

Social determinants of health associated with underweight among middle-aged Japanese men and women: a cross-sectional study[†]



Original article

Akiko Morimoto*, Hideaki Furuki, Aina Muta, Liqian Sun, Nao Sonoda

Department of Nursing Informatics, Graduate School of Nursing, Osaka Metropolitan University, Osaka 545-0051, Japan

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Abstract **Objective:** This study examined the gender-specific associations between social determinants of health and underweight status among middle-aged Japanese adults.
Methods: This cross-sectional study analyzed data from a postal survey of 2799 healthy middle-aged Japanese adults. Underweight was defined as a body mass index (BMI) $<18.5 \text{ kg/m}^2$ based on self-reported height and weight. The following variables were included as covariates in the multivariable-adjusted models: age, economic status, educational level, health literacy, living alone status, daily working hours, smoking status, drinking status, physical activity, sleep quality, and self-reported mental health.
Results: Of the 2799 participants, the prevalence of underweight was 5.0% in men (59/1170) and 14.9% in women (242/1629). Among men, living alone was significantly associated with underweight (adjusted risk ratio [RR]: 1.97, 95% confidence interval [CI]: 1.16–3.36), as was current smoking (RR: 1.75, 95% CI: 1.04–2.95). Self-reported average and poor/very poor mental health also had strong associations with underweight among men: average mental health (RR: 2.51, 95% CI: 1.21–5.19) and poor/very poor mental health (RR: 3.05, 95% CI: 1.36–6.87) versus very good/good mental health. Among women, no significant associations were observed. However, sensitivity analyses indicated an association between smoking and being underweight.
Conclusions: This study identified gender-specific factors associated with underweight in healthy middle-aged Japanese adults, highlighting the importance of social and psychological influences on nutritional status. Gender-specific approaches may be essential for early identification of underweight and appropriate interventions.

Keywords: Japan • mental health • middle-aged adults • social determinants of health • underweight

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1. Introduction

Underweight, although frequently receiving less attention than obesity in health research and policy discussions, has emerged as a clinically significant concern

due to its association with increased risks of stroke and functional decline. Large-scale studies conducted in Korea and Japan have demonstrated that individuals

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*Corresponding author.
E-mail: morimoto@omu.ac.jp (A. Morimoto).

with a body mass index (BMI) below 18.5 kg/m² are more likely to experience stroke.^{1,2} Underweight is also associated with frailty, a multidimensional syndrome characterized by reduced physiological reserves and increased vulnerability to stressors. A meta-analysis of 12 observational studies involving 37,985 older adults found that individuals with a BMI <18.5 kg/m² had a significantly elevated risk of frailty, highlighting underweight as a clinically relevant predictor of functional decline.³ Although frailty is commonly associated with later life, its precursors, including undernutrition and low body weight, may appear as early as middle adulthood (typically 40–64 years of age), a transitional period marked by emerging chronic conditions and increasing physiological vulnerability.^{4–6} Therefore, it is crucial to understand the determinants of underweight during this life stage to identify at-risk populations and guide early preventive strategies.

Social determinants of health such as economic status, education level, and living arrangements play a foundational role in shaping vulnerability to health risks. While social determinants of health have been extensively examined in relation to obesity,^{7,8} their associations with underweight remain underexplored, particularly among middle-aged populations. This life stage can heighten susceptibility to underweight through factors such as economic hardship and social isolation. In Japan, national data have indicated a consistently higher prevalence of underweight in women than in men, particularly among younger and middle-aged adults.⁹ This gender disparity underscores the importance of stratified analyses. In this context, this study investigated gender-specific associations between social determinants of health and underweight status in a large sample of middle-aged adults in Japan.

