronounced cold sensations predominantly in the extremities. It is prevalent among young women and associated with autonomic imbalances, reduced peripheral circulation, and lifestyle factors. Despite its prevalence, diagnostic standards remain inconsistent, and discrepancies between subjective symptoms and objective measures complicate clinical assessments. We investigated the prevalence, subjective experiences, and physiological correlates of CH among female university students using questionnaire-based assessments and objective physiological tests. **Methods:** One hundred sixteen female university students were recruited. Participants completed a self-administered questionnaire based on established diagnostic criteria and prior studies on CH, autonomic function, and circulation. Objective assessments included heart rate variability (HRV) for autonomic balance, peripheral circulation indices (stroke volume, vascular elasticity, and residual blood volume), blood pressure, and fingertip skin temperature. Thermal recovery was evaluated by a cold-water immersion test (10˚C, 1 min). Data were analyzed using chi-square tests, Mann-Whitney U tests, and Welch's t-tests, with significance set at $p < 0.05$. **Results:** CH was identified in 92 (79.3%) participants. Relative to non-CH (NCH), CH individuals had a higher mean age and lower BMI. CH was associated with significantly more autonomic symptoms (mean 3.2 vs. 2.2) with severe extremity coldness and numbness. Autonomic assessments of this group revealed sympathetic predominance and reduced parasympathetic activity. Stress levels did not differ

significantly, but irritability and depressed mood were more common in CH. Circulatory indices showed no significant group differences, although CH tended be associated with lower vascular elasticity. In the cold-water immersion test, baseline fingertip temperature was slightly higher in CH individuals; however, recovery at 10 min was incomplete, with poor recovery in 20.6% (relative to 4.2% in NCH individuals). **Conclusions:** CH is highly prevalent among young women and associated with lower BMI, autonomic imbalance, and impaired thermal recovery. While objective circulatory measures showed limited group differences, recovery patterns following cold stress revealed impaired regulation in CH. These findings underscore the multifactorial nature of CH and highlight the need for preventive health education and supportive interventions targeting lifestyle, thermoregulation, and self-care practices among young women.

Keywords

Cold Hypersensitivity, Autonomic Nervous System, Peripheral Circulation, Body Mass Index, Young Women

1. Introduction

Cold hypersensitivity, often referred to as *hiesho* in Japan, is characterized by pronounced cold sensations in peripheral regions, such as the hands, feet, and lower back, often accompanied by sleep disturbances, numbness, and other impairments in daily life [1]-[3]. Although structural abnormalities are rarely identified, cold hypersensitivity is recognized as a major contributor to nonspecific complaints [4] [5]. Population studies indicate that women report cold sensitivity more frequently than men, with elevated rates in adolescence and young adulthood, suggesting contributions from hormonal fluctuations and autonomic dysregulation [5]-[7].

The diagnosis largely depends on subjective complaints, with no universally accepted criteria. Terasawa proposed criteria based on traditional Kampo medicine, whereas Sakaguchi *et al*. developed questionnaire-based diagnostic standards that showed good agreement with self-awareness of symptoms [3] [5] [7] [8]. Objective indicators such as skin surface temperature and peripheral blood flow have been introduced, but discrepancies between subjective sensations and objective measurements persist [9]. Reliance solely on self-reporting may delay interventions, potentially leading to secondary health issues such as shoulder stiffness, fatigue, and insomnia [10].

Etiological factors include impaired peripheral circulation, autonomic dysfunction, hormonal insufficiency, psychological stress, and excessive dieting [3] [11] [12]. In older adults, vascular stiffness, reduced metabolism, and loss of muscle mass may also contribute [13]. Experimental studies using a cold pressor or head-up tilt test have demonstrated sympathetic vasoconstriction [14]. Exagger-

ated sympathetic activity is thought to induce peripheral vasoconstriction in cold-sensitive individuals, which is consistent with the reduced parasympathetic activity reported in women with *hiesho* [14]. Because autonomic function is sensitive to psychological stress, excessive burden may precipitate dysregulation [12] [15]. Despite these findings, its fundamental pathophysiology remains unclear.

2. Methods

2.1. Participants and Study Period

As cold hypersensitivity is commonly reported by women in adolescence and early adulthood [5]-[7], this study recruited 116 female university students from Kumamoto University. The purpose and procedures of the study were explained orally and in writing, and written informed consent was obtained. The participants were assured that the data would be anonymized and used solely for analytical purposes.

