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ORIGINAL ARTICLE

Association of body mass index with chronic pain prevalence: a large population-based cross-sectional study in Japan

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Abstract

Purpose The aim of this study was to examine the association between body mass index and chronic pain.

Methods The outcome was chronic pain prevalence by body mass index (BMI). BMIs of less than 18.5, 18.5–25.0, 25.0–30.0, and 30.0 or over kg/m^2 were defined as underweight, normal weight, overweight, and obese.

Subjects We used data from 4993 participants (2464 men and 2529 women aged 20–79 years) of the Pain Associated Cross-sectional Epidemiological survey in Japan. Sex-stratified multivariable-adjusted odds ratios were calculated with 95% confidence intervals using a logistic regression model including age, smoking, exercise, sleep time, monthly household expenditure, and presence of severe depression. We analyzed all ages and age subgroups, 20–49 and 50–79 years.

Results The prevalence of chronic pain was higher among underweight, overweight, and obese male respondents than those reporting normal weight, with multivariable odds ratios of 1.52 (1.03–2.25), 1.55 (1.26–1.91), and 1.71 (1.12–2.60). According to underweight, only older men showed higher prevalence of chronic pain than normal weight men with odd ratios, 2.19 (1.14–4.20). Being overweight and obese were also associated with chronic pain in women; multivariable odds ratios were 1.48 (1.14–1.93) and 2.09 (1.20–3.64). Being underweight was not associated with chronic pain.

Conclusion There was a U-shaped association between BMI and chronic pain prevalence among men ≥ 50 years, and a dose–response association among women. Our finding suggests that underweight should be considered in older men suffering chronic pain.

Keywords Chronic pain · Body mass index · Underweight · Overweight · Obese

Introduction

The association between obesity and chronic pain has been well-documented by researchers [1]. We have the clinical impression, however, that underweight people are also more likely to report chronic pain. People with severe chronic pain may lose their appetite for food and, therefore, lose weight. Few studies, however, have examined whether being underweight is correlated with chronic pain. This study, therefore, sought to investigate this issue.

Body mass index (BMI), calculated using the square of the height in meters (kg/m^2), is a simple index designed to consider health risks by body proportions [2]. The current WHO classification defines underweight as having a BMI of less than 18.50 kg/m^2 [2]. The proportion of underweight people in Japan (4.4% of men and 11.0% of women aged 20 and over in 2009) is higher than other developed countries [3]. For example, the proportion of underweight adults was 1.0% of men and 2.6% of women aged 20 and over in the

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United States in 2009–2010 [4], and 2.2% of men and 2.5% of women aged 16 and over in the United Kingdom in 2009 [5]. Being underweight can sometimes signal a life-threatening condition medically. Some underlying diseases such as cancer, cardiac failure, and infectious diseases, might have cause underweight. Although far, fewer people are underweight than overweight or obese in developed countries, this does not mean being underweight should be ignored. For example, an association between being underweight and increasing all-cause mortality has previously been reported [6]. It is, therefore, important to examine the association between being underweight and chronic pain as well as to reinvestigate the association between being overweight or obese and chronic pain among Japanese people.

Methods

Study population

The Pain Associated Cross-sectional Epidemiological (PACE) study was a web-based survey designed to investigate pain in a large Japanese population using a self-reported questionnaire. It was conducted from 10 to 18 January 2009. The profiles of the PACE study participants have been reported previously [7, 8]. The aim of this study was completely different from the previous PACE-related studies, which examined the association between work-related psychosocial factors, childhood adversity, and chronic pain [8, 9]. A total of 20,044 respondents (9746 men and 10,298 women) aged 20–79 years, and matching the Japanese demographic composition in 2007, were recruited by e-mail from 1477,585 candidates who registered with the web-based survey company (Rakuten Research Inc., Tokyo, Japan) (see Fig. 1) [10]. Candidates were sent invitational e-mails with a link to the first questionnaire, and invitations were sent until the targeted sample number was achieved. Incomplete questionnaires were rejected automatically, so the response rate could not be calculated. The first questionnaire included items on age, sex, and pain, and was completed by 20,044 respondents. The second round of questionnaires, about lifestyle and psychosocial factors, was sent to 5000 of these respondents, chosen to be consistent with the Japanese demographic composition for sex and age in 2007 [10]. Half of these 5000 respondents were chosen from those who had reported being without pain in the first questionnaire, and the other half had reported pain. We excluded seven respondents (two men and five women) who reported with pain from cancer, because we wished to focus on non-cancer-related chronic pain. Data on 4993 individuals (2464 men and 2529 women) aged 20–79 were, therefore, included in the analyses.