2. Methods

2.1. Study design and participants

A cross-sectional study using a self-administered postal questionnaire was conducted in 2020. The questionnaire was mailed to the participants, who were asked to complete the questionnaire independently and return it using a prepaid envelope. The estimated time to complete the questionnaire was approximately 10 min, and the return period was set at 1 month. To improve the response rate, a reminder postcard was mailed at 1 week after the initial mailing. Full details of the study were described in a previous report.¹⁰

This study used a convenience sample of 33,902 community residents aged 40–64 years from 5 cities in Osaka Prefecture, Japan. Of these, 12,446 (36.7%) agreed to participate in the survey. We excluded 8174

individuals who reported regular visits to medical institutions to mitigate potential reverse causation, wherein underlying medical conditions (endocrine/metabolic, psychiatric, neurological, oncological, cardiovascular, respiratory, and musculoskeletal) and interventions from primary care physicians may have affected body weight. We also excluded 979 individuals with obesity (BMI ≥25.0 kg/m²) and 494 individuals with missing data. Ultimately, a total of 2799 healthy middle-aged Japanese adults were included in the analysis.

2.2. Measurements

2.2.1. Underweight

BMI was calculated as the self-reported weight in kilograms divided by the square of the self-reported height in meters. The participants were classified into 2 groups based on their BMI: underweight (BMI <18.5 kg/m²) and normal weight (BMI ≥18.5 kg/m² but <25.0 kg/m²) (Japanese classification).¹¹

2.2.2. Social determinants of health

According to the World Health Organization Commission on Social Determinants of Health framework,¹² variables were collected as social determinants of health (structural and intermediary determinants): economic status (very good, good, average, poor, or very poor), education level (9–12 years or >12 years), health literacy, living alone status (yes or no), daily working hours, smoking status (nonsmoker or ex-smoker vs. current smoker), drinking status (nondrinker or occasional drinker vs. daily drinker), physical activity (presence or absence), sleep quality (restorative vs. non-restorative sleep), and self-reported mental health (very good, good, average, poor, or very poor). Health literacy was measured using the Communicative and Critical Health Literacy (CCHL) scale.¹³ The scores of the 5 items were summed and divided by the number of items on the scale to yield a CCHL score (theoretical range: 1–5).¹³ The reliability and validity of the CCHL scale were confirmed in a previous study.¹³ In this study, the Cronbach's alpha of the scale was 0.88. Daily working hours included time spent on work, housework, childcare, and nursing care. People with physical activity were defined as those who accumulated at least 150 min of moderate-intensity physical activity throughout the week.^{14,15} Non-restorative sleep was assessed using the following single item: "Do you feel refreshed after a night's sleep?" Responses of "no" were classified as non-restorative sleep, and responses of "yes" were classified as restorative sleep.^{16,17} Self-reported health is a widely recognized, valid, and reliable indicator of health status.¹⁸ In this study, self-reported mental health

was assessed using the following question: “How would you rate your current mental health?”

2.3. Statistical analysis

The analyses were stratified according to gender. Differences in the factors between the underweight and normal weight groups were evaluated using a *t*-test for continuous data and the chi-square test for dichotomous and categorical data. Log-binomial regression models were used to estimate the multivariable-adjusted risk ratio (RR) and 95% confidence interval (CI) for underweight (response variable: 1 = underweight and 0 = normal weight) for each factor. The covariates included age, economic status, education level, health literacy, living alone status, daily working hours, smoking status, drinking status, physical activity, sleep quality, and self-reported mental health status. For the sensitivity analysis, we used the same approach with a modified Poisson regression and robust error variance.

All data were analyzed using SPSS statistical software version 26 (IBM SPSS Japan, Tokyo, Japan) or R version 4.4.2 (R Foundation for Statistical Computing, Vienna, Austria). All reported *P*-values were 2-tailed, and values of *P* < 0.05 were considered statistically significant (α level: 0.05).

2.4. Ethical considerations

The study protocol was written in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Osaka Prefecture University (date of approval: October 5, 2020; approval number: 2020–28). Informed consent was obtained from all participants included in this study.

