



Original Article

Obesity and low back pain: a retrospective cohort study of Japanese males

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Abstract. [Purpose] This study evaluated whether obesity is a risk factor for low back pain, by using body fat percentage (%FAT) and body mass index (BMI) as indices of obesity among Japanese males. [Subjects and Methods] This study included 1,152 males (average age: 28.0 ± 4.6 years). BMI was calculated from subject's height and weight, and %FAT was estimated by the thickness of two parts of skin. Low back pain, drinking and smoking were surveyed using a self-administered questionnaire, and maximal oxygen uptake was measured by a submaximal exercise test using a cycle ergometer. [Results] A significant positive dose-response relationship was shown between %FAT and persistent low back pain prevalence. Similarly, a significant positive dose-response relationship was confirmed between BMI and persistent low back pain. [Conclusion] This study suggests that both high %FAT and BMI are risk factors for persistent low back pain.

Key words: Obesity, Low back pain, Epidemiology

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INTRODUCTION

Low back pain is a global health concern and the top condition impacting the “disability-adjusted life-years” metric¹⁾. In addition, low back pain is currently the most common condition in Japan²⁾, comprising 65% of chronic musculoskeletal pain symptoms and was ranked as the most common condition among males with subjective symptoms due to diseases and injuries in Annual Health, Labour and Welfare Report³⁾. Low back pain also affects not only the health of workers but also their productivity, and other problems, leading to negative economic effects^{4, 5)}.

In addition, being overweight and obese is a global health concern⁶⁾. Cardiovascular diseases, diabetes, and some cancers are the top three diseases affecting disability-adjusted life-years, which are thought to be caused by overweight/obesity⁷⁾. According to a Global Health Observatory report in 2014, among adults over the age of 18 years in 149 countries in the World Health Organization area, 39% are overweight and 13% are obese, accounting for over 50% of all adults⁶⁾.

There have been several cohort studies related to low back pain and obesity^{8–11)}. Previous longitudinal studies reported that overweight/obesity is a risk factor for low back pain. However, no long-term cohort studies have been conducted focus-

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ing on Asian populations, who exhibit lower levels of obesity compared with Western populations⁷). In addition, most studies conducted to date have used body mass index (BMI) as an index of obesity. However, as BMI does not consider overall body composition and a high BMI value can be attributed to people with both high fat and muscle mass; risk factors for low back pain may not be evaluated accurately from the perspective of body composition.

In this study, body fat percentage (%FAT) data was added as an index of obesity; using over 20 years of follow-up data for Japanese males, we conducted an exploratory assessment of the relationship between %FAT, BMI, and low back pain.

SUBJECTS AND METHODS

This study was one of the cohort studies investigating the relationship between obesity, physical fitness, and health outcomes in Japanese males^{12, 13}). Participants in this study were employees of companies based in the greater Tokyo metropolitan area. All employees receive annual health examinations and exercise tests as part of employee health management plans implemented in accordance with the Occupational Safety and Health Act and related laws in Japan.

There were 8,638 participants in this study who underwent routine physical examinations and exercise tests in 1986 (April 1986–March 1987). Thirty people who failed to continue the exercise test for more than 4 min were excluded. In addition, 6,912 people for whom the presence of low back pain could not be determined as of 2009 because of retirement during the period between 1987 and 2008 were excluded, as well as 9 people for whom data that was considered to contain potential confounding factors that were missing were excluded. In addition, 536 people with low back pain at the time of baseline measurement in 1986 and who had experienced low back pain prior to 1986 were excluded. Ultimately, 1,152 males were enrolled as participants in this study.

In our observational study, the clinical examinations were done under the Industrial Safety and Health Act and related laws in Japan. This study was approved by the ethics committee of the National Institutes of Health and Nutrition of Japan (290-01).