2.2. Measurements

2.2.1. Subjective Assessment

A self-administered questionnaire on cold symptoms was administered, referencing prior studies on cold hypersensitivity, autonomic function, and peripheral circulation [2]-[5] [7]-[12]. The menstrual cycle phase was not controlled for during data collection.

2.2.2. Objective Assessment

Autonomic and cardiovascular function, blood pressure, and peripheral skin temperature were measured. Peripheral circulation and autonomic activity were assessed using a non-invasive device ("Body Checker," Tokyo Iken Co., Ltd., Japan). This device estimates circulatory indices using impedance plethysmography and pulse wave analysis, combined with heart rate variability-based algorithms. Vascular elasticity is calculated from pulse wave characteristics reflecting arterial compliance, while cardiac output strength (stroke volume-based index) is primarily derived from estimated stroke volume.

A heart rate variability (HRV) analysis was used to derive indices of sympathetic and parasympathetic activity, following established recommendations [15] [16]. Peripheral circulation indices included stroke volume, vascular elasticity, and residual blood volume [15].

Blood pressure was measured with an upper-arm sphygmomanometer (HEM-7500F; Omron Healthcare, Japan) using standardized procedures.

2.3. Cold-Water Immersion Test

The index finger was immersed in water at 10˚C for 1 min. Skin temperature was measured immediately after immersion and at 5 min and 10 min post-immersion using an infrared thermometer (Fluke Connect, USA) to assess the recovery of peripheral temperature regulation [15].

2.4. Statistical Analysis

Chi-square tests, Mann-Whitney U tests, and Welch's t-tests were applied, with $p < 0.05$ considered significant. The graph values were rounded to one decimal place.

2.5. Ethical Considerations

All procedures were approved by the Ethics Committee of Epidemiological Studies at Yamagata Prefectural Yonezawa University of Nutrition Sciences and Kumamoto University. All the data were anonymized to protect privacy.

3. Results

3.1. Participant Characteristics

A total of 116 female university students were enrolled in the study. Using the diagnostic criteria [12], 92 participants (79.3%) were classified as having cold hypersensitivity (CH) and 24 (20.7%) as non-cold hypersensitivity (NCH). Although the proportion of CH increased with age, chi-square tests revealed no significant differences among age groups ($p \geq 0.05$). Relative to the NCH group, the CH group had a significantly higher mean age ($p < 0.05$) and lower BMI ($p < 0.05$). Height and diastolic blood pressure were comparable, whereas systolic blood pressure was modestly higher in the NCH group (Table 1).

Table 1. Basic characteristics.

Variable	CH (n = 92)	NCH (n = 24)	p-value
Age (years), mean ± SD	21.1 ± 1.8	19.8 ± 2.0	$p < 0.05^{\dagger}$
Height (m), mean ± SD	1.58 ± 0.06	1.58 ± 0.05	n.s.†
BMI, mean ± SD	20.9 ± 2.7	22.0 ± 2.5	$p < 0.05^{\dagger}$
BMI categories, n (%)			n.s.‡
Underweight	6 (6.5%)	0 (0.0%)	
Normal	82 (89.1%)	21 (87.5%)	
Obese	4 (4.3%)	3 (12.5%)	
Resting pulse, n (%)			n.s.‡
Bradycardia (≤60 bpm)	7 (7.6%)	5 (20.8%)	
Normal (60 - 100 bpm)	81 (88.0%)	19 (79.2%)	
Tachycardia (≥100 bpm)	4 (4.3%)	0 (0.0%)	
Systolic BP (mmHg), mean ± SD	106.1 ± 9.0	110.5 ± 10.0	$p < 0.05^{\dagger}$
Diastolic BP (mmHg), mean ± SD	72.7 ± 8.3	72.7 ± 6.3	n.s.†
BP categories, n (%)			n.s.‡

Continued

Low	27 (29.3%)	5 (20.8%)
Normal	65 (70.7%)	19 (79.2%)
High	0 (0.0%)	0 (0.0%)

[†]Welch's t-test; [‡]Mann-Whitney test; n.s., not significant.