3. Results

3.1. Differences in the factors between the underweight and normal weight groups

Differences in the factors between the underweight and normal weight groups among middle-aged Japanese men were summarized in Table 1. Among the 1170 male participants, 59 (5.0%) were classified as underweight. Significant differences were observed in living alone (*P* < 0.001), smoking status (*P* = 0.04996), and self-reported mental health (*P* = 0.001) between the underweight and normal weight groups.

Table 2 presents the corresponding data for middle-aged Japanese women. Among the 1629 female participants, 242 (14.9%) were classified as underweight. Smoking status differed significantly between the underweight and normal weight groups (*P* = 0.016).

3.2. Associations between social determinants of health and underweight

Table 3 shows the multivariable-adjusted RRs and 95% CIs for underweight according to the social determinants of health among middle-aged Japanese men. After adjusting for all covariates, men who lived alone had a multivariable-adjusted RR of 1.97 (95% CI: 1.16–3.36) for being underweight versus those who lived with others. Similarly, current smokers had a multivariable-adjusted RR of 1.75 (95% CI: 1.04–2.95) for being underweight versus nonsmokers and ex-smokers. In addition, men with self-reported average mental health had a multivariable-adjusted RR of 2.51 (95% CI: 1.21–5.19), and those with self-reported poor or very poor mental health had a multivariable-adjusted RR of 3.05 (95% CI: 1.36–6.87), versus those with self-reported very good or good mental health. The results were similar to those of the sensitivity analysis using modified Poisson regression with robust standard errors.

Table 4 shows the multivariate-adjusted RRs and 95% CIs for underweight middle-aged Japanese women. The multivariable analysis revealed no significant associations between any of the examined factors and being underweight. However, in a sensitivity analysis using modified Poisson regression with robust standard errors, current smokers had a multivariable-adjusted RR of 1.33 (95% CI: 1.00–1.76) for being underweight versus nonsmokers and ex-smoker.

4. Discussion

This study identified gender-specific factors associated with underweight among healthy middle-aged Japanese adults, highlighting the importance of social and psychological influences on nutritional status. Among men, living alone, current smoking, and self-reported poor mental health were significantly associated with underweight, indicating that social isolation and psychosocial stressors may contribute to nutritional vulnerability during this life stage. In contrast, no significant associations were observed among women in multivariable-adjusted models, despite women having a higher prevalence of underweight; however, in a sensitivity analysis, current smoking was associated with underweight.

The mechanisms underlying the associations between living alone, current smoking, self-reported poor mental health, and being underweight among middle-aged men may involve physiological, psychosocial, and behavioral pathways. Living alone has been associated with lower dietary quality and reduced motivation to prepare nutritious meals,¹⁹ which may contribute to chronic undernutrition and weight loss. Smoking suppresses appetite and increases resting energy

Factors	Underweight (n = 59)	Normal weight (n = 1111)	P-value
BMI (kg/m ²)	17.6 (0.8)	22.2 (1.7)	—
Age (years)	53.2 (5.7)	52.5 (6.7)	0.384
Economic status			0.286
Very good or good	10.2	15.7	
Average	16.9	21.4	
Poor or very poor	72.9	62.9	
Education level			0.284
>12 years	50.8	43.7	
9–12 years	49.2	56.3	
Health literacy (CCHL scale score)	3.5 (0.8)	3.4 (0.8)	0.765
Living alone			<0.001
No	67.8	85.0	
Yes	32.2	15.0	
Daily working hours*	7.3 (4.5)	8.4 (4.3)	0.059
Smoking status			0.049
Nonsmoker or ex-smoker	47.5	60.3	
Current smoker	52.5	39.7	
Drinking status			0.679
Nondrinker or occasional drinker	54.2	57.0	
Daily drinker	45.8	43.0	
Regular exercise			0.672
Yes	35.6	38.3	
No	64.4	61.7	
Sleep quality			0.499
Restorative sleep	57.6	62.0	
Non-restorative sleep	42.4	38.0	
Self-reported mental health			0.001
Very good or good	16.9	39.8	
Average	52.6	41.8	
Poor or very poor	30.5	18.4	

Note: Continuous data were analyzed with a *t*-test and are shown as mean (standard deviation); dichotomous and categorical data were analyzed with the chi-square test and are shown as %; BMI, body mass index; CCHL, Communicative and Critical Health Literacy; *Includes time for work, housework, childcare, and nursing care.