Definitions and measures

Pain

The first questionnaire included a question about whether the respondents were in pain or not. If they were, they answered about the location of their pain and its intensity at each site, the site and duration of the dominant pain, and the main episodes that evoked pain. The nine options of episodes that evoked pain were described in the questionnaire; spontaneous, accident at work, working motion or posture, during commuting, daily motion or posture, traffic accident, in sports, disease, and others. Pain intensities were scored on an 11-point Numerical Rating Scale (NRS) (0 = no pain, 10 = worst pain imaginable).

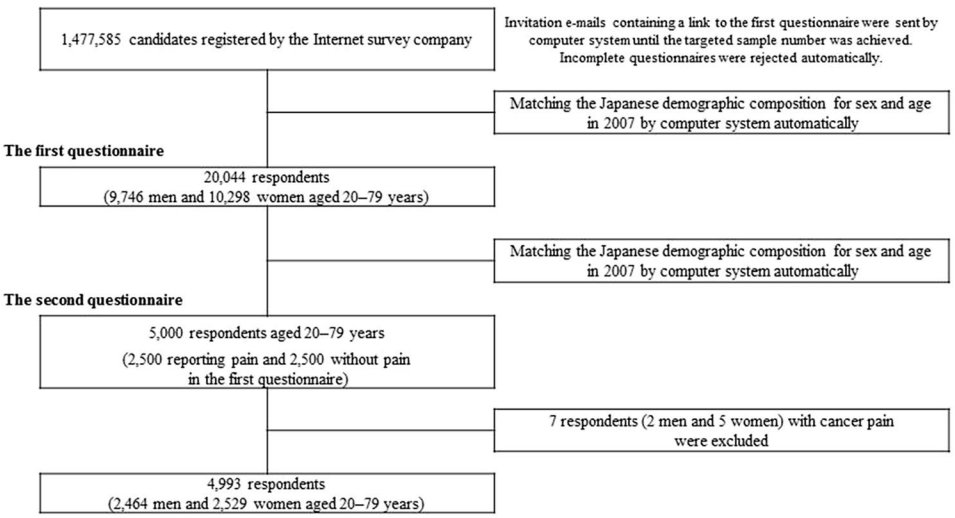

Fig. 1 Sampling procedure that culminated in the sample analyzed in the current study

Chronic pain

We defined 'chronic pain' as pain over a period of 3 months, in line with the definition of the International Association for the Study of Pain [11].

Severe depressive symptoms

The Mental Health Inventory (MHI-5), which is identical to the 'Mental Health' domain of the 36-Item Short-Form Health Survey (SF-36), was used to evaluate mental health status. The MHI-5 includes five items, each rated on a six-point scale ranging from 1 to 6. The five items were summed to give a total score ranging from 5 to 30 points, which was then converted to a 100-point scale. The cut point of <52 on the MHI-5 (corresponding to ≥ 56 on the 20-item Zung Self-rating Depression Scale, ZSDS) was useful for screening severe depressive symptoms with sensitivity of 91.8% and specificity of 84.6% in a previous Japanese study, so we used a cut-off point of <52 to define severe depression [12].

Statistical analysis

We used Dunnett's method to test for differences in mean values and proportions of risk factors for chronic pain by BMI category. We examined the association between BMI category (less than 18.5 kg/m^2, from 18.5 up to 25.0, from 25.0 up to 30.0, and 30.0 or over) and the prevalence of chronic pain. We calculated sex-stratified multivariable-adjusted odds ratios (ORs) and 95% confidence intervals (95% CIs) using a logistic regression model, because the sex difference in chronic pain pathogenesis was reported in the previous study [13]. To examine the influence of age, we stratified respondents into two age groups: younger, aged 20–49 years and older, aged 50–79 years.