Participants in this study were measured for height and weight at annual health examinations conducted in 1986. Body weight was measured using a body weight scale, with participants removing their shoes and wearing light clothing. Based on the results, BMI (weight (kg) divided by the square of height (m)) was determined. To estimate %FAT, the thickness of skin pinched at the posterior midpoint between acromion and tip of olecranon, and lower edge of the scapula was measured using a subcutaneous fat thickness-measuring device (TK-11258, Takei Scientific Instruments, Niigata, Japan). Total fat thickness of these two regions was inputted into Nagamine and Suzuki's equation to estimate body density¹⁴). Next, %FAT was estimated by inputting body density into Brozek's equation¹⁵).

The results of the questionnaire regarding the presence of low back pain (none, in the past, present) were used to exclude participants (both in the past and present) with low back pain at baseline. Further, maximal oxygen uptake was used as an index of physical fitness and was considered a potential confounding factor of low back pain. This factor was adjusted during analysis to evaluate the relationship between obesity and low back pain. Maximal oxygen uptake was measured by a submaximal exercise test using a cycle ergometer and was estimated using the Åstrand and-Ryhming nomogram¹⁶) and Åstrand age correction factors¹⁷). Additionally, lifestyles considered to present potential confounding factors, including smoking (nonsmoking, 1–20 cigarettes per day, 21 or more cigarettes per day) and alcohol intake (none, 1–20 g per day, 21 g or more per day), were evaluated.

We determined the presence or absence of “persistent low back pain” from the results of the self-administered questionnaire about low back pain (none, sometimes (intermittent), always (persistent)) in 2009. We defined participants who responded “always (persistent)” as persistent low back pain sufferers.

First, we classified the participants by quartile based on their %FAT and BMI at baseline and compared the physical characteristics at baseline for each group. All data is displayed as the mean and standard deviation. The relationship between %FAT and BMI was confirmed using Pearson's correlation coefficient. Next, we used a logistic regression model to calculate the multivariable-adjusted odds ratio and the 95% confidence interval for persistent low back pain prevalence while taking potential confounding factors (age, alcohol intake, smoking habits, and maximal oxygen uptake) into account. Further, to examine the relationship between obesity and persistent low back pain prevalence, the odds ratio and 95% confidence interval of persistent low back pain prevalence were calculated using a logistic regression model with the presence or absence of persistent low back pain as a dependent variable and %FAT and BMI quartiles as independent variables. In the logistic regression model, age (continuous number) was input as a covariate, and the age-adjusted odds ratio and 95% confidence interval were calculated. In addition, multivariable-adjusted odds ratios and 95% confidence intervals were determined while considering smoking habits (nonsmoker, 1–20 cigarettes per day, 21 or more cigarettes per day), alcohol intake (none, 1–20 g per day, 21 g or more per day), and maximal oxygen uptake (continuous number). To evaluate whether a linear relationship existed between obesity and persistent low back pain prevalence, continuous numbers for %FAT and BMI were inputted into the model to calculate *p* for linearity.

Many previous studies evaluated relationships with low back pain using the WHO criteria for BMI. Therefore, to compare these studies with our study, we also conducted our assessment based on 4 categories: thin (<18.50), average (18.51–24.99), overweight (25.00–29.99), and obesity (≥30.00) according to WHO classification.

All statistical analyses were performed using SPSS Statistics version 23 (IBM Corp, Armonk, NY, USA), and a two-tailed

Table 1. Baseline characteristics of Japanese males in 1986 according to body fat percentage and body mass index (quartiles)

