Letter to the Editor

Metabolic Syndrome and Medical Expenditure in Japan

To the Editor:

Although obesity is required for some definitions of metabolic syndrome, clustering of other risk factors also indicates an increased risk of cardiovascular disease. Whether the relationship between clustering of cardiovascular risk factor and medical expenditures differs with obesity requires investigations, especially in a population with a low prevalence of obesity such as in Japan. Okamura et al investigated this point in a 10-year cohort study of National Health Insurance in Shiga Prefecture and reported that the excess medical expenditures by risk-factor-clustering in normal weight categories were higher than those in overweight categories because more participants were of normal weight! The former expenditures were 16.5% and the latter were 7.1% of the total medical expenditures! The excess medical expenditures in the category of overweight with 2 or 3 other cardiovascular risk factors was only 2.9% of the total medical expenditure! Therefore, requiring obesity as an inevitable component of metabolic syndrome may be dangerous from a viewpoint of cutting down medical expenditure, though their definition of risk factors was somewhat different from ordinary components of metabolic syndrome. Kadota et al also reported in NIPPON DATA 90 that because the prevalence of non-obese participants with several metabolic risk factors was quite high, and their cardiovascular disease risk was high, excluding them from the diagnosis of metabolic syndrome because of absence of obesity might overlook their risk[2] Therefore, the definition of metabolic syndrome proposed by the examination Committee of Criteria for Metabolic Syndrome should not be used in clinical practice or in preventive medicine because this definition requires obesity as an obligate component[3] Besides, this definition was already revealed to be quite inappropriate as a prediction of cardiovascular disease by the Hisayama Study[4] We examined agreements among various definitions of metabolic syndrome for Japanese and elucidated that there are substantial disagreements[5] Therefore, we should not clinically label people with metabolic syndrome as the American Diabetes Association and the European Association for the Study of Diabetes jointly stated[6] until a truly consensus definition of metabolic syndrome for Japanese is established. Rather, it seems to me that we should address CRP as a link from obesity to insulin resistance and atherosclerosis, instead of anthropometric parameters of obesity[7,8]

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Author's Reply

Cardiovascular Risk Clustering With Obesity: A Good Target to Reduce Medical Expenditures as a First Step of High-Risk Approach in Communities and Worksites

We appreciate the letter by Dr Oda concerning about our recently published paper entitled "Effect of combined cardiovascular risk factors on individual and population medical expenditures: a 10-year cohort study of national health insurance in a Japanese population"[1] Cardiovascular risk factors are often clustered, which has resulted in a high incidence of cardiovascular disease accounted for by metabolic syndrome, recognized as visceral fat accumulation[2] Metabolic syndrome is diagnosed according to several criteria, some of which require obesity for the diagnosis. The definition proposed by the Examination Committee of Criteria for Metabolic Syndrome also requires abdominal obesity measured by waist circumference[3] From April 2008, the Ministry of Health, Labour and Welfare has decided to start a new health service system, which gives an opportunity for all citizens to prevent cardiovascular disease and diabetes by both screening for metabolic syndrome and lifestyle modification[4] This system requires the measurement of waist circumference and its main purpose is to ensure appropriate medical expenditure. As pointed out, the excess medical expenditure by cardiovascular risk clustering in normal weight categories (16.5%) was higher than those in overweight categories (7.1%) because more participants were of normal weight. Accordingly, intervention for obese persons only may not work well to hold back the increase in medical expenditure. However, we did not have values for fasting blood glucose, triglycerides or high-density lipoprotein-cholesterol, which are major components of metabolic syndrome. We may also have misclassified abdominal obesity because we used body mass index instead of waist circumference.

On the other hand, it is an important message that individual medical expenditure is highest for overweight persons with cardiovascular risk factor clustering. Such people are the main target for a high-risk approach to suppress the increase in medical expenditure. High-risk strategies, such as comprehensive health guidance by public health nurses, dieticians or physicians, can be readily understood and strongly motivate a person to change lifestyle to control cardiovascular risk factors. I believe it is feasible to spread a systematic way of health guidance to prevent metabolic syndrome in communities and worksites, because high-risk status due to obesity is easy to detect and easy to give a way to manage it. At least, as the first step in health guidance, public health nurses in local municipalities or nurses in factories do not need to have accurate evaluation of salt intake, the balance of polyunsaturated and saturated fatty acids, mental stress and so on. It is a kind of 'Selection and Concentration' in health service business.

However, another approach for the non-obese majority with cardiovascular risk factor clustering could be made, because they show a high-risk of cardiovascular disease[5] and account for a greater proportion of the excess medical expenditure than the obese minority. Effective and low-cost individual intervention methods are needed. Another way to solve this problem may be a 'population approach', which is useful for shifting the distribution of cardiovascular risk levels towards the low-risk side, even if this shift is minimal[6,7] For example, ingredient labeling for foods in supermarkets which shows accurate amounts of salt and details of fatty acids, is an effective method of giving information to many citizens. The contents of dishes in the restaurant and box lunches delivered by caterers should be evaluated, followed by a health professional's recommendations for improving the amount of sodium and potassium intake, nutritional balance, and caloric intake from fat. For physical activity, walking paths should be constructed for every area. Anyway, the criteria for metabolic syndrome and lifestyle modifications will be improved after the development of ongoing clinical and epidemiologic studies.

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2) Body Mass Index と医療費の関連；滋賀県国保コホートにおける 10 年間の追跡による検討

Nakamura K, Okamura T, Kanda H, Hayakawa T, Okayama A, Ueshima H; Health Promotion Research Committee of the Shiga National Health Insurance Organizations. Medical costs of obese Japanese: a 10-year follow-up study of National Health Insurance in Shiga, Japan. Eur J Public Health. 2007; 17: 424-429.