3.2. Diagnostic Items

The prevalence of each diagnostic item is summarized in Table 2. In the CH group, "Hands and feet colder than others," "Coldness in waist, hands, or feet causing discomfort," and "Consider oneself more sensitive to cold than others" were most frequently endorsed. In the NCH group, "frequent urination on cold days" and "the use of electric blankets or hot packs during winter" were common.

Table 2. Prevalence of diagnostic items for cold hypersensitivity.

Item No.	Category	Diagnostic item (summary)	CH (n = 92) %	NCH (n = 24) %
1	Key	Consider oneself more sensitive to cold than others	78.3	4.2
2	Key	Coldness in waist, hands, or feet causing discomfort	80.4	0.0
3	Key	Cold discomfort in air-conditioned environments	58.7	16.7
4	Key	Hands and feet colder than others	87.0	12.5
5	Key	Cold hands even in summer	56.5	0.0
6	Key	Difficulty sleeping due to cold feet in winter	52.2	8.3
7	Reference	Whole body feels cold	43.5	0.0
8	Reference	Wear thick socks even in summer	52.2	0.0
9	Reference	Use of electric blankets or hot packs in winter	40.2	25.0
10	Reference	Cold sensitivity has persisted for several years	65.2	4.2
11	Reference	Frequent urination on cold days	55.4	41.7
12	Reference	Pale facial complexion in comparison to others	67.4	8.3
13	Reference	Persistent sensation of coldness in hands and feet	27.2	0.0

Note. The key and reference items were defined according to the report of Sakaguchi *et al.*

3.3. Self-Awareness of Cold Hypersensitivity

Among the CH group (n = 92), 72 participants (78.3%) reported recognizing themselves as having cold hypersensitivity, while 20 (21.7%) did not. Only one participant (4.1%) in the NCH group (n = 24) reported perceiving herself as cold-hypersensitive.

3.4. Characteristics of Self-Aware CH Participants

Supplementary questions were asked of participants who both belonged to the CH group and recognized themselves as cold-hypersensitive (n = 72). Table 3 presents the main findings.

- Extremity cold was the most common reason for self-recognition (70.8%).
- Onset typically occurred during adolescence (mean 15.0 years).
- Cold was most often localized to the feet (87.5%) and hands (84.7%) and most frequently occurred in winter and at bedtime.

Table 3. Characteristics of self-aware CH participants.

Domain	Main findings	%
Reasons for self-recognition	Coldness in extremities	70.8
	Slow to warm up	9.7
	Told by others	8.3
Age of first awareness	Mean 15.0 years; most at middle/high school age (13 - 18 years)	73.6
Main affected body sites	Feet	87.5
	Hands	84.7
	Face	8.3
Perceived severity	Sometimes bothersome	72.2
	Not bothersome	19.4
	Often bothersome	8.3
Season of cold awareness	Winter	100
	Autumn	52.8
	Spring	16.7
	Summer	9.7
Time of day	When cold	72.2
	Bedtime	65.3
	Morning	55.6

3.5. Countermeasures Against Cold

A greater proportion of participants in the CH group (73.9%) reported taking

countermeasures than the NCH group (37.5%) (Table 4). The CH participants most frequently used socks, layered clothing, hot packs, and warm drinks. Participants in the NCH group used heating devices and futons more often.

Table 4. Countermeasures against cold.

Domain	CH group %	NCH group %	Typical methods
Any countermeasures	73.9	37.5	-
Clothing adjustments	77.9	77.8	Socks/tights (71.7% CH, 42.9% NCH); Layers; Scarves
Bathing practices	77.8	100	Long bathing; foot baths
Heating devices	44.4	66.7	Hot packs, kotatsu, electric carpets (CH); heating appliances (NCH)
Bedding/blankets	73.5	66.7	Lap blankets (CH); futon (NCH)
Food/drinks	76.3	75.0	Warm drinks; ginger; avoid cold drinks (CH only)
Massage	13.2	0	During/after bathing, hands/feet

"Any countermeasures" indicates the proportion of participants reporting at least one countermeasure. Percentages for specific subcategories were calculated independently and therefore may exceed the value for "Any countermeasures."

3.6. Association with Autonomic Symptoms

Seventeen autonomic symptoms were assessed in this study (Table 5). The mean number of symptoms per person was higher in the CH group (3.2) than in the NCH group (2.2) ($p < 0.05$). Both groups reported stiff shoulders and morning weakness. Coldness or numbness of the extremities was more frequent in the CH group (41.3%) than in the NCH group (4.2%).