Characteristic	All men	Q1 (lowest)	Q2	Q3	Q4 (highest)
Body fat percentage (%)		≤12	13–14	15–17	≥18
n	1,152	335	282	295	240
Age (yrs)	28.0 ± 4.6	27.6 ± 4.8	27.9 ± 4.7	28.3 ± 4.5	28.2 ± 4.5
Body mass index (kg/m ²)	22.6 ± 2.7	20.8 ± 1.9	22.1 ± 2.0	23.1 ± 1.9	25.2 ± 3.0
VO ₂ max (ml/kg/min)	43.2 ± 8.9	46.5 ± 8.8	43.9 ± 8.2	42.2 ± 8.5	38.7 ± 8.3
Current drinkers (%)	64.1	60.0	61.0	67.5	69.6
Current smokers (%)	63.4	71.0	61.0	57.3	62.9
Body mass index (kg/m ²)		≤20.82	20.83–22.31	22.32–24.05	≥24.06
n	1,152	285	290	289	288
Age (yrs)	28.0 ± 4.6	27.1 ± 5.0	27.4 ± 4.4	28.7 ± 4.5	28.7 ± 4.4
Body fat percentage (%)	14.7 ± 3.5	12.3 ± 2.4	13.8 ± 2.5	15.2 ± 3.0	17.6 ± 3.7
VO ₂ max (ml/kg/min)	43.2 ± 8.9	46.5 ± 9.0	44.7 ± 8.6	43.3 ± 8.3	38.2 ± 7.6
Current drinkers (%)	64.1	59.3	59.0	69.6	68.8
Current smokers (%)	63.4	65.6	59.3	64.0	64.6

Data are means ± standard deviation or %
 VO₂max: maximal oxygen uptake

Table 2. Multivariable-adjusted odds ratios for incidence of persistent low back pain by potential confounders

Characteristic	Participants	Odds Ratio ^a	95% CI
Age (yrs)	1,152	0.98	0.93–1.03
VO ₂ max (ml/kg/min)			
1st quartile ≤36	301	1.00 (reference)	
2nd quartile 37–42	285	1.22	0.68–2.20
3rd quartile 43–49	309	0.90	0.48–1.67
4th quartile ≥50	257	0.81	0.41–1.58
Alcohol intake			
None	413	1.00 (reference)	
1–20 g/day	517	0.73	0.44–1.22
≥21 g/day	222	1.19	0.66–2.15
Current smokers			
None	422	1.00 (reference)	
1–20 cigarettes/day	457	1.20	0.74–1.94
≥21 cigarettes/day	273	0.68	0.36–1.28

^aAdjusted for all items in the table.

CI: confidence interval; VO₂max: maximal oxygen uptake

p value less than 0.05 was considered to be statistically significant.

RESULTS

In this study 1,152 people were recruited, and the average age, weight, and height at the time of baseline measurement (1986) were 28.0 ± 4.6 years, 65.5 ± 8.4 kg, and 170.0 ± 5.6 cm. The number of people who had persistent low back pain in 2009 was 90. Table 1 shows the physical characteristics of the participants at the baseline. The average %FAT and BMI as an index of obesity were 14.7 ± 3.5% and 22.6 ± 2.7 kg/m², respectively, and a clear positive correlation was found between %FAT and BMI (r=0.62). There was no correlation between %FAT and age; however, for BMI, the age of the 3rd and 4th quartiles was higher than that of the 1st and 2nd quartiles. Regarding maximal oxygen uptake, both %FAT and BMI showed lower values in the group tending towards obesity. In contrast, presence of current drinkers was higher in the group with obesity tendencies. No trends concerning smoking habits were observed.

Table 2 shows the multivariable-adjusted odds ratio and 95% confidence interval for persistent low back pain prevalence

Table 3. Multivariable-adjusted odds ratios for incidence of persistent low back pain according to body fat percentage and body mass index (quartiles)

	Q1 (lowest)	Q2	Q3	Q4 (highest)	p for linearity
Body fat percentage (%)	≤12	13–14	15–17	≥18	
n	335	282	295	240	
Men-years of follow-up	7,705	6,486	6,785	5,520	
Persistent LBP per 10,000 men-years	27	23	37	53	
Age-adjusted odds ratio (95% CI)	1.00 (reference)	0.85 (0.43–1.68)	1.41 (0.77–2.58)	2.10 (1.16–3.78)	**
Multivariable-adjusted ^a odds ratio (95% CI)	1.00 (reference)	0.86 (0.43–1.71)	1.46 (0.79–2.72)	2.12 (1.13–3.98)	*
Body mass index (kg/m ²)	≤20.81	20.82–22.30	23.31–24.05	≥24.06	
n	285	290	289	288	
Men-years of follow-up	6,555	6,670	6,647	6,624	
Persistent LBP per 10,000 men-years	26	33	33	44	
Age-adjusted odds ratio (95% CI)	1.00 (reference)	1.31 (0.68–2.52)	1.37 (0.71–2.65)	1.86 (0.99–3.49)	**
Multivariable-adjusted ^a odds ratio (95% CI)	1.00 (reference)	1.32 (0.68–2.55)	1.37 (0.71–2.68)	1.74 (0.89–3.39)	*