【目的】

Body Mass Index（以下、BMI）は肥満の簡便な指標である。肥満、特に内蔵性肥満はメタボリック症候群を介して循環器疾患の危険因子となるだけではなく、一部のがんや変形性膝関節症などの危険因子でもあり、これらの疾患を介して医療費の上昇をもたらす可能性があり、これを追跡調査によって明らかにすることを試みた。

【方法】

滋賀県内の 7 町 1 村における 40-69 歳の国民健康保険加入者 4,532 名（男性 1,938 名、女性 2,594 名）を約 10 年間追跡した。追跡開始時における BMI 値(kg/m^2)によって、対象者を「BMI＜18.5」、「18.5≦BMI＜25.0」と「25.0≦BMI」３つのカテゴリーに分けて、各カテゴリーの一人あたりの医療費と総死亡のハザード比（18.5≦BMI＜25.0 を基準）を評価した。

【結果】

25.0≦BMI 群の頻度は全対象者 4,532 名中それぞれ 18.0%であった。表に示すように、各カテゴリー一人あたりの医療費（算術平均）は 26,970（円/月）（BMI＜18.5）、19,115（円/月）（18.5≦BMI＜25.0）、22,072（円/月）（25.0≦BMI）であった。この３群の調整医療費（幾何平均）も同様な傾向を示し、BMI と医療費の関係は 18.5≦BMI＜25.0 群を底辺とするＪカーブであった。18.5≦BMI＜25.0 群と 25.0≦BMI 群の間には統計学的有意差を認めた。BMI＜18.5 群と 25.0≦BMI 群の総死亡のハザード比(それぞれ、1.76、1.21)も上昇を示した。25.0≦BMI 群を 2 つに分けた場合の医療費(算術平均)は 19,839（円／月）（25.0≦BMI＜30.0）、55,120（円／月）（30.0≦BMI）であった。喫煙状況で層化した場合、非喫煙者においても喫煙者においても BMI と医療費の関係は同様な Ｊカーブを呈した。対象集団の肥満関連医療費は対象集団の総医療費の 3.1%を占めていると考えられた。

【結論】

BMI 高値、すなわち肥満は医療費増加と有意に関連していた。肥満は生活習慣の是正によって予防や治療が可能なため、医療費抑制の観点からも、肥満対策は重要である。一方、BMI 低値は追跡開始時に重篤な疾患を持っていたため、この時には既に痩せた状態となっていて、その結果、医療費の上昇をもたらしたと推測される。

表. 一人あたり医療費と総死亡のハザード比(滋賀県国保コホート)

BMI カテゴリー	対象者数	一人あたり医療費(円/月)		総死亡	
		算術平均	幾何平均 *	ケース数	ハザード比(95%CI) *
BMI＜18.5	220	26,970	9,210	22	1.76 (1.12-2.77)
18.5≦BMI＜25.0	3,334	19,115	7,974	150	1.00
25.0≦BMI	948	22,072	10,384	40	1.21 (0.85-1.73)
			P<0.01		
25.0≦BMI＜30.0	888	19,839	10,017		
30.0≦BMI	60	55,120	17,872		

* 年齢、性、喫煙、飲酒を調整
注:論文中では医療費はEuroとして表示

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1) 論文発表

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Medical costs of obese Japanese: a 10-year follow-up study of National Health Insurance in Shiga, Japan

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Background: For the Japanese population, a body mass index (BMI) of 25.0–29.9 is classified as obesity and is a risk factor for cardiovascular disorders such as hypertension. **Methods:** A cohort study to clarify obesity costs for a Japanese population was conducted utilizing baseline BMI and medical costs over a 10-year follow-up period. The participants were 4502 community dwelling Japanese National Health Insurance (NHI) beneficiaries aged 40–69 years. According to their baseline BMI values (kg/m^2), participants were classified into the following three categories: BMI < 18.5, 18.5 ≤ BMI < 25.0 and 25.0 ≤ BMI. Medical costs per person per month were compared among the three categories. Excess medical costs attributable to the 25.0 ≤ BMI category compared to the 18.5 ≤ BMI < 25.0 category were estimated. **Results:** Approximately 20% of the Japanese population studied had a BMI of 25.0 or over. A J-shaped relationship between BMI and personal total medical costs was observed. Personal total medical costs per month determined from the 10-year follow-up in each category were 189 Euros (BMI < 18.5), 134 Euros (18.5 ≤ BMI < 25.0) and 155 Euros (25.0 ≤ BMI). A J-shaped pattern was observed after adjusting for age, sex, smoking and drinking habits, and excluding early deceased participants. Furthermore, smoking habit did not modify the J-shaped pattern of total medical costs. The estimated excess medical costs for the 25.0 ≤ BMI category represented 3.1% of the total medical costs for the entire study population (634 105 Euros). **Conclusion:** The Japanese NHI beneficiaries with a BMI of 25.0 or over showed increased medical costs compared to those with a BMI of 18.5–24.9.

Keywords: obesity, body mass index, medical costs, Japan

Introduction

Obesity is an important public health problem, and a cause of excess death[1–5] and medical costs[6–12] in many developed countries. In the United States, the impact of obesity on medical economics has been a major burden which has been examined by many studies.[6–10] However, the mean body mass index (BMI) in Asian populations is quite different from that found in Western populations[13,14], and the results of studies in the United States may not be directly relevant or adaptable to the Japanese population. Furthermore, no long-term cohort studies investigating obesity costs have been conducted for Asian populations. Therefore, we attempted to measure the effect of obesity, evaluated by BMI, on medical economics, using a 10-year follow-up study in a community-based population in Japan.