Table 5. Autonomic symptoms and mean number of symptoms.

Measure	CH group	NCH group	Statistical result
Mean number of symptoms per person	3.2 ± 0.3	2.2 ± 0.2	*p* < 0.05
Most frequent symptoms	Stiff shoulders (54.3%), dizziness (35.9%), morning weakness (35.9%)	Stiff shoulders (41.7%), morning weakness (45.8%)	-
Cold/numb extremities	41.3%	4.2%	Markedly higher in CH

3.7. Autonomic Balance and Stress

Autonomic balance differed between groups (Table 6). Participants in the CH group more often showed sympathetic predominance, whereas parasympathetic predominance was more frequent in the NCH group. The stress scores did not differ significantly between the groups (Table 7 and Table 8).

Table 6. Autonomic balance in the CH and NCH groups.

Balance type	CH (%)	NCH (%)	Total (%)
Balanced	35.9	16.7	31.9
Sympathetic predominance	41.3	33.3	39.7
Parasympathetic predominance	22.8	50.0	28.4

Table 7. Stress symptoms in the CH and NCH groups.

Measure	CH group	NCH group	Notes
Mean number of symptoms per person	2.6	2.1	n.s.
Main stressors	Busy lifestyle (57.6%), sleep deprivation (41.3%), troubles/worries (40.2%)	Busy lifestyle (41.7%), sleep deprivation (41.7%), bowel tendency (37.5%)	-
Psychological stress	Irritability (20.7%), depressed mood (31.5%)	Lower prevalence	Suggests stronger psychosomatic component in CH

Table 8. Stress scores in the CH and NCH groups.

Stress category	CH (%)	NCH (%)	Total (%)
Healthy (0 - 50)	82.6	83.3	82.8
Slightly stressed (51 - 80)	17.4	16.7	17.2
Highly stressed (81 - 100)	0	0	0

3.8. Association between Cold Hypersensitivity and Blood Circulation

Four indices of blood circulation (cardiac output strength (stroke volume-based index), vascular elasticity, residual blood volume, and vascular stage) were measured using a Body Checker device. No statistically significant differences were observed between the CH and NCH groups (Mann-Whitney test, $p > 0.05$). Table 9 presents the distribution of each index.

3.9. Relationship between Cold Hypersensitivity and Local Cold Water Load Test

To evaluate the peripheral circulatory function, a cold-water load test (10˚C, 1 min) was performed. Baseline fingertip temperature was significantly higher in the CH group (24.9˚C ± 2.6˚C) than in the NCH group (24.0˚C ± 1.5˚C) ($p < 0.05$, Welch's t-test) (Table 10).

The temperature-recovery curves are shown in Figure 1. At 10 min post-immersion, the NCH group recovered above the baseline, whereas the CH group did not reach baseline levels.

Table 9. Indices of blood circulation in the CH and NCH groups.

Measure	Category	CH (n = 92)	NCH (n = 24)	Total (n = 116)	Key finding
Cardiac output strength (stroke volume-based index)	Below standard	4 (4.3%)	0 (0%)	4 (3.4%)	Few CH cases below standard
	Standard	25 (27.2%)	11 (45.8%)	36 (31.0%)	-
	Above standard	63 (68.5%)	13 (54.2%)	76 (65.5%)	-
Vascular elasticity	Below standard	28 (30.4%)	2 (8.3%)	30 (25.9%)	CH more often low
	Standard	37 (40.2%)	17 (70.8%)	54 (46.6%)	-
	Above standard	27 (29.3%)	5 (20.8%)	32 (27.6%)	-
Residual blood volume	Below standard	30 (32.6%)	6 (25.0%)	36 (31.0%)	CH higher
	Standard	61 (66.3%)	18 (75.0%)	79 (68.1%)	-
	Above standard	1 (1.1%)	0 (0%)	1 (0.9%)	-
Vascular stage	Stage 1 (very good)	62 (67.4%)	19 (79.2%)	81 (69.8%)	NCH more often stage 1
	Stage 2 (good)	24 (26.1%)	5 (20.8%)	29 (25.0%)	-
	Stage 3 - 4 (aging/attention)	6 (6.5%)	0 (0%)	6 (5.2%)	Only in CH

Table 10. Mean fingertip skin temperature before cold water load (˚C).

