SPECIAL FEATURES

Indoor temperature and BP control

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Excess winter mortality and the Smart Wellness Housing survey

Excess winter mortality (EWM) from cardiovascular diseases (CVDs)[1] is a global public health challenge, with cold exposure-induced hypertension as a key factor. A previous study reported a greater incidence of EWM in people living in cold homes.[2] However, existing countermeasures aimed at preventing hypertension and CVDs emphasize improvements to lifestyle habits, not life environment.

In 2018, WHO's publication of Housing and health guidelines[3] resulted in increased attention to improving life environment. The guidelines identify 'low indoor temperatures and insulation' as a priority area. Given that in today's society most people spend 60-70% of their time at home, evidence regarding the association between indoor temperature and blood pressure (BP) is essential.

We initiated a nationwide prospective intervention study in Japan, named the Smart Wellness Housing (SWH) survey. Our aim was to quantitatively evaluate the association between indoor temperature and BP in a real-world context. The intervention consisted of thermal insulation retrofitting applied to existing houses. Home BP (HBP) and indoor temperature measures were taken for the 2-week periods before and after the intervention in winter (November-March) of FY 2014 to 2019. We set four research questions, as described in the following sections.

Question 1: Is it warm enough indoors during the winter?[4]

Average temperature readings from approximately 2,200 houses before insulation retrofitting were: living room, 16.8°C; changing room, 13.0°C; and bedroom, 12.8°C, with average minimum temperatures of 12.6°C, 10.4°C, and 11.2°C, respectively. In over 90% of the houses these minimum temperatures were below the 18°C recommended by WHO. The paradoxical relationship was found: whereas the lowest living room temperature (13.1°C) was in Kagawa, where the winter climate is considered mild, the highest (19.8°C) was in Hokkaido, which has the most severe climate in Japan. The reason is that houses in Hokkaido have more efficient thermal insulation and uninterrupted heating. We also found that lower-income householders lived in colder houses. Energy (fuel) poverty is widespread in Europe and North America, where houses are generally better thermally insulated than in Japan. Thus, the problem of living in cold homes concerns not only Japan, but other countries also.