Table 1. Differences in factors between the underweight and normal weight groups among middle-aged Japanese men.

expenditure, potentially leading to lower body weight.²⁰ Moreover, smoking may serve as a maladaptive coping strategy in response to psychological stress, further disrupting healthy eating behaviors. Poor mental health has been linked to dysregulation of the hypothalamic–pituitary–adrenal axis and elevated cortisol levels,²¹ which may impair appetite and metabolic balance, potentially resulting in weight loss. The interplay among these factors could contribute to a reinforcing cycle of social isolation, psychological distress, and nutritional vulnerability, particularly in middle-aged men.

No significant associations were identified between social or psychological factors and underweight among

middle-aged Japanese women in the multivariable-adjusted models in the primary analysis. However, the sensitivity analysis indicated that smoking was associated with underweight among women. In women, social desirability-driven underreporting of smoking could attenuate the observed association.^{22,23} Thus, a true smoking–underweight relationship may be present; however, it may appear weaker or null in self-report-based models. However, living alone and mental health associations observed in men were not detected among women, raising the possibility that unmeasured factors such as body image perception play a larger role. Previous studies have reported stronger thin-ideal

Factors	Underweight (<i>n</i> = 242)	Normal weight (<i>n</i> = 1387)	<i>P</i> -value
<i>BMI (kg/m²)</i>	17.4 (1.0)	21.3 (1.7)	–
<i>Age (years)</i>	53.6 (6.7)	54.0 (6.7)	0.421
<i>Economic status</i>			0.157
Very good or good	18.2	23.2	
Average	22.7	23.6	
Poor or very poor	59.1	53.2	
<i>Education level</i>			0.903
>12 years	52.5	52.1	
9–12 years	47.5	47.9	
<i>Health literacy (CCHL scale score)</i>	3.5 (0.8)	3.6 (0.7)	0.447
<i>Living alone</i>			0.650
No	88.8	87.8	
Yes	11.2	12.2	
<i>Daily working hours*</i>	8.8 (5.5)	9.3 (5.7)	0.174
<i>Smoking status</i>			0.016
Nonsmoker or ex-smoker	77.7	84.0	
Current smoker	22.3	16.0	
<i>Drinking status</i>			0.259
Nondrinker or occasional drinker	78.9	82.0	
Daily drinker	21.1	18.0	
<i>Regular exercise</i>			0.680
Yes	29.3	28.0	
No	70.7	72.0	
<i>Sleep quality</i>			0.185
Restorative sleep	55.4	59.9	
Non-restorative sleep	44.6	40.1	
<i>Self-reported mental health</i>			0.198
Very good or good	35.5	38.0	
Average	39.3	41.9	
Poor or very poor	25.2	20.1	

Note: Continuous data were analyzed with a *t*-test and are shown as mean (standard deviation); dichotomous and categorical data were analyzed with the chi-square test and are shown as %; BMI, body mass index; CCHL, Communicative and Critical Health Literacy; *Includes time for work, housework, childcare, and nursing care.

Table 2. Differences in factors between the underweight and normal weight groups among middle-aged Japanese women.

internalization and greater body image misperception among women, suggesting that these factors lead to excessive weight control behaviors.^{24,25} Altogether, these findings suggest that the null hypothesis in women may reflect a combination of under-ascertained smoking and unmeasured sociocultural pathways. Therefore, further research using biomarker-verified smoking status and validated body image instruments is needed to evaluate this mechanism.