Group	n	Mean ± SD (˚C)
Cold hypersensitivity	92	24.9 ± 2.6
Non-cold hypersensitivity	24	24.0 ± 1.5

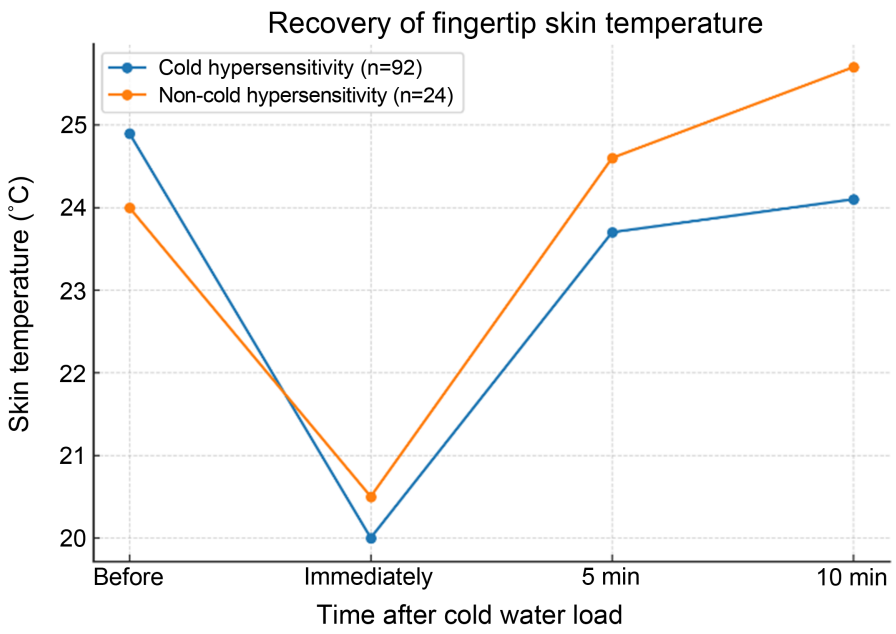

Figure 1. Recovery of fingertip skin temperature after cold-water load.

The distribution of the recovery rate categories is presented in Table 11. Poor recovery (<90%) was observed in 20.6% of the individuals in the CH group and 4.2% of the individuals in the NCH group. The recovery patterns are shown in Figure 2.

Table 11. Distribution of recovery rate at 10 min after cold water load.

Recovery category	Cold hypersensitivity (n = 92)	Non-cold hypersensitivity (n = 24)
≥90% (Good recovery)	73 (79.4%)	23 (95.8%)
<90% (Poor recovery)	19 (20.6%)	1 (4.2%)

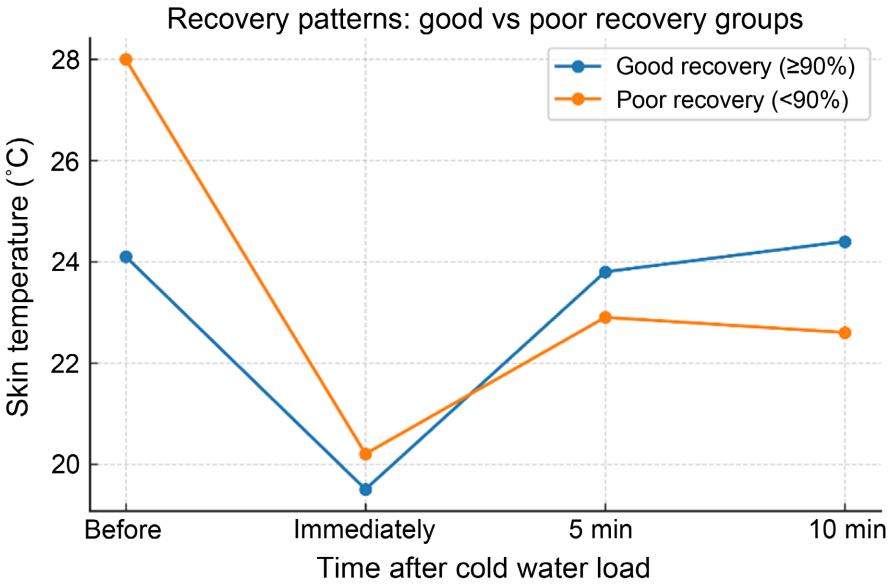

Figure 2. Skin temperature recovery patterns in good vs. poor recovery groups.