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Methods

Medical costs

In Japan, medical costs are based on the original medical insurance institution[15,16] which is under control of the National Government. This official medical insurance institution consists of two insurance systems, and everyone living in Japan is required to enroll in one of these insurance systems. There is no private medical insurance. The eligibility for each insurance system is as follows: the first system is for employees and their dependants and covers 65.3% of the overall population, while the other system is for self-employed individuals such as farmers and fishermen, as well as retirees and their dependants, and covers the remaining 34.7% of the population. All eligible beneficiaries in both insurance systems must pay an annual fee to help fund the system. In principle, both insurance systems guarantee that each beneficiary can have access to medical services for any condition at any clinic or hospital throughout Japan. Medical costs depend upon the medical services which a beneficiary receives at a clinic or hospital. No taxes are imposed on the medical costs. The clinic or hospital requests medical costs from both the insurance system and the beneficiary, with insurance paying 70% and the beneficiary paying 30% of the total costs. In the present study, total medical costs were divided into outpatient and inpatient medical costs.

Study design and participants

The cohort in the present study comprised 4535 Japanese beneficiaries of the National Health Insurance (NHI), the insurance system for self-employed individuals. The details of the present cohort have been reported previously.[17]

The participants, aged 40–69 years, lived in seven rural towns and one village in Shiga Prefecture, West Japan and had undergone a voluntary baseline survey in 1989–1991. In 1990, the study area had 82 155 residents, including 31 564 individuals aged 40–69 years old, of whom 11 900 were NHI beneficiaries.[18] Therefore, the participants in the present study represented approximately 38% of all NHI beneficiaries aged 40–69 years living in this area. Of the 4535 participants, 33 were excluded because of missing information at the time of the baseline survey. The remaining 4502 participants were included in the analysis. Monthly NHI claim history files of the Shiga NHI Organizations were linked with the baseline survey data files at the organizations. In order to protect the participants' privacy their names were deleted from the linked data at the organizations. Therefore, the data were analysed without knowledge of the participants' identity. The present study was approved by the Institutional Review Board of Shiga University of Medical Science for ethical issues (No. 16–15).

Data collection

A baseline survey was performed in the period 1989–1991 using standardized methods according to the Manual for Health Check-ups under the Medical Service Law for the Aged, issued by the Japan Public Health Association in 1987.[19] Body height and weight were measured, and BMI was calculated as body weight (kg) divided by the square of body height (m). Referring to the obesity classification of the World Health Organization[20] and that of the Japan Society for the Study of Obesity[21], the participants were classified into the following three categories: BMI $< 18.5\,kg/m^2$, $18.5 \leq$ BMI $< 25.0\,kg/m^2$ and $25.0 \leq$ BMI kg/m^2. Obesity is defined as a BMI of 25.0 or over for the Japanese population[21], although it is defined as a BMI of 30.0 or over for Western populations.[20] Thus, we also defined obesity as a BMI $\geq$ 25.0 in the present study. Smoking and drinking habits, and medication status for hypertension or a history of diabetes mellitus were evaluated from interviews performed by well-trained public health nurses. Blood pressure was measured using a standard mercury sphygmomanometer on the right arm of each participant in the sitting position after at least a five-minute rest. Serum total cholesterol levels were measured by an enzymatic method. Hypertension was defined as a systolic blood pressure $\geq$140 mmHg, a diastolic blood pressure $\geq$90 mmHg or taking anti-hypertensive medication. Hypercholesterolemia was defined as a serum total cholesterol level $\geq$5.69 mmol/l (220 mg/dl). Diabetes was defined as having a history of diabetes.

We evaluated medical costs per person after a 10-year follow-up, as well as all-cause mortality for each BMI category. We used the $18.5 \leq$ BMI < 25.0 category as a reference in the evaluation.[20,21] Medical costs per person in the two sub-categories of obesity ($25.0\,kg/m^2 \leq$ BMI $< 30.0\,kg/m^2$ and $30.0\,kg/m^2 \leq$ BMI) were also evaluated. Information on medical costs for each participant, as well as on participants who withdrew from the NHI or those who died, were obtained from monthly NHI-claim history files, beginning from April in the year following their initial health check-up until March 2001. Costs were expressed in Euros (i.e. 1 Euro = 143 Japanese Yen or 1.21 US Dollars, at the foreign exchange rate on 1 April 2006). Data on medical costs for each participant differed depending upon the period of subscription to the NHI. Therefore, medical costs for each participant were divided by the period of subscription and expressed as costs per month of follow-up. If a beneficiary withdrew from the NHI or died, the follow-up was stopped at that point, but was restarted for beneficiaries who withdrew and then re-enrolled in the NHI. Reasons for withdrawal from the NHI included moving to regions outside of Shiga Prefecture or transfer to the other insurance system.

Data analysis

Because the distribution of real medical costs was positively skewed, the data were logarithmically transformed in order to normalize the distribution, and the results were expressed as geometric means. For participants with 0 Euros (per month) in costs, the logarithmic transformations were performed by replacing 0 Euros with 0.01 Euros. There were 15 participants with total medical costs of 0 Euros and 16 participants with outpatient medical costs of 0 Euros. For comparisons of total and outpatient medical costs per person in each BMI category, we performed an analysis of covariance with the Bonferroni correction to adjust the *P*-value for multiple *post-hoc* comparisons. The analysis of covariance incorporated the following variables as covariates: age, sex, smoking habit (non-smoker or current smoker), and drinking habit (non-, current occasional or current daily drinker, using two dummy variables with the non-drinker as a reference). Because 2589 participants (57.5%) had inpatient medical costs of 0 Euros, logarithmic transformations were not performed, and the Wilcoxon's rank sum test was used to compare medical costs in each BMI category.

