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Title:

The interrelationships among exercise habits, cold constitution, and sleep in Japanese people aged 15 to 69 years

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Running Title:

Exercise habits and coldness

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Abstract

Many women are aware of feeling cold in their daily lives. To elucidate the interrelationships among having a cold constitution, exercise habits, and sleep, we conducted an Internet survey that included 600 women and 600 men aged 15 to 69 years. The items in the survey included sex, age, coldness, practice of exercise, and sleep condition. The participants answered all questions with a "yes" or "no" answer. In all age groups, women reported a significantly higher number of coldness-related items than men; however, no differences were found among the age groups. Men who exercise regularly reported a higher number of applicable coldness-related items than those who did not ($p = 0.027$), but this was not found in women ($p = 0.208$). In both men and women, regular exercise was positively associated with falling asleep ($p < 0.05$) and getting enough rest through sleep ($p < 0.01$). These findings suggest that regular exercise is beneficial for sleep in men and women of all ages; however, in men, it is also associated with increased cold-related symptoms.

Keywords: Cold constitution, Exercise, Sleep, Sex difference, Aging

タイトル： 15 歳から 69 歳までの日本人における運動習慣，冷え症，および睡眠の相互関係

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抄録： 日常生活の中で冷えを感じる女性が多い。冷え症，運動習慣，睡眠の間の相互関係を明らかにするために 15 歳から 69 歳までの男女 600 名ずつを対象にインターネット調査を実施した。調査項目は，性別，年齢，冷え症，運動の実施状況，睡眠状態であり，参加者はすべての質問に「はい」または「いいえ」で回答した。すべての年齢層において，女性は男性よりも冷え関連項目に有意に多く該当してしたが，年齢層間の差は認められなかった。運動習慣のある男性は習慣のない男性よりも冷え関連項目の該当数が多かった ($p = 0.027$) のに対して，女性では同様の傾向は見られなかった ($p = 0.208$)。男女ともに運動習慣は入眠 ($p < 0.05$) および睡眠による十分な休息 ($p < 0.01$) に対して良好な関係を示した。これらの結果は，すべての年齢層の男女において定期的運動は睡眠に有益であることを示唆しているが，男性においては定期的運動は冷えに関連する症状の増加と関係していた。

キーワード： 冷え症，運動，睡眠，性差，加齢

1 Introduction

2 Many women are aware of feeling cold in their daily lives. In a survey conducted on 470
3 adult women working in a hospital aged 20–60¹⁾, 63.6% were aware of feeling cold. Moreover,
4 in a survey of the young people, Nakagawa et al.²⁾ reported that 70.6% of female students and
5 30.4% of male students responded that they “have cold constitution”. A cold constitution with
6 higher sensitivity to cold sensations is called “*hi-e-sho*” in Japanese, which is frequently
7 accompanied by stiff shoulders, headaches, swelling, or insomnia^{3–5)} and reduced quality of life.

8 One way to alleviate coldness is to perform aerobic exercise to increase body temperature⁶⁾.
9 In a previous study of young adult women with a cold constitution, we reported that a two-week
10 aerobic exercise intervention, including brisk walking and jogging, alleviated cold symptoms at
11 room temperature and prolonged deep sleep length⁷⁾. On the other hand, performing similar
12 aerobic exercise for women without a cold constitution did not change their thermal sensation at
13 room temperature⁸⁾.

14 To examine the influence of exercise and susceptibility to cold, a previous study that
15 classified female university students into groups with and without a cold constitution, based on
16 previous studies on women with exercise habits^{9,10)}, found no significant differences in the amount
17 of physical activity¹¹⁾. On the other hand, in an Internet survey of 6,729 patients, Kawagoe et al.¹²⁾
18 reported that 8.5% had a cold constitution, and that this tendency was lower among those who
19 exercised regularly (6.2%) than among those who did not exercise at all (9.9%). Thus, previous
20 studies on exercise habits and having a cold constitution have yielded inconsistent results,
21 possibly due to the limited subject populations such as young adult women or patients with
22 specific diseases. Further research involving healthy men and women among a broader age range
23 is needed.