Adjusted variables were age, smoking status (never, ex-smoker, or current smoker), exercise (exercise longer than 30 min more than twice a week: yes or no), sleep duration (an average over the last month; hours/day), household expenditure (JPY/month), and presence of severe depressive symptoms (MHI-5 <52). Those adjusted variables were considered as confounding factors or risks of chronic pain from the previous studies [14–23].

p values of <0.05 for two-tailed tests were considered statistically significant. All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Ethical provisions

A credit point for Internet shopping was given to the respondents as an incentive. All procedures followed were in accordance with the ethical standards of the Helsinki Declaration of 1975, as revised in 2000. The institutional review boards of The University of Tokyo (No. 1264) and Japan Labour Health and Welfare Organization (No. 452) approved the study. All participants gave their informed consent before responding to the questionnaire.

Results

Of the 4993 respondents (2464 men and 2529 women) aged 20–79 in this study, 1723 (815 men and 908 women) (34.5%) reported chronic pain. Table 1 shows chronic pain characteristics. Table 2 shows the mean values or proportions of characteristics by BMI category. Underweight and obese men were younger (42.7 and 42.9 vs. 47.7 years), and overweight men were older (49.8 vs. 47.7 years) than normal weight men. Overweight men were more likely to sleep for fewer than 6 h each night than normal weight men (20.2 vs. 15.2%). A greater proportion of underweight men showed severe depressive symptoms compared with normal weight men (30.0 vs. 20.8%). Fewer underweight and obese men (25.8 and 19.6%) had an exercise routine than their normal weight peers (37.2%).

Underweight women were younger (43.8 vs. 49.0 years), taller (157.5 vs. 156.5 cm), and more likely to be current smokers (19.9 vs. 14.3%) than normal weight women. They were also more likely to have severe depressive symptoms (33.1 vs. 21.0%).

The multivariable-adjusted ORs for chronic pain prevalence (Table 3; Fig. 2) were 1.52 (95% CI 1.03–2.25, $p<0.05$) for underweight men, 1.55 (1.26–1.91, $p<0.001$) for overweight men, 1.71 (1.12–2.60, $p<0.05$) for obese men, 1.48 (1.14–1.93, $p<0.01$) for overweight women, and 2.09 (1.20–3.64, $p<0.01$) for obese women. No associations were observed between being underweight and chronic pain among women. Table 4 and Fig. 2 show the multivariable-adjusted ORs for chronic pain prevalence by BMI category, stratified into two age groups: younger and older. The association between underweight and chronic pain was only observed among older men, where the multivariable-adjusted OR was 2.19 (1.14–4.20, $p<0.05$). Younger underweight men also had slightly more chronic pain, but this was not statistically significant (OR 1.23, 95% CI 0.74–2.03, $p>0.05$). There was no association between being underweight and chronic pain prevalence among younger or older women.

Overweight and obese younger men were more likely to have chronic pain, with ORs of 1.51 (1.11–2.06, $p<0.01$) and 1.70 (1.02–2.83, $p<0.05$). Older overweight men were also more likely to have chronic pain, with multivariable-adjusted OR of 1.55 (1.17–2.07, $p<0.01$). Obese