A Cox proportional hazards model for all-cause mortality was used to calculate the hazard ratio in each BMI category compared to the $18.5 \leq$ BMI < 25.0 category. This model also incorporated the same covariates previously listed.

Initially, the significance of an interaction for total medical costs and for all-cause mortality between BMI and sex was tested using an interaction term for the categorical variables in each multivariate-adjusted model. Next, medical costs per person and the hazard ratio for all-cause mortality in each of the three BMI categories were evaluated.

Smoking habit or poor health status is significantly associated with unintentional weight loss.[22] This may affect the relationship between BMI and medical costs, especially the medical costs of underweight people. Therefore, similar analyses were performed after taking into account smoking habit—i.e. non-smoking, including ex-smoking, or current smoking—for the three BMI categories. In addition, similar analyses were performed after excluding participants who had died in the first 5 years of follow-up.

Finally, we examined excess medical costs attributable to the $25.0 \leq$ BMI category compared to the $18.5 \leq$ BMI < 25.0 category by using the arithmetic means of total medical costs, when a significant difference in medical costs between the two BMI categories was observed. The excess medical costs attributable to the $25.0 \leq$ BMI category were calculated as follows: (total medical costs in the $25.0 \leq$ BMI category—total medical costs in the $18.5 \leq$ BMI < 25.0 category) $\times$ number of the participants in the $25.0 \leq$ BMI category.

The statistical package SPSS 14.0J for Windows (SPSS Japan Inc., Tokyo, Japan) was used for the statistical analyses. All probability values were two-tailed and the significance level was set at $P < 0.05$.

Results

The baseline risk characteristics of the 4502 participants grouped by BMI are summarized in Table 1. For both sexes, approximately 20% of all participants had a BMI of 25.0 or over, and approximately 1% had a BMI of 30.0 or over. For both sexes, the $25.0 \leq$ BMI category had the highest prevalence of hypertension, hypercholesterolaemia and diabetes mellitus in the three BMI categories. The BMI < 18.5 category had the highest mean age and the highest prevalence of current smokers and drinkers.

Table 1 Baseline risk characteristics of 4502 National Health Insurance beneficiaries in Shiga, Japan from 1989–1991, grouped by sex and body mass index

	Body mass index (BMI) (kg/m^2) category		
	BMI ≤ 18.5	18.5 ≤ BMI < 25.0	25.0 ≤ BMI
Men			
Number of participants (percentage)	95 (4.9%)	1492 (77.1%)	349 (18.0%)
Age (year)[a,c]	58.3 ± 8.0	54.0 ± 8.3	52.4 ± 7.6
Body mass index (kg/m^2)[a,c]	17.6 ± 0.7	22.0 ± 1.7	26.7 ± 1.6
Current smoker (%)[b,c]	74.7	60.5	54.4
Current drinker[b,c]			
Occasional drinker (%)	18.9	20.8	24.1
Daily drinker (%)	46.3	60.1	52.6
Hypertension (%)[b,c]	27.4	33.6	57.6
Hypercholesterolaemia (%)[b,c]	11.6	16.2	25.8
Diabetes mellitus (%)[b]	5.3	4.1	5.7
Women			
Number of participants (percentage)	125 (4.9%)	1842 (71.8%)	599 (23.3%)
Age (year)[a,c]	56.3 ± 7.9	54.3 ± 8.2	54.4 ± 7.2
Body mass index (kg/m^2)[a,c]	17.5 ± 0.9	22.1 ± 1.7	27.1 ± 1.9
Current smoker (%)[b,c]	11.2	3.0	2.8
Current drinker[b]			
Occasional drinker (%)	13.6	16.1	17.3
Daily drinker (%)	7.2	4.2	2.2
Hypertension (%)[b,c]	23.2	29.7	53.9
Hypercholesterolaemia (%)[b,c]	21.6	28.6	37.4
Diabetes mellitus (%)[b,c]	2.4	1.4	3.8

a: One way analysis of variance.
b: Chi-square test.
c: Significant difference among the three BMI categories, $P < 0.05$.

Table 2 Medical costs per person and all-cause mortality grouped by body mass index, from a 10-year follow-up from 1990 to 2001, in National Health Insurance in Shiga, Japan

Body mass index (BMI) (kg/m^2) category	Number of participants	Medical costs per person						
		Total		Outpatient		Inpatient	All-cause mortality	
		Arithmetic mean	Adjusted geometric mean[a]	Arithmetic mean	Adjusted geometric mean[a]	Arithmetic mean[c]	Number	Adjusted hazard ratio (95% CI)[d]
BMI < 18.5	220	189 Euros	65 Euros	83 Euros	43 Euros	105 Euros	22	1.76(1.12–2.77)
18.5 ≤ BMI < 25.0	3334	134 Euros	56 Euros	74 Euros	42 Euros	60 Euros	150	1.00
25.0 ≤ BMI	948	155 Euros	73 Euros[b]	86 Euros	53 Euros[b]	68 Euros	40	1.21(0.85–1.73)

1 Euros = 143 Japanese Yen or 1.21 US Dollars, at the foreign exchange rate on 1 April 2006
a: Analysis of covariance adjusted for age, sex, smoking habit and drinking habit.
b: Significant difference, vs. 18.5 ≤ BMI < 25.0, for multiple post-hoc comparisons with Bonferroni correction, $P < 0.05$.
c: Wilcoxon's rank sum test.
d: Analysis of a Cox proportional hazards regression model adjusted for age, sex, smoking habit and drinking habit.