24 Previous studies examining the relationship between sleep and chronic exercise in healthy
25 adults suggested a favorable effect of exercise training on sleep^{13–15)}. However, there are no
26 studies investigating the interrelationships among exercise habits, coldness, and sleep in healthy
27 men and women with a wide age range such as from adolescence to old age. In this study, we
28 epidemiologically investigated these relationships in Japanese people aged 15 to 69 years.

30 Methods

31 Participants

32 The participants were 600 women and 600 men, aged 15–69 years. Participants were
33 recruited from a pool of 3.82 million research monitors among Japan by an internet research
34 company (INTAGE Research Inc., Tokyo, Japan). A total of 100 women and 100 men were
35 assigned to six age groups: 15–19 years, 20–29 years, 30–39 years, 40–49 years, 50–59 years,
36 and 60–69 years.

The purpose of the research and the handling of personal data were explained onscreen to the participants beforehand. Only those who agreed to participate were included in the study. The study was implemented after approval by the Bioethics Committee of Yamaguchi Prefectural University (Approval No. 2025-06).

Questionnaire items

The items in the Internet survey consisted of: sex, age, coldness (11 items), exercise (one item), and sleep (two items). The participants answered all questions about coldness, exercise, and sleep with a "yes" or "no" answer. The survey was conducted in November using monitors from all over Japan.

The questionnaire regarding cold consisted of the following questions: 1) Are you sensitive to a reduction in environmental temperature? 2) Do you feel colder in a cold environment than others do? 3) Do you sometimes feel cold even in summer? 4) Do you dislike being barefoot even in summer due to coldness? 5) Do you feel cold in an air-conditioned room in summer when most people feel comfortable? 6) Do you need thicker clothes than others do? 7) Do you need an electric blanket for better sleep in winter? 8) Do you wear socks while sleeping in winter? 9) Do you often wake up due to coldness or cold extremities in winter? 10) Do you often have pain or color changes in the fingertips or toes due to bad circulation in cold? Participants were judged to be cold-sensitive or not based on the number of times they answered yes to each of the 10 questions¹⁶⁾. In addition, the following cold-related question was added: 11) Do you think you have a cold constitution?

Exercise habits were assessed by the following item: Have you been exercising for at least 30 min, two days a week or more for at least a year? Sleep was assessed by the following two items: 1) Do you fall asleep easily? 2) Are you getting enough rest through sleep?

Data analysis and statistics

Participants who answered yes seven or more times to the 10 coldness-related questions and those who answered yes five or more times to the questions including question 11 were determined to have a cold constitution^{16,17)}. A chi-squared goodness-of-fit test was performed to verify the normality of the distribution of the number of applicable items for the coldness-related questions. The Kruskal–Wallis test was applied to evaluate differences in the number of applicable items across experimental conditions (sex, age group, and exercise status). The chi-square test was used to compare proportions for categorical variables other than the number of applicable items. The null hypothesis was rejected at the level of $p < 0.05$.

Results

Among all participants ($n = 1200$), the mean number of applicable items regarding coldness in the 10-item questionnaire was 3.5 ± 2.5 (mean $\pm$ SD). The chi-squared goodness-of-fit test rejected the null hypothesis of normal distribution for the data ($\chi^2 = 446.1$, $\chi^2_{0.95} = 14.1$, $p < 0.0001$). Figure 1 shows the number of applicable items among the 10 questionnaire items by age group in women and men. The number of applicable items was higher ($p < 0.0001$) in women than in men in all age groups; however, no difference was observed among age groups ($p = 0.089$). When participants who responded 'yes' to seven or more interview items were classified as having a cold constitution, 23.7% of women and 9.8% of men met this criterion, with a significantly higher proportion in women ($p < 0.0001$); however, no significant differences were observed among age groups ($p = 0.440$).

(Insert Fig. 1)

Figure 2 shows the number of applicable responses to the 10 coldness-related questionnaire items, stratified by exercise status and sex. Among men, those who engaged in regular exercise had a higher number of applicable items than non-exercisers ($p = 0.027$); however, this was not found in women ($p = 0.208$). Regardless of the status of exercise practice, there were significantly more applicable items in women than men ($p < 0.0001$).