In our findings, being underweight was more common in women than in men, a pattern that aligns with previous Asian studies. A nationwide survey in China reported that approximately 11% of women and 6%

of men were underweight.²⁶ Similarly, in Thailand, a national cohort study showed that approximately 22% of women were underweight compared to 6% of men,²⁷ indicating a higher prevalence among women in both settings. However, the factors related to underweight status may vary by region. Our findings suggest that living alone, current smoking, and mental health are associated with being underweight. In the East Asian context, similar to Japan, studies from Korea and China have indicated that living alone, smoking, and mental health are intermediary determinants associated with being underweight.^{6,28} In contrast, studies from the South Asian context, including those from Bangladesh

Factors	RR (95% CI)	Multivariable-adjusted RR (95% CI)
<i>Age (years)</i>	1.01 (0.98–1.05)	1.00 (0.97–1.04)
<i>Economic status</i>		
Very good or good	1.00	1.00
Average	1.21 (0.45–3.27)	1.02 (0.38–2.77)
Poor or very poor	1.74 (0.75–4.02)	1.29 (0.54–3.09)
<i>Education level</i>		
>12 years	1.00	1.00
9–12 years	0.76 (0.46–1.25)	0.61 (0.37–1.03)
<i>Health literacy (CCHL scale score)</i>	1.05 (0.76–1.45)	1.18 (0.84–1.66)
<i>Living alone</i>		
No	1.00	1.00
Yes	2.51 (1.49–4.24)	1.97 (1.16–3.36)
<i>Daily working hours*</i>	0.95 (0.89–1.01)	0.95 (0.89–1.01)
<i>Smoking status</i>		
Nonsmoker or ex-smoker	1.00	1.00
Current smoker	1.64 (0.99–2.69)	1.75 (1.04–2.95)
<i>Drinking status</i>		
Nondrinker or occasional drinker	1.00	1.00
Daily drinker	0.90 (0.55–1.48)	0.85 (0.51–1.43)
<i>Regular exercise</i>		
Yes	1.00	1.00
No	0.89 (0.53–1.50)	1.02 (0.61–1.71)
<i>Sleep quality</i>		
Restorative sleep	1.00	1.00
Non-restorative sleep	0.84 (0.51–1.39)	0.96 (0.57–1.62)
<i>Self-reported mental health</i>		
Very good or good	1.00	1.00
Average	2.83 (1.40–5.70)	2.51 (1.21–5.19)
Poor or very poor	3.66 (1.72–7.81)	3.05 (1.36–6.87)

Note: Log binomial regression models were used to estimate the RRs and 95% CIs for underweight (response variable: 1 = underweight and 0 = normal weight); CCHL, Communicative and Critical Health Literacy; CI, confidence interval; RR, risk ratio; *Includes time for work, housework, childcare, and nursing care.

Table 3. Multivariable-adjusted RR and 95% CIs for underweight according to different factors among middle-aged Japanese men.

and Nepal, have reported that structural determinants such as educational level and income are associated with being underweight.^{29,30} These findings suggest a regional contrast. In South Asia, being underweight is closely tied to structural determinants, such as lower education and poverty, whereas in East Asia, intermediary determinants, such as living alone, smoking, and mental health issues, may play a larger role. Accordingly, structural determinant-oriented strategies may