The total person-years were 40 565 and mean follow-up period was 9.0 years. There was no interaction for total medical costs and all-cause mortality between BMI and sex. Furthermore, when we performed sex-specific analyses of the relationships between BMI and total medical costs or all-cause mortality, the pattern of results was similar for both men and women. Therefore, we reported the relationships for both sexes combined. The relationship between BMI and total medical costs per person was J-shaped, with the nadir of the curve occurring at a BMI of 18.5–24.9, as shown in Table 2. For the multivariate-adjusted geometric means of total medical costs, the differences among the three BMI categories were statistically significant ($P < 0.01$). The 25.0 ≤ BMI category showed a statistically significant 1.3-fold increase compared to the 18.5 ≤ BMI < 25.0 category. The BMI < 18.5 category also showed a 1.2-fold increase compared to the 18.5 ≤ BMI < 25.0 category, although the increase was not statistically significant. Similar statistically significant differences were observed in outpatient medical costs as well ($P < 0.01$). Inpatient medical costs showed statistically significantly differences among the three BMI categories ($P < 0.01$). When we performed the analyses with the obese participants classified into the two sub-categories, the arithmetic means for total medical costs were 139 Euros (per month) (25.0 ≤ BMI < 30.0; $n = 888$) and 386 Euros (30.0 ≤ BMI; $n = 60$). The adjusted geometric means of the total medical costs were 70 Euros (per month) (25.0 ≤ BMI < 30.0) and 125 Euros (30.0 ≤ BMI) (data not shown in the table). On the other hand, the relationship between BMI and all-cause mortality was inversely J-shaped, as shown in Table 2.

The pattern of personal medical costs was J-shaped among the non-smoking participants as well as the current smokers (data not shown in the table). The adjusted geometric means

for the total medical costs were 66 Euros (per month) (BMI < 18.5 non-current smokers; $n = 135$), 55 Euros ($18.5 \leq$ BMI < 25.0 non-current smokers; $n = 2376$), 72 Euros ($25.0 \leq$ BMI non-current smokers; $n = 741$), 63 Euros (BMI < 18.5 current smokers; $n = 85$), 59 Euros ($18.5 \leq$ BMI < 25.0 current smokers; $n = 958$) and 75 Euros ($25.0 \leq$ BMI current smokers; $n = 207$).

The pattern of personal medical costs was J-shaped after excluding the early deceased participants (data not shown in the table). The adjusted geometric means for the total medical costs were 61 Euros (per month) (BMI < 18.5; $n = 212$), 54 Euros ($18.5 \leq$ BMI < 25.0; $n = 3264$) and 70 Euros ($25.0 \leq$ BMI; $n = 931$).

The excess medical costs attributable to the $25.0 \leq$ BMI category as contrasted with the $18.5 \leq$ BMI < 25.0 category were estimated to be 19 908 Euros (per month), and were calculated as follows: (155 Euros − 134 Euros) × 948 participants with a BMI of 25.0 or over. Accordingly, the excess medical costs attributable to obesity, which was defined as a BMI of 25.0 or over, represented 3.1% of entire total medical costs for the 4502 participants (634 105 Euros), and was calculated as follows: 19 908 Euros/634 105 Euros.

Discussion

To our knowledge, few studies on medical costs for obesity have been conducted for Asian populations[12], and no long-term investigations have been conducted. The strength of the present study is that we conducted a much longer follow-up period (10-year) compared to previous studies.[12] We demonstrated that the relationship between BMI and medical costs in a general Japanese population was J-shaped, with the nadir of the curve occurring at a BMI between 18.5 and 24.9, after adjusting for confounding factors. In particular, personal total medical costs for groups with a BMI of 30.0 or over were much higher than those in groups with a BMI between 25.0 and 29.9. Smoking habit did not modify the J-shaped pattern of total medical costs. A similar J-shaped pattern was observed even after excluding participants who had died in the first 5 years of follow-up. After a 10-year follow-up, the excess medical costs attributable to participants with a BMI of 25.0 or over represented 3.1% of the total medical costs for all groups.

Obesity has been identified as a significant risk factor for hypertension[23,24], diabetes mellitus[23,25] and dyslipidaemia.[23,25] A combination of these syndromes is known as metabolic syndrome[26], which is a major risk factor for cardiovascular disease.[27,28] Obesity has also been identified as a significant risk factor for colorectal, prostate, endometrial, ovary and breast cancer.[29] Furthermore, obesity is a risk for knee osteoarthritis.[23,30,31] Some obese patients with knee osteoarthritis may require symptomatic relief or joint replacement surgery.[30] Obesity can lead to increased mortality and medical costs as a result of the associated diseases previously mentioned. In fact, the present study showed that the obese participants had a higher prevalence of hypertension, hypercholesterolaemia and diabetes mellitus at baseline. The prevalence of hypertension in the obese participants was substantially high. Accordingly, some obese participants in the present study may have incurred medical costs due to these disorders. Furthermore, serious diseases caused by these disorders (e.g. cardiovascular disease)[27,28] may also have led to increased medical costs of the obese participants. The latter possible explanation is supported by the higher hazard ratio for all-cause mortality in the obese participants.

Kuriyama *et al.*[12] reported a J-shaped relationship between BMI and medical costs after a 4-year follow-up in Miyagi Prefecture, East Japan. In their study[12], the estimated excess medical costs attributable to obesity from a BMI of 25.0 or over represented 3.2% of the entire costs for their study population. Our results are consistent with these results in spite of the different regions and follow-up periods. Accordingly, our results may be applicable to the Japanese population in general, despite some regional differences in lifestyle.[32] Wolf *et al.*[10] reported that medical costs associated with obesity defined as a BMI of 30.0 or over represented 5.7% of National Health Expenditure in the United States in 1995. The prevalence of people with a BMI of 30.0 or over in Western populations is 20–30%[33,34] which is almost equal to the prevalence of people with a BMI of 25.0 or over in the Japanese population.[13,15] These results suggest that the impact of people with a BMI of 25.0 or over on medical economics for the entire Japanese population is almost two-thirds that of people with a BMI of 30.0 or over in the United States.