^aAdjusted for age, drinking, smoking, and maximal oxygen uptake.

*p<0.05, **p<0.01

CI: confidence interval

Table 4. Multivariable-adjusted odds ratios for incidence of persistent low back pain according to body mass index category based on WHO classification

	<18.50	18.50–24.99	25.00–29.99	≥30.00	p for linearity
n	45	924	169	14	
Men-years of follow-up	1,035	21,252	3,887	322	
Persistent LBP per 10,000 men-years	29	32	44	93	
Age-adjusted odds ratio (95% CI)	0.89 (0.27–2.94)	1.00 (reference)	1.47 (0.84–2.57)	3.46 (0.94–12.73)	**
Multivariable-adjusted ^a odds ratio (95% CI)	0.91 (0.27–3.03)	1.00 (reference)	1.37 (0.75–2.49)	3.31 (0.86–12.70)	*

^aAdjusted for age, drinking, smoking, and maximal oxygen uptake.

*p<0.05, **p<0.01

CI: confidence interval

taking into account the factors considered to be potential confounding factors, affecting the relationship between persistent low back pain prevalence and obesity. No clear relationship between age, maximal oxygen uptake, alcohol intake, smoking habits, and persistent low back pain was observed with respect to any of these factors.

Table 3 shows the age-adjusted and multivariable-adjusted odds ratios for %FAT and BMI and persistent low back pain prevalence by quartile. A significant positive dose-response relationship was shown between %FAT and persistent low back pain prevalence (p for linearity=0.010). Similarly, a significant positive dose-response relationship was confirmed between BMI and persistent low back pain (p for linearity=0.018). Using the group with the lowest %FAT as a reference, the multivariable-adjusted odds ratio (95% confidence interval) for the group with the highest %FAT with persistent low back pain was 2.12 (1.13–3.98). In contrast, this ratio was 1.74 (0.89–3.39) for BMI, and %FAT exhibiting a higher odds ratio.

To facilitate comparison of our results with those of previous studies, four BMI groups, thin (>18.50), average (18.51–24.99), overweight (25.00–29.99), and obesity (≥30.00), were designated according to WHO obesity classification. The odds ratios for persistent low back pain prevalence for these four groups are displayed in Table 4. This study targeted Asian populations, who comprise a small portion of the number of obese people worldwide. In addition, only 14 (1.2%) people classified as obese according to WHO criteria participated in the study, and participants included only 169 (14.7%) people classified as overweight. In contrast, the multivariable-adjusted odds ratio for persistent low back pain prevalence was 1.37 in the overweight group and 3.31 in the obese group, confirming that the risk for persistent low back pain was higher in overweight and obese groups.

DISCUSSION

In this study, the relationship between %FAT and BMI, which are an index of obesity, and persistent low back pain prevalence was evaluated longitudinally based on data collected from male workers in Japan. Our results revealed a positive dose-response relationship between obesity index and persistent low back pain, suggesting that obesity is a risk factor for persistent low back pain prevalence. This result was the same even when adjusting for multiple confounding factors using a logistic regression model.

The results of previous studies of the relationship between obesity and low back pain-related diseases in Japanese people showed similar results based on short-term follow-up^{18, 19)}, but this is the first study to determine the relationship between obesity and low back pain over a long period.