Factors	RR (95% CI)	Multivariable-adjusted RR (95% CI)
<i>Age (years)</i>	0.99 (0.98–1.01)	0.99 (0.98–1.01)
<i>Economic status</i>		
Very good or good	1.00	1.00
Average	1.20 (0.83–1.73)	1.18 (0.81–1.71)
Poor or very poor	1.35 (0.99–1.85)	1.28 (0.91–1.79)
<i>Education level</i>		
>12 years	1.00	1.00
9–12 years	0.99 (0.78–1.24)	0.91 (0.72–1.16)
<i>Health literacy (CCHL scale score)</i>	0.94 (0.80–1.10)	0.97 (0.82–1.15)
<i>Living alone</i>		
No	1.00	1.00
Yes	0.92 (0.63–1.33)	0.87 (0.60–1.26)
<i>Daily working hours*</i>	0.98 (0.96–1.01)	0.98 (0.95–1.01)
<i>Smoking status</i>		
Nonsmoker or ex-smoker	1.00	1.00
Current smoker	1.41 (1.07–1.85)	1.33 (0.99–1.77)
<i>Drinking status</i>		
Nondrinker or occasional drinker	1.00	1.00
Daily drinker	0.85 (0.64–1.13)	0.87 (0.66–1.16)
<i>Regular exercise</i>		
Yes	1.00	1.00
No	1.06 (0.82–1.36)	1.10 (0.85–1.43)
<i>Sleep quality</i>		
Restorative sleep	1.00	1.00
Non-restorative sleep	0.85 (0.68–1.08)	0.87 (0.67–1.12)
<i>Self-reported mental health</i>		
Very good or good	1.00	1.00
Average	1.00 (0.76–1.31)	0.94 (0.71–1.24)
Poor or very poor	1.28 (0.95–1.73)	1.11 (0.80–1.56)

Note: Log binomial regression models were used to estimate the RRs and 95% CIs for underweight (response variable: 1 = underweight and 0 = normal weight); CCHL, Communicative and Critical Health Literacy; CI, confidence interval; RR, risk ratio; *Includes time for work, housework, childcare, and nursing care.

Table 4. Multivariable-adjusted RR and 95% CIs for underweight according to different factors among middle-aged Japanese women.

be highly effective in South Asia, while intermediate determinant-oriented strategies may be more effective in East Asia.

5. Strengths and limitations

An important strength of the present study is the examination of a large sample of middle-aged adults. However, the study also had several limitations that warrant

consideration. First, a cross-sectional design cannot prove causality; therefore, a prospective study is necessary to confirm the present findings. Second, the response rate was 36.7%, raising concerns regarding the potential prevalence of being underweight and the magnitude of the associations, which could be biased toward the null hypothesis because individuals in relatively good health may have been more likely to participate.³¹ Additionally, by excluding individuals with regular medical visits, our inference pertains to healthy middle-aged adults; consequently, the external validity for patients with chronic illnesses is limited. Third, the BMI was derived from self-reported height and weight. Self-reports tend to overestimate height and underestimate weight in Japanese and other populations.^{32,33} Accordingly, our estimates may have misclassified some truly underweight or obese individuals as having normal weight, which could bias toward the null.

6. Conclusions

This study examined gender-specific associations between social determinants of health and underweight among middle-aged adults in Japan. The findings revealed that living alone, current smoking, and self-reported poor mental health were significantly associated with underweight among men, suggesting that social isolation and psychological distress may contribute to nutritional vulnerability during middle adulthood. Among women, the primary multivariable models were null despite the higher prevalence of being underweight; however, sensitivity analyses indicated an association between smoking and being underweight. Combined with evidence that women underreporting smoking have stronger thin-ideal internalization and greater body

image misperception, these results may reflect exposure misclassification and/or sociocultural pathways. Future longitudinal studies are needed to clarify causal relationships and inform targeted interventions.

Authors contributions

AM: Conceptualization, data curation, formal analysis, funding acquisition, investigation, project administration, literature review, and writing-original draft. HF, AM, and LS: Contributed to data interpretation, literature review, and critical review and editing of the manuscript. NS: Conceptualization, data curation, funding acquisition, investigation, project administration, and critical review and editing of the manuscript. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Ethical approval

The study protocol was written in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Osaka Prefecture University (No. 2020–28).

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Conflicts of interest

All contributing authors declare no conflicts of interest.

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