Table 1 Chronic pain characteristics

	Men, $n=815$		Women, $n=908$	
	n	%	*n*	%
Dominant pain site				
Head	45	5.5	67	7.4
Face	23	2.8	12	1.3
Neck	58	7.1	68	7.5
Shoulder	122	15.0	173	19.1
Arm	40	4.9	24	2.6
Hand	67	8.2	92	10.1
Abdomen	34	4.2	35	3.9
Back	220	27.0	184	20.3
Inguinal	14	1.7	23	2.5
Leg	44	5.4	29	3.2
Knee	82	10.1	127	14.0
Foot	55	6.7	64	7.0
Genitals	4	0.5	2	0.2
Anal	7	0.9	8.0	0.9
Duration				
≥3 and <6 months	84	10.3	94	10.4
≥6 and <12 months	108	13.3	123	13.5
≥12 months	623	76.4	691	76.1
Pain intensity of dominant pain site				
1/10	44	5.4	40	4.4
2/10	139	17.1	110	12.1
3/10	149	18.3	167	18.4
4/10	83	10.2	98	10.8
5/10	140	17.2	130	14.3
6/10	93	11.4	96	10.6
7/10	91	11.2	114	12.6
8/10	53	6.5	99	10.9
9/10	12	1.5	34	3.7
10/10	10	1.2	19	2.1
Invalid answer	1	0.1	1	0.1
Main episodes that evoked pain				
Spontaneous	332	40.7	335	36.7
Accident at work	13	1.6	6	0.7
Working motion or posture	102	12.5	93	10.2
During commuting to work	4	0.5	2	0.2
Daily motion or posture	166	20.4	242	26.7
Traffic accident	37	4.5	26	2.9
In sports	53	6.5	38	4.2
Disease	67	8.2	79	8.7
Others	41	5.0	87	9.6

and overweight younger women had an increased risk of chronic pain, although those associations were not statistically significant. Overweight and obese older women were more likely to have chronic pain, with multivariable ORs of 1.52 (1.06–2.17, $p<0.05$) and 2.98 (1.07–8.31, $p<0.05$).

Discussion

Our main finding was that there was a U-shaped association between BMI and chronic pain prevalence among older men and a dose–response association among women, regardless of age (Fig. 2). The association between being overweight or obese and the prevalence of chronic pain is consistent with the previous studies [1].

Previous studies suggested that the association between being overweight or, obese and chronic pain could be a result of mechanical stress or a chemical mediator [1]. Heavy loads on joints and the spine may lead to chronic musculoskeletal pain among obese people [24, 25]. Suffering from the eating disorder bulimia as a result of obesity may be linked to a central nervous disorder and severe chronic pain. Both eating disorders and chronic pain are associated with disorders of the reward system in the brain [26, 27], as well as with systemic inflammation [28].

There are several reasons why being underweight might be associated with chronic pain among older men. Being underweight as a result of muscle weakness from inactivity or aging burdens the intervertebral disks and joints, and causes chronic musculoskeletal pain, which is also mediated by systemic inflammation [29]. Those with chronic pain may also lose their appetite and, therefore, lose weight. In that case, removing the persistent pain would also prevent them from being underweight [30].

It has also recently been pointed out that the mechanism behind being underweight (e.g., systemic inflammation or eating disorder due to central nervous abnormality) partially overlaps with that for being overweight and obese, both pathologically and psychologically [26–28, 31]. Systemic inflammation may be common mechanism between underweight, overweight, and obese in this study. Although neuroimaging showed that patients with anorexia nervosa had hyper sensitivity in the orbitofrontal cortex and the insula which are key regions of the brain reward system which is known as a reason chronic pain

Table 2 Mean values and proportions of characteristics by body mass index category

Body mass index, kg/m^2	< 18.5	≥ 18.5 and < 25.0	≥ 25.0 and < 30.0	≥ 30.0
Men, *n* = 2464				
Number of respondents, *n* (%)	120 (4.9)	1726 (70.0)	516 (20.9)	102 (4.1)
Age, years (SE)	42.7 (1.4)‡	47.7 (0.4)	49.8 (0.7)*	42.9 (1.5)†
Height, cm (SE)	170.3 (0.6)	169.6 (0.1)	169.2 (0.3)	170.6 (0.6)
Current smoker, %	30.0	26.5	29.3	33.3
Have an exercise routine, %	25.8*	37.2	31.6	19.6‡
Sleep duration per night < 6 h, %	13.3	15.2	20.2*	23.5
Household expenditure, *10000JPY/month (SE)	31.7 (4.2)	29.7 (1.1)	30.0 (2.0)	29.2 (4.6)
Severe depressive symptoms, %	30.0*	20.8	18.4	29.4
Women, *n* = 2529				
Number of respondents, *n* (%)	357 (14.1)	1838 (72.7)	279 (11.0)	55 (2.2)
Age, year (SE)	43.8 (0.8)‡	49.0 (0.4)	50.1 (0.9)	44.9 (2.0)
Height, cm (SE)	157.5 (0.3)†	156.5 (0.1)	155.9 (0.3)	156.9 (0.7)
Current smoker, %	19.9*	14.3	15.1	20.0
Have an exercise routine, %	26.1	29.7	26.2	20.0
Sleep duration per night < 6 h, %	15.4	15.8	19.4	27.3
Household expenditure, *10000JPY/month (SE)	25.6 (1.9)	26.8 (0.9)	27.0 (2.2)	24.5 (4.9)
Severe depressive symptoms, %	33.1‡	21.0	25.8	27.3