Welch's t-test showed a significant difference ($p < 0.05$), with a higher baseline temperature in the CH group relative to the NCH group.

Cold hypersensitivity group: 24.9˚C (before), 20.0˚C (immediately), 23.7˚C (5 min), 24.1˚C (10 min).

Non-cold hypersensitivity group: 24.0˚C (before), 20.5˚C (immediately), 24.6˚C (5 min), 25.7˚C (10 min).

The subjects with a poor recovery showed a larger immediate temperature drop and incomplete recovery after 10 min. Subjects with a good recovery exhibited a smaller temperature drop and reached near or above the baseline by 10 min.

4. Discussion

4.1 Prevalence of Cold Sensitivity

Cold hypersensitivity was observed in 79.3% of participants, which was higher than the estimated prevalence in community-based and student samples that typically range around 40% - 60% among women [15] [16]. Most cold-sensitive par-

ticipants were aware of the symptoms (78.3%) and reported discomfort (80.5%). In addition, previous research indicated that menstrual pain may enhance sensitivity to cold and pain perception, which could partly explain the heightened prevalence among young women [17]. This may partly reflect selection bias, as participants were university students who volunteered for a health-related survey and were classified using questionnaire-based criteria, which may overestimate prevalence compared with population-based studies.

4.2. Anthropometric Factors

Lower BMI in the CH group may reduce the basal metabolic rate and exacerbate peripheral cold sensation. Reduced subcutaneous fat further increases the heat loss. These findings are consistent with reports linking lower BMI and reduced subcutaneous fat with greater cold sensitivity [12] [15].

4.3. Autonomic Nervous System Activity

A higher autonomic symptom burden, together with sympathetic dominance and reduced parasympathetic activity, suggests impaired peripheral circulation. This pattern aligns with prior studies showing vagal withdrawal and sympathetic predominance in women with *hiesho* and in young women reporting cold hypersensitivity [14] [18]. Furthermore, sex differences in autonomic regulation have also been reported as contributing factors [8]. The significantly lower systolic blood pressure observed in the CH group may reflect mild hypotension associated with autonomic imbalance, a feature commonly reported in individuals with *hiesho*. Reduced sympathetic vasomotor tone may contribute to both lower blood pressure and impaired peripheral thermoregulation.

4.4. Stress and Cold Sensitivity

Although this study did not find a direct association between self-reported stress and cold hypersensitivity, psychological stress is known to disturb autonomic balance and could indirectly exacerbate cold sensitivity [12] [18].

4.5. Peripheral Circulation

Group differences were not observed for most hemodynamic indices; however, the higher proportion of reduced vascular elasticity in the CH group may contribute to peripheral cold sensations [4].

4.6. Cold Water Immersion

Delayed post-immersion thermal recovery in the CH group, supporting reduced peripheral temperature regulation capacity, in line with prior observations of cold-induced vasodilation dynamics and recovery kinetics in young women [4].

4.7. Age of Onset and Symptom Localization

The mean onset around mid-adolescence, with the feet and hands most com-

monly affected, highlights puberty as a critical window for the onset of CH and suggests opportunities for early education and intervention.

4.8. Implications for Health Guidance

These findings highlight the importance of health education for young women. Practical guidance may include promoting adequate sleep, a balanced diet, physical activity, stress management, and monitoring of excessive thinness related to dieting. In addition, self-care practices, such as layered clothing, use of thermal aids, and bathing, may help alleviate discomfort. Furthermore, warm-water foot-bathing has been shown to enhance parasympathetic activity and peripheral circulation in young women with cold sensitivity [19].

5. Conclusion

CH is highly prevalent among female university students and is associated with a lower BMI and autonomic imbalance. Objective measures of peripheral circulation show limited but suggestive correspondence with subjective symptoms, underscoring the multifactorial nature of sensitivity to cold.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Epidemiological Studies at Yamagata Prefectural Yonezawa University of Nutrition Sciences and Kumamoto University. Written informed consent was obtained from all the participants.

Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest in association with the present study.

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