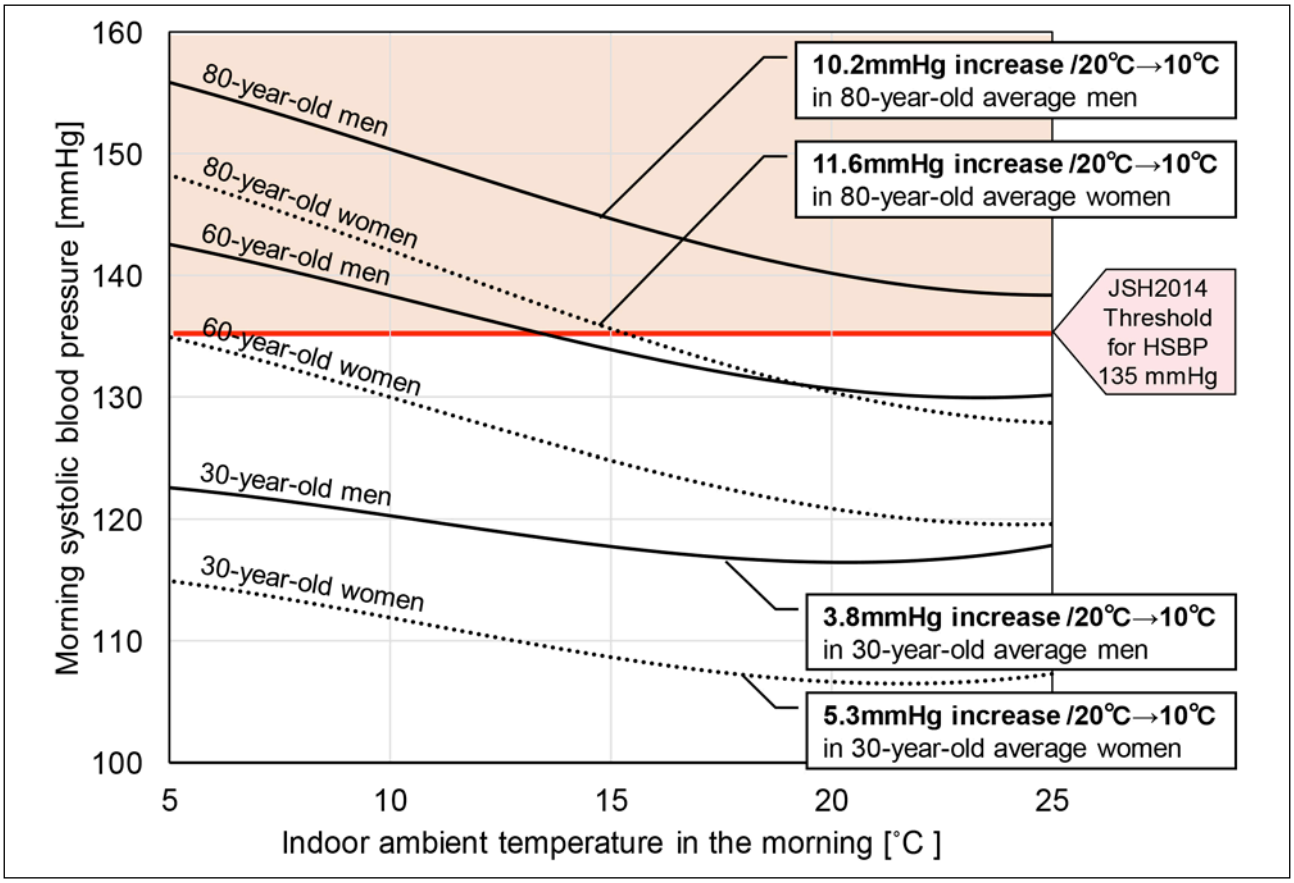

Figure 1. Relationship between indoor temperature and morning systolic blood pressure. (Figure taken from the graphical abstract of Hypertension, 2019)[5]

Question 2: Does higher indoor temperature decrease HBP?[5]

Based on 33,000 data points from 2,900 residents we found a significant inverse association: HBP was lower at high indoor temperatures. Morning systolic BP (SBP) was significantly more sensitive to changes in indoor temperature (8.2 mmHg decrease/10°C increase) than evening SBP (6.5 mmHg decrease/10°C increase) in participants, whose mean age was 57 years. As CVD-related events occur frequently in the morning, morning indoor temperature management may have a major role in reducing CVDs. In addition, although previous studies considered the temperature–BP relationship as a linear function, we showed a nonlinear cubic relationship between morning SBP and indoor temperature **(Fig.1)**. Furthermore, we established that SBP in older residents and women was vulnerable to indoor temperature change. We believe that these findings will contribute to determining optimum home temperature recommendations for each population group.

Question 3: Does stable indoor temperature decrease HBP variability?[6]

The association between indoor temperature instability and BP variability was analyzed using the morning-evening (ME) difference as an index of diurnal variability, and the standard deviation (SD) of 2-week data as an index of day-by-day variability. Compared to residents living in houses with a ME difference in indoor temperature of ≥ 4°C, the ME difference in SBP was less than half this value in residents living in houses with an ME difference < 1°C (9.3 vs 3.9 mmHg). Compared to residents whose houses had an indoor temperature SD ≥4 °C, the SD of SBP was smaller in residents whose houses had an SD <1 °C (9.5 vs 6.3 mmHg).

Question 4: Does insulation retrofitting of houses reduce HBP?[7]

Insulation retrofitting led to a morning indoor temperature increase of 1.5°C. Comparing HBP before and after intervention, morning SBP was significantly reduced by 3.1 mmHg following insulation retrofitting. There was also a dose–response relationship between indoor temperature and HBP, underlining the effectiveness of a substantial improvement in indoor temperature. Analysis by subgroups revealed heterogeneity in the effect of the insulation retrofitting intervention on morning SBP. While the overall average decrease was 3.1 mmHg, the morning SBP of older residents, smokers, and hypertensive patients decreased by 5.0 mmHg, 4.6 mmHg, and 7.7 mmHg, respectively. These results indicate that insulation retrofitting was especially beneficial for subgroups at high risk of CVDs.

New concept of "life-environmental diseases" [8]

We obtained answers for 4 research questions as follows:

A1: Over 90% of houses did not meet the WHO-recommended minimum indoor temperature of 18ºC.