Test for significance from the category of body mass index ≥ 18.5 and < 25.0: *$p < 0.05$, †$p < 0.01$, ‡$p < 0.001$

SE standard error

Table 3 Odds ratios (ORs, 95% CI) of chronic pain prevalence by body mass index category

Body mass index (kg/m^2)	< 18.5	≥ 18.5 and < 25.0	≥ 25.0 and < 30.0	≥ 30.0
Men, *n* = 2464				
Number of respondents	120	1726	516	102
Number of respondents with chronic pain	46	516	209	44
Age-adjusted OR (95% CI)	1.53 (1.04–2.25)*	1	1.57 (1.28–1.93)‡	1.87 (1.24–2.81)†
Multivariable-adjusted OR (95% CI)	1.52 (1.03–2.25)*	1	1.55 (1.26–1.91)‡	1.71 (1.12–2.60)*
Women, *n* = 2529				
Number of respondents	357	1838	279	55
Number of respondents with chronic pain	119	633	127	29
Age-adjusted OR (95% CI)	1.01 (0.79–1.29)	1	1.58 (1.22–2.04)‡	2.24 (1.30–3.84)†
Multivariable-adjusted OR (95% CI)	0.90 (0.70–1.16)	1	1.48 (1.14–1.93)†	2.09 (1.20–3.64)†

Adjusted for age, smoking, exercise routine, sleep time, household expenditure, and existence of severe depressive symptoms

Test for significance from the category of body mass index ≥ 18.5 and < 25.0: *$p < 0.05$, †$p < 0.01$, ‡$p < 0.001$

CI confidence interval

[27], prevalence of anorexia nervosa are higher among young women than older men, so anorexia nervosa may not explain the association between underweight and chronic pain prevalence in the current study [32].

In contrast to men, being underweight was not associated with chronic pain in women. The reason for this discrepancy is unclear, but one potential reason may be misclassification. In this study, women may have

Table 4 Odds ratios (ORs, 95%CI) of chronic pain prevalence according to body mass index

Body mass index (kg/m^2)	< 18.5	≥ 18.5 and < 25.0	≥ 25.0 and < 30.0	≥ 30.0
Men, *n* = 2464				
20–49 years old, *n* = 1301				
Number of respondents	80	899	249	73
Number of respondents with chronic pain	26	249	93	31
Age-adjusted OR (95% CI)	1.32 (0.80–2.16)	1	1.46 (1.08–1.98)*	1.85 (1.14–3.02)*
Multivariable-adjusted OR (95% CI)	1.23 (0.74–2.03)	1	1.51 (1.11–2.06)†	1.70 (1.02–2.83)*
50–79 years old, *n* = 1163				
Number of respondents	40	827	267	29
Number of respondents with chronic pain	20	267	116	13
Age-adjusted OR (95% CI)	2.09 (1.10–3.95)*	1	1.62 (1.22–2.15)‡	1.72 (0.81–3.64)
Multivariable-adjusted OR (95% CI)	2.19 (1.14–4.20)*	1	1.55 (1.17–2.07)†	1.66 (0.78–3.52)
Women, *n* = 2529				
20–49 years old, *n* = 1264				
Number of respondents	218	882	127	37
Number of respondents with chronic pain	70	285	53	17
Age-adjusted OR (95% CI)	1.05 (0.76–1.45)	1	1.47 (1.00–2.15)*	1.73 (0.89–3.36)
Multivariable-adjusted OR (95% CI)	0.94 (0.67–1.32)	1	1.44 (0.97–2.12)	1.76 (0.89–3.47)
50–79 years old, *n* = 1265				
Number of respondents	139	956	152	18
Number of respondents with chronic pain	49	348	74	12
Age-adjusted OR (95% CI)	0.94 (0.67–1.37)	1	1.68 (1.19–2.37)†	3.61 (1.33–9.78)*
Multivariable-adjusted OR (95% CI)	0.83 (0.56–1.22)	1	1.52 (1.06–2.17)*	2.98 (1.07–8.31)*