Being underweight, which is usually defined as a BMI below 18.5[20,21], also represents a high risk of death when there has been unintentional weight loss.[22] Unintentional weight loss is significantly associated with older age, a lower BMI, a smoking habit or poor health status.[22] Furthermore, Wannamethee *et al.*[35] reported that increased mortality of underweight people was likely to be a direct result of a pre-existing disease which led to the underweight condition.[35] Smokers are especially likely to have a lower BMI than non-smokers due to serious diseases associated with smoking.[36–38] Therefore, some of the underweight participants in the present study, especially those with smoking habit, may also have had a serious disease which caused unintentional weight loss, thus leading to increased mortality and medical costs. Meanwhile, it is also possible that some of the normal weight participants may have experienced weight loss prior to baseline due to pre-existing diseases, which may have influenced medical costs during follow-up. The differences in medical costs between the obese participants and the normal weight participants, as well as the underweight participants, may have been underestimated in the present study. In order to examine the effects of smoking habit or pre-existing diseases, we performed analyses taking into account smoking habit and excluded premature death. We still found a J-shaped pattern of personal medical costs in these further analyses. Medical costs of underweight people are likely to be higher than those of normal weight people, irrespective of smoking habit or premature death. As for smoking habit, Hayashi *et al.*[5] reported increased all-cause mortality in the lower BMI groups regardless of smoking status (never smokers, ex-smokers and current smokers) for Japanese men. This result supports our result demonstrating increased medical costs of underweight participants with or without current smoking habit.

The present study has several limitations. First, medical cost data from the official medical insurance records in Japan do not include costs for any services used to prevent disease or to promote health status (e.g. special diet for weight control). If the obese participants took advantage of such services more frequently than the normal weight participants, the obese participants would have incurred medical costs more in excess of what we observed. Therefore, there may be a possibility that we underestimated obesity cost in the present study. However, all beneficiaries can take advantage of therapeutic services without paying an extra insurance fee, even if he or she suffers from a serious disease. Therefore, the results in the present study may be sufficient to reveal long-term medical costs of obese people. Second, participation was limited to NHI beneficiaries belonging to self-employed occupational groups in one area of Shiga prefecture in Japan.[15,16] The socio-economic status and lifestyle of these NHI beneficiaries may have had an effect on their health status, and may be a confounding factor among the three BMI categories. However,

socioeconomic status and lifestyle were not available in the present study. Third, we had no serial data for obesity-associated factors such as blood pressure after the baseline survey. Furthermore, medical diagnosis, medical treatment status and causes of mortality during the follow-up period were also not available in the present study. Therefore, we could not identify the events which directly increased medical costs among the obese participants. Finally, it is better to classify obesity into the two subcategories, $25.0 \leq \text{BMI} < 30.0$ and $30.0 \leq \text{BMI}$. However, we did not classify obesity further in the analysis, because the number of obese participants with a BMI of 30.0 or over was very small ($n = 60$) in our study population.

In spite of the limitations previously mentioned, we believe that medical costs of the obese or underweight participants increased due to diseases associated with a higher or lower BMI, and that the J-shaped relationship between BMI and medical costs in the present study are reasonable, and are supported by similar relationships between BMI and mortality in previous studies on Japanese populations.[3–5]

In conclusion, approximately 20% of the Japanese NHI beneficiaries in the present study had a BMI of 25.0 or over, and this BMI level was associated with a burden on medical economics in Japan.

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Key points

- The relationship between BMI and medical costs in a general Japanese population was J-shaped, with the nadir of the curve occurring at a BMI between 18.5 and 24.9, after a 10-year follow-up.
- Smoking habit did not modify the J-shaped pattern of total medical costs.
- The excess medical costs attributable to obese individuals having a BMI of 25.0 or over represented 3.1% of the total medical costs for all groups.
- Our results are consistent with finding reported after a 4-year follow-up, in spite of differing regions and follow-up periods, and may be applicable to the Japanese population in general.
- A BMI level of 25.0 or over may be associated with a burden on medical economics in Japan.

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Appendix

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4. 兵庫県T市における住民健診所見と国民健康保険医療費の関連

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背景

国民皆保険を柱とした医療制度を持続していくため、国は平成17年「医療制度改革大綱」を踏まえて総合的な医療制度の見直しを提示し、その中心的な事業の一つとして「生活習慣病予防の徹底」を図ることとした。平成20年4月から施行される「高齢者の医療の確保に関する法律」では、保険者を生活習慣病予防の実施主体と位置づけ、被保険者およびその扶養家族に対して、糖尿病等の生活習慣病に関する健康診断（「特定健康診査」）およびその結果により健康の保持に努める必要がある者に対する保健指導（「特定保健指導」）を実施するよう義務づけた。これにより医療費の伸びを抑制することを目指している。

これに伴い市町村は国民健康保険の医療保険者として特定健康診査等実施計画、特定健康診査、特定保健指導を実施することとなる。しかしながら従来の老人保健法保健事業の対象者と特定健康診査の対象者が異なること、今までメタボリックシンドロームに着目した健診がほとんどなされていないこと、さらには保健指導の医療費適正化の効果が明らかにされていないことから、特定健診・特定保健指導による医療費適正化の効果は不明である。本研究は、医療費適正化計画とその中間評価の設定期間に合わせ、過去の老人保健法に基づく基本健康診査の所見とその時点から3～5年間の国民健康保険医療費を突合し、その関連を明らかにすることを目的としている。主な狙いは二点あり、一つはどの所見を有する対象者が集団全体（国保加入者）の医療費を上昇させているか、またその有所見率がどの程度であるかを明らかにすることである。もう一つは、医療費上昇の原因となっている有所見者（メタボリックシンドローム該当者または予備群）を保健指導によりどの程度減らせば医療費がどの程度変化するのかを明らかにすることである。本研究班で同様の検討が滋賀県下で行われており、本研究は地理的・文化的背景が異なる地域で同様の知見が得られるかどうかを検証することも目的とした。