The results of meta-analysis studies of the relationship between obesity and low back pain suggest that there is a positive relationship between obesity and low back pain, similarly to the results of this study^{8, 9)}. Further, in a large-scale nationwide survey conducted in Norway over an 11 year period^{10, 11)}, a significant positive dose-response relationship between an obesity index (BMI) and chronic low back pain was reported for both males and females. However, studies targeting Western populations include a considerably different distribution of obesity compared to the participants assessed in this study. Male participants in the Norwegian National Large Scale Survey¹¹⁾ were divided into three groups: average (<25.0), overweight (25.1–29.9), and obesity (≥ 30.0), and the respective proportion of participants falling into these groups were 33%, 54%, and 13%, respectively, which is markedly different from the 84%, 15%, and 1% distribution observed during this study. In contrast, a positive dose-response relationship was observed between obesity and low back pain in both studies targeting Western populations and our study focusing on Asian populations; accordingly, a relative obesity trend is considered to be a risk factor for low back pain prevalence rather than the absolute obesity index.

Two plausible mechanisms may explain the relationship between obesity and persistent low back pain observed in this study: 1) biomechanical viewpoint and 2) association with endogenous substances.

The biomechanical viewpoint considers factors such as burden on the spinal column (intervertebral disc) when obesity increases abdominal size. Fabris de Souza et al.²⁰⁾ researched postural changes in obese subjects who exhibited a collapsed condition of whole body alignment resulting from increased downward gravity, excessive thoracic posterior curvature, and lumbar anterior curvature with respect to the spinal column. As such, the gain in mass in the upper body because of obesity increases the load on the vertebral discs, even when in standing or sitting positions. In addition, because gravitational pressure is further increased when an obese person bends the upper body forward, a greater force on the back muscle group becomes necessary, which is the main source of increased disc load.

Next, regarding the association with endogenous substances, it is thought that the proinflammatory cytokines induced by adipokines, which are secreted by adipocytes that proliferate in the obese state, may be associated with pain. Tumor necrosis factor α and interleukin-6 are representative proinflammatory cytokines, and serum interleukin-6 levels are thought to be elevated in obese people²¹⁾. As such, in hypertrophied adipocytes, abnormal secretion of endogenous substances such as adipokines and inflammatory cytokines may disrupt the balance of the endocrine system and be associated with pain.

In this study, BMI, which is one index of obesity calculated as a ratio of weight to height, and %FAT, which is more accurately, but indirectly evaluates the amount of adipocytes in the body, were calculated. We confirmed that %FAT is more strongly correlated with the prevalence of persistent low back pain than BMI. This supports the consideration that the amount of adipocytes is associated with persistent low back pain. Therefore, based on our results and those of previous studies as well as the mechanisms explained above, maintaining one's current weight regardless of the obesity standard and avoiding increases in body weight (increases in fat mass) are thought to be important for preventing persistent low back pain in both the near and far future. Our results suggest that obesity education and exercise guidance to avoiding increasing weight need to be importantly considered for prevention and treatment of low back pain.

The present study has some limitations. First, the study only included males in a metropolitan area. Second, it did not survey psychosocial or ergonomic factors associated with low back pain. Therefore, these parameters could not be adjusted for as confounders in the analysis. However, this is the first long-term cohort study designed to investigate the relationship between obesity and low back pain in Japanese workers. Moreover, by investigating the relationship with persistent low back pain using %FAT as well as BMI as an index of obesity even in a population with a relatively low prevalence of obesity, we demonstrated that accumulation of body fat is a risk factor for low back pain. These results will contribute to studies of methods aimed at preventing persistent low back pain. Further studies should include additional populations including females as study participants in order to broaden the applicability of the sample population and produce results that more accurately reflect the prevalence of persistent low back pain.

In conclusion, a significant positive dose-response relationship was observed between obesity index and persistent low back pain prevalence in Japanese males, and a relatively high %FAT and BMI were found to be risk factors for persistent low back pain. The results of this study suggest that weight control is important for preventing future persistent low back pain.

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