Adjusted for age, smoking, exercise routine, sleep time, household expenditure, and existence of severe depressive symptoms

Test for significance from the category of body mass index ≥ 18.5 and < 25.0: *$p < 0.05$, $^{\dagger}p < 0.01$, $^{\ddagger}p < 0.001$

CI confidence interval

underreported their weight, since Japanese women generally wish to be thin [33]. The proportion of underweight women in this study was higher and that of overweight/obese women in this study was lower than in a national statistical report of actually measured weight in women aged 20 years or older in 2009 (underweight, 14.1 vs. 11.0%, overweight, 11.0 vs. 17.3%, and obese, 2.2 vs. 3.5%) [7]. The proportion of underweight, overweight, and obese men, in contrast, was almost identical to that in the national statistical report (underweight, 4.9 vs. 4.4%, overweight, 20.9 vs. 26.1%, and obese, 4.1 vs. 4.3%) [3]. Many normal weight women were, therefore, likely to be included in the underweight group in our study, so the effect of being underweight on the prevalence of chronic pain could have been underestimated.

This study had several limitations. First, the respondents may not be truly representative of the general population in Japan. The internet survey has a number of sampling issue, as described previously [34]. People without internet access could not participate in this research. Second, a self-administered questionnaire was used to measure body weight and height. According to a previous prospective population-based study among Japanese people aged 40–59 years at baseline, self-reported BMIs were slightly lower but almost equivalent to the actual measured values, and the Spearman correlation coefficient was approximately 0.9 in both sexes [35]. However, these results were derived from middle-aged people, so misclassification of BMI in the underweight category may have occurred among younger and older people. Third, the study was cross-sectional and cannot show the direction of causality. Finally, respondents with chronic pain as a result of severe diseases other than cancer may lose weight.

In conclusion, being underweight was associated with chronic pain among men ≥ 50 years. This result suggests that being underweight should be considered when treating those with chronic pain.

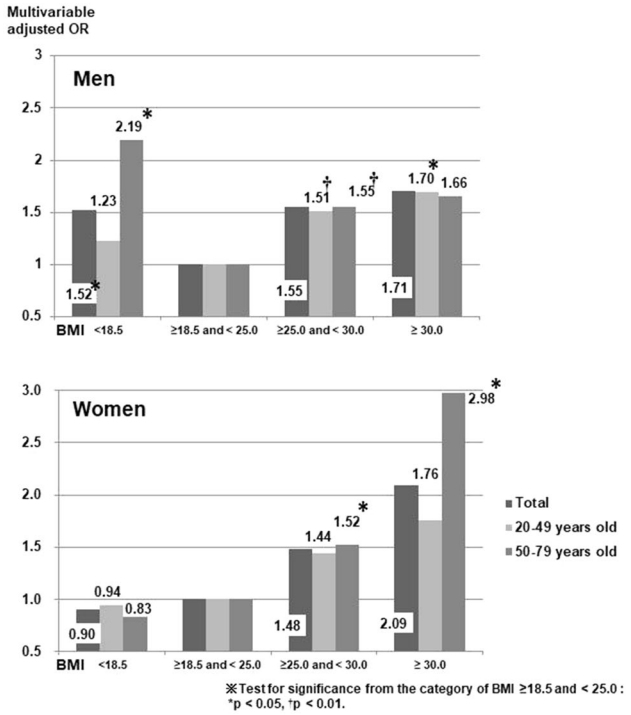

Fig. 2 Multivariable-adjusted odds ratios of chronic pain prevalence by body mass index category

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