対象と方法

対象

本研究では兵庫県T市（人口約7万人）を対象として、過去の基本健康診査検査所見(以下、健診データ)と受診後4年間の国民健康保険医療費(以下、医療費データ)の関

連を検討した。医療費データは対象者の1年あたりの平均医療費（年間医療費）とし、入院医療費、入院外医療費、保健調剤費のそれぞれについて求め、同時に入院外医療費＋保険調剤費、医療費総額についても検討した。なお訪問看護や柔道・整復については、すべての医療費に占める比率が低いため今回は集計に含めなかった。本解析における医療費総額は、入院医療費、入院外医療費、保健調剤費の合計であり、上記のレセプト情報は含まれていない。

T市では、平成14年度の健診データと平成15年4月から平成18年3月までの4年間の医療費データを突合し解析した。T市では、当市部局内で健診データと医療費データが突合可能な状況になかったため、T市が委託した株式会社HITSにて両データの突合を実施した。なおT市では対象者の正確な国保加入期間が不明であり上記4年間の医療費データを解析する際に、平成15年3月31日以前に国保に加入しその後脱退していない者を分析対象とした。その結果、平成14年度の基本健診受診者12,662人のうち6,432人がこの条件に該当し、40歳以上75歳未満の4,993人を健診・医療費解析対象者とした。

解析方法

解析方法は、本研究班において滋賀県下で実施した方法に準じて実施した。はじめに個々の危険因子と年間医療費の関連を検討した。基本健康診査には腹囲のデータが含まれていないため、BMI（Body Mass Index, kg/m²）を代わりに用い、男女とも25 kg/m²を基準とした。メタボリックシンドローム関連の危険因子として、1．肥満（BMI 25 kg/m²以上）、2．コレステロール以外の血清脂質異常(トリグリセリド:150 mg/dl以上、HDLコレステロール:40 mg/dl未満)、3．高血圧(収縮期血圧、SBP:130 mmHg以上または拡張期血圧、DBP:85 mmHg以上)、4．耐糖能異常(HbA1c:5.2%以上)の4つを選定した。なお高血糖についてはメタボリックシンドロームの学会基準では110 mg/dlとなっているが、T市のデータでは食後採血時間が不明なこと、HbA1cを健診で全員測定していることから、「標準的な健診・保健指導プログラム（確定版）」の保健指導の階層化基準に合わせてHbA1cを用いて層別化した。またやはり階層化基準の項目である5．喫煙（現在及び過去に喫煙あり）、メタボリックシンドロームの構成要素には入っていないが重要な危険因子である6．高コレステロール血症（総コレステロール220 mg/dl以上)を加え、計6つの危険因子と年間医療費の関連を検討した。

まず初めに個々の危険因子についてその有無別に年間医療費を計算した。医療費は、総医療費（入院＋入院外＋保険調剤費）、入院医療費、入院外医療費、入院外医療費＋保険調剤費の4つを対象とし、5年間のそれぞれのレセプトを個人単位で合算し、その合計を国保加入期間で除して1年間の平均医療費（年間医療費）を求めた。次に各危険因子の保有者と非保有者の一人あたり医療費の比を「医療費増加比」、各危険因子の保有者と非保有者の一人あたり医療費の差を「医療費差額」とした。

$$医療費増加比 = \frac{危険因子ありの人の年間医療費}{危険因子なしの人の年間医療費}$$

医療費差額＝危険因子ありの人の年間医療費－危険因子なしの人の年間医療費

医療費増加比は、その危険因子があった場合の個人の医療費の増加比を示す。例えばこの数字が 1.6 であれば、年間医療費はその危険がない場合に比し 60%高いことを意味している。逆に危険因子があったほうが、医療費が安かった場合はこの値は 1 より小さくなる。医療費差額は、その危険因子があった人となかった人の 1 年間にかかった医療費の差であり、実際に何円多くなっているかを示している。ただし医療費増加比が 1 より小さい場合は、医療費差額はマイナスとして計算されてしまい、その危険因子があったほうが、むしろ医療費が低くなるものとして計算されてしまう。このような場合は、「危険因子があると医療費が減少する」という仮定をおくのは危険なため、偶然の変動と考えて医療費差額の計算は行わなかった。

次にその危険因子の存在によって集団全体（この場合は健診受診者）の医療費がどのくらい（%）増加しているかを求めた。これはその危険因子の保有により生じた医療費全体に占める過剰医療費の割合と考えられるため「過剰医療費割合」と名付けた。

$$過剰医療費割合 = \frac{医療費差額 \times 危険因子保有者人数}{医療費総額} \times 100\%$$

ここで注意が必要なのは、この値は「集団全体の」医療費に対する影響を示す指標であるため、高い医療費増加比を示す危険因子であっても、該当者の人数が少ないと過剰医療費割合は大きくならない点である。すなわち医療費増加比が大きいことに加えて、その危険因子を持つ人の人数が多くないと過剰医療費割合は大きくならない。医療費適正化計画は、個人ではなく被保険者全体の医療費を考えることになるため、この指標が非常に重要となる。なお医療費差額が計算されない場合（医療費増加比が 1 以下の場合）は、過剰医療費割合は欠損値として扱った。次に保健指導後の有病率と改善後過剰医療費を示した。保健指導後の有病率は、その危険因子の保健指導後の有病率を示しており、何の変化もなければ（有病率が不変であれば）100 のままであり、半減すると 50 となる。ここでは有病率を半減（50%）させた場合の改善後過剰医療費を示した（過剰医療費の半分となる）。