(Insert Fig. 2)

The proportion of people who were aware of having a cold constitution was higher in women than in men in all age groups ($p < 0.0001$) (Table 1), but no difference was observed among age groups ($p = 0.936$). A significant difference was found in awareness of having a cold constitution between women and men (58.3% vs. 28.0%, $p < 0.0001$).

(Insert Table 1)

No differences were observed among age groups in the items of "exercise", "falling asleep", and "getting enough rest through sleep" ($p > 0.816$) (Table 1). When all age groups were combined, the exercise item was significantly higher in men than in women (31.2% vs. 23.8%, $p = 0.004$). On the other hand, there was no significant difference between sex groups in the items of "falling asleep" and "getting enough rest through sleep" ($p > 0.116$). For both women and men, the "exercise" item was not related to the "awareness of cold constitution" item ($p > 0.486$). In both men and women, the "exercise" item was associated with the "falling asleep" item (women, $p < 0.01$; men, $p < 0.05$) and the "getting enough rest through sleep" item (women, $p < 0.0001$; men, $p < 0.01$).

In women, the "awareness of cold constitution" item was negatively associated with the "falling asleep" item ($p < 0.01$) and the "getting enough rest through sleep" item ($p < 0.0001$). In men, the "awareness of cold constitution" item was not associated with "falling asleep" ($p = 0.206$), but was negatively associated with the "getting enough rest through sleep" item ($p < 0.05$).

Discussion

In this study, we investigated the interrelationships among exercise habits, coldness, and sleep in healthy men and women across a wide age range. The key findings of this study are: 1) the number of applicable items among the 10 questionnaire items related to coldness and the proportion of people who were aware of having a cold constitution were significantly higher in women than in men, and these sex differences were not dependent on age; 2) among male participants, regular exercise was associated with a higher number of positive responses to coldness-related questionnaire items compared with those who did not exercise regularly; and 3) habitual exercise has beneficial effects on sleep in both men and women among all age groups.

Most studies on cold constitution have been conducted on young adult women. It has been reported that 51.9–73% of women in these populations are aware of having a cold constitution¹⁸⁾. In this study, which examined a wide range of age groups, the proportion of women who were aware of having a cold constitution (58.3%) was similar to previous studies. On the other hand, we found that the proportion of men who were aware of having a cold constitution (28.0%) was roughly half that of women (Table 1). Possible causes of this sex difference include the lower metabolic rate observed in women^{19,20)} and their greater skin vasoconstrictor response²¹⁾.

In the present study, male exercisers had a higher number of items related to coldness than non-exercisers. This finding is contrary to previous studies that reported the alleviating effect of short-term aerobic exercise on a cold constitution; however, these studies were conducted in young adult women^{7,8,22)}. People who exercise typically lose body fat as a result of exercise, which may explain why they had more cold-related symptoms, especially in men who have relatively low body fat. Previous studies reported that women who are thin and have less body fat are more likely to have a cold constitution^{8,10)}. In an epidemiological study in a Swiss urban population aged 20–40 years, Mozaffarieh et al.²³⁾ reported that thermal discomfort with cold extremities occurred at the highest intensity in younger, slimmer women and at the lowest intensity in elderly, stouter men. Thus, significant loss of body fat due to excessive exercise can contribute to discomfort from feeling cold. Second, differences in the environmental temperature and clothing used during exercise may have an effect. Typically, men who exercise wear light clothing and are more exposed to the outside air during exercise, which may result in them feeling colder more frequently. To reduce discomfort from feeling cold, male athletes with low body fat may perform thermoregulatory behaviors, including frequent changing of clothing. However, since there are few studies that have investigated the incidence of coldness in athletes, further research is needed to verify the hypotheses regarding the effects of body fat and clothing on thermal discomfort during sports activities.

Previous studies reported a relationship between coldness of the lower extremities and difficulty in falling asleep^{24,25)}. The present study also showed that women who were aware of

having a cold constitution had trouble falling asleep and felt a negative impact on their sense of rest after sleep. On the other hand, for men who were aware of having a cold constitution, there was no effect on their ability to fall asleep but there was a negative effect on the feeling of rest after sleep. Overall, the relationship between having a cold constitution and worse sleep was weaker for men than women. Sex differences in the prevalence of a cold constitution and the effect of factors other than thermal comfort on sleep may be reasons for this relationship. This suggests that it is important for women to take measures to prevent coldness in order to improve sleep quality.