A2: Higher indoor temperature was associated with decreased HBP, especially in older residents.

A3: Stable indoor temperature decreased diurnal and day-by-day HBP variability.

A4: Insulation retrofitting reduced HBP, especially in subgroups at high risk of CVDs.

Residents should keep the indoor temperature high to both reduce and stabilize BP through strategies such as installing effective thermal insulation. We hope that these results will be useful for preventing EWM due to CVDs.

Based on our findings, we propose that hypertension and CVDs might be not only lifestyle diseases but also life-environment diseases (Fig.2). Further, we hypothesize that living in cold homes for a long time has a cumulative effect – which we refer to as a "cold debt" – on blood vessels. The impetus for starting the SWH cohort survey was to clarify whether this cold debt existed or not.

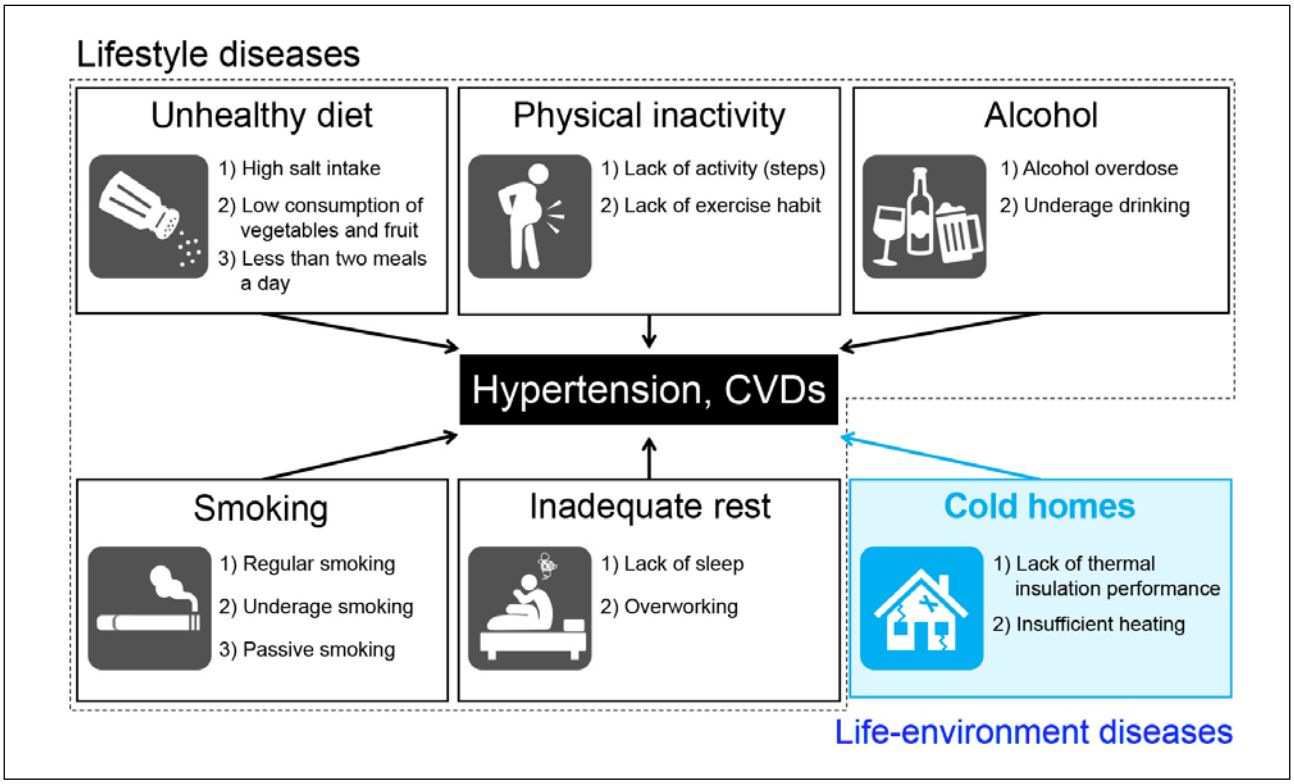

Figure 2. New concept of "life-environmental diseases" (Figure taken from the graphical abstract of Hypertension Res, 2023)8

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