For both men and women, exercising had a positive effect on how easily they fell asleep and how rested they felt after sleep. Previous studies examining the relationship between sleep and chronic exercise in healthy adults reported a favorable effect of exercise on sleep^{26–28}. The findings of this study are consistent with previous studies reviewing the relationship between chronic exercise and sleep^{29–32}. Moreover, this study newly demonstrated a positive effect of chronic exercise on subjective sleepiness in men and women with a wide age range. Short-term aerobic exercise interventions to decrease cold sensation in the peripheral extremities in young women with a cold constitution may improve their sleep status^{8,22,25}. Although the physiological mechanisms underlying the positive effects of exercise on sleep are not fully understood, several theoretical models, including the thermoregulatory, body restoration, and energy conservation hypotheses, have been proposed to explain its sleep-promoting effects²⁹. Thus, exercise may improve falling asleep through factors other than reducing coldness in men.

Methodological considerations and limitations

The prevalence of a cold constitution varies depending on the criteria used to define it. Based on the definition used in a previous study (satisfying seven or more of the 10 questions regarding coldness)¹⁶, 23.7% of the total female participants and 9.8% of the total male participants had a cold constitution. When recalculated based on other criteria for having a cold constitution (five or more of 10 items)¹⁷, 44.3% of the total female participants and 23.5% of the total male participants had a cold constitution. Thus, this suggests that defining a cold constitution as five or more applicable items is reasonable, as this definition captures the general characteristics of individuals with a cold constitution such as the awareness of cold sensations despite normothermic conditions¹⁷.

The participants answered all questions about coldness, exercise, and sleep using a yes/no format. This approach referenced previous survey methods; however, it is limited in its ability to capture symptom severity, exercise intensity, and sleep quality. In addition, the lack of

investigation into the type of exercise (e.g., endurance or resistance exercise) also limits the interpretation of the results.

In conclusion, we found that long-term exercise habits have a positive effect on sleep in both men and women aged 15 to 69 years old, but they can also increase symptoms of coldness in men.

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Consent for publication

There are no identifiable details included.

Authors' contributions

The study was designed by FY. Analyses and interpretation of data was done by FY. Drafting the manuscript was done by FY. Revising the manuscript critically for important intellectual content was done by FY. The author read and approved the final manuscript.

Competing interests

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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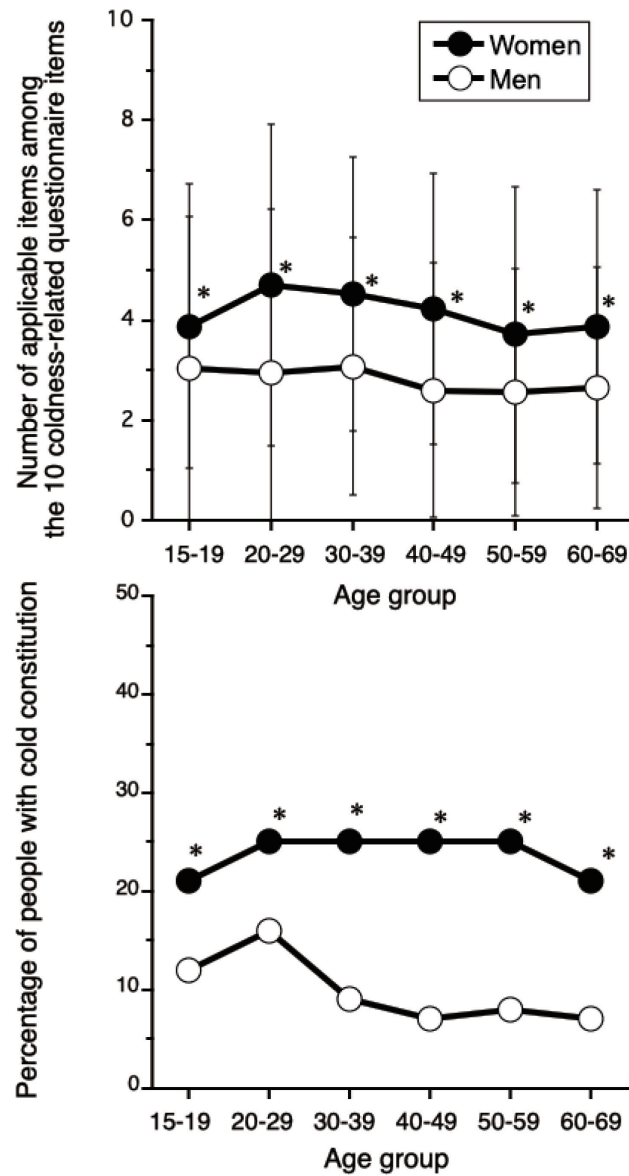


Figure 1 Average number ($\pm$ SD) of applicable items (upper panel) and percentage of people who answered yes seven or more times in the cold-related interview (lower panel) by age group in women and men. The participants were 100 men and 100 women in each of six age groups (15–19 years, 20–29 years, 30–39 years, 40–49 years, 50–59 years, and 60–69 years). * $p < 0.05$ vs. Men.

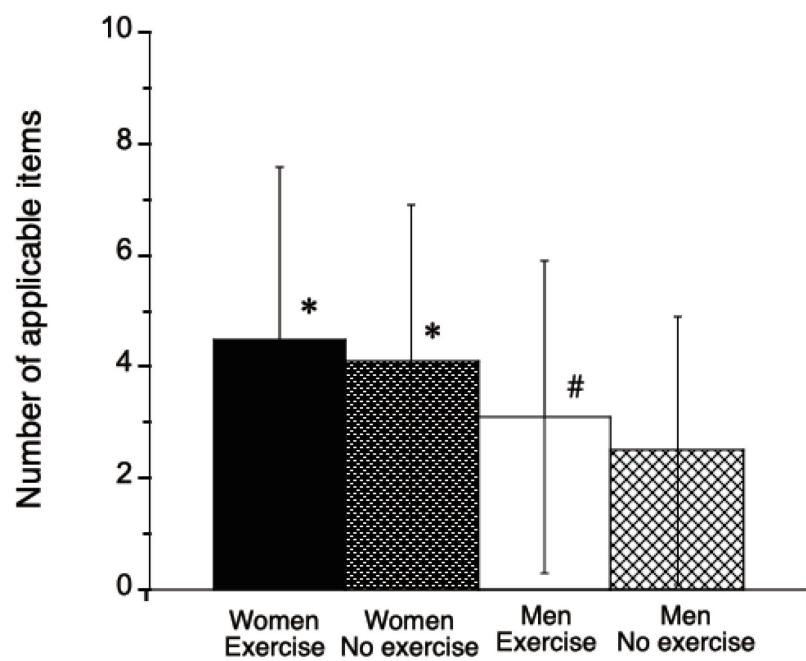


Figure 2 Average number ($\pm$ SD) of applicable items related to coldness and exercise status in women ($n = 600$) and men ($n = 600$). Data in four categories were averaged for all age groups. * $p < 0.05$ vs. Men, # $p < 0.05$ vs. No exercise.

Table 1. Percentage of people who answered "yes" to the relevant question for each item

Items	Sex	Age groups						Total	<i>p</i> values*
		15-19	20-29	30-39	40-49	50-59	60-69		
Awareness of cold constitution, %	Women	58	62	67	65	50	48	350	0.936
	Men	33	30	31	26	24	24	168	0.000
Exercise, %	Women	28	22	20	19	24	30	143	0.901
	Men	34	31	30	31	28	33	187	0.004
Falling asleep, %	Women	51	52	50	57	59	57	326	0.866
	Men	48	55	47	63	68	72	353	0.116
Rest from sleep, %	Women	49	48	45	47	45	52	286	0.816
	Men	53	50	43	48	34	43	271	0.385

* For each item, the numbers in the upper row show the *p* values between age groups in women and men, and the numbers in the lower row show the *p* values between women and men in all age groups.