最後に個々の危険因子が集積することによる医療費への影響を検討した。危険因子の累積については、本邦のメタボリックシンドロームの基準に準じて、「肥満」を必須項目とし、総コレステロール血症を除く 4 項目のうち、危険因子ありの個数を求めて、0 個 、1 個、2 個以上の 3 群にカテゴリ分けして医療費との関連を検討した。ここで

も医療費増加比と過剰医療費割合、保健指導後の有病率を半減（50%）させた場合の改善後過剰医療費を求めた。なお特定保健指導は肥満者に実施することとなっており、階層化基準に合わせて「肥満あり」の対象者については、総医療費について、危険因子０個、１個、２個以上のそれぞれの状態について、医療費増加比、過剰医療費割合、改善後過剰医療費に加えて、保健指導での改善が必要な対象者数（現在の有病者数に保健指導後の有病率の減少割合を乗じた人数）を求めた。またそれによる「期待される医療費減少割合（過剰医療費の減少分）を男女別に示した。ここでは前述のように保健指導後の有病率が 50%の場合の医療費減少割合を提示した。

結果

図に各危険因子と年間医療費総額（総医療費）の分布を男女別に示した。肥満については図１に示したように、男女とも肥満者ではそうでない者に比べ年間医療費総額は高い傾向があった。脂質異常症（高トリグリセリド血症または低 HDL コレステロール血症、高コレステロール血症除く）については図２に示すとおり、男女ともに脂質異常症のものとそうでない者では年間医療費総額はほぼ同じであった。高血圧については図３に示すとおり、男女とも高血圧である者はそうでない者に比べて年間医療費総額が高い傾向を示した。また高血糖についても同様に、図 4 に示すとおり、男女ともに高血糖のものが高い傾向を示した。高コレステロール血症については図５に示すとおり、男女ともに高コレステロール血症の者とそうでない者では年間医療費総額はほぼ同じであった。喫煙については図 6 に示すとおり、男女ともに喫煙者のほうが非喫煙者に比べて年間医療費総額がやや低い傾向を示した。 図７、８は年間医療費総額について、肥満なし・ありに分けて、危険因子の個数別に総医療費の分布を帯グラフとして示した。男女ともに、肥満の有無にかかわらず、危険因子の数が増えるにしたがって医療費が増える傾向を認めた。

表１（入院医療費）、表２（入院外医療費）、表３（入院外医療費＋保険調剤費）、表４（医療費総額）に各危険因子の有無別にみた年間医療費の平均値（算術平均）、標準偏差、最小値、最大値、医療費増加比、医療費差額、過剰医療費割合（%）を示した。医療費は正規分布しないため算術平均と標準偏差に加え、最大値・最小値を示すことで分布の範囲を提示した。また本表の目的である過剰医療費割合を提示するため、実際にかかった医療費の算術平均を使用し計算を行った。その結果、入院医療費で過剰医療費割合が高かったのは、男性の高血圧（28.3%）、高血糖（14.4%）、女性の高血圧（22.6%）であった。また入院外医療費では、男女ともに高血圧の過剰医療費割合が高かった（31.8%と 15.2%）。入院外医療費＋保険調剤費では、男女の高血圧（30.4%と 16.7%）の過剰医療費割合が高かった。医療費総額でみると、男女の高血圧（29.7%と 18.3%）の過剰医療費割合が高かった。肥満による過剰医療費は、男性で 2.3%、女性で 6.4%であった。保健指導後の有病率を 50%と設定したため（保健指導で半分の人

の危険因子が消失)、改善後過剰医療費割合はこれらの過剰医療費割合の半分で示されている。

表５は医療費総額について、肥満なし・ありに分けて、危険因子の個数別に、医療費総額の平均値（算術平均)、標準偏差、最小値、最大値、医療費増加比、医療費差額、過剰医療費割合、改善後過剰医療費割合（保健指導後の有病率を 50%に設定）を示した。また特定保健指導の対象者である肥満者については、保健指導後の有病率を 50%とした際、保健指導での改善が必要とされる対象者数、その結果として減少が期待される医療費割合を求めた。特定保健指導の対象者の指導後の有病率を 50%とすると、保健指導での改善が必要とされる対象者数は 574 人（肥満者の 48%）であり、期待される医療費減少割合は、男性で 3.9%、女性で 5.8%であった。

考察

兵庫県 T 市の過去の健診データと国保医療費データを突合し、医療費の上昇をもたらしている危険因子について検討した。本研究における保険者支援としての新しい試みは、各危険因子による過剰医療費割合（その危険因子の存在によって増加したと考えられる医療費の医療費全体に占める割合）を明らかにした点である。医療費適正化計画は保険者の責務であるため、個人ではなく、集団（被保険者）全体の医療費上昇要因を明らかにする必要がある。T 市では、高血圧、次いで高血糖を有する者の過剰医療費割合が高かった。一方、肥満による過剰医療費は、男性 2.3%、女性 6.4%と低かったが、これは過剰医療費の比較対照群を単純に非肥満群としたためである。メタボリックシンドロームの階層化の基準に沿って、対象者を肥満と危険因子の数によって分類し、「危険因子を伴わない非肥満者」を比較対照群とした場合、「危険因子を伴う肥満」の過剰医療費割合は、男性で 7.9%、女性で 11.7%となり、保健指導で有所見者を半減させた場合、期待される医療費減少割合(%)はこれらの半分となるため、それぞれ 3.9%と 5.8%と考えられた。またそのために保健指導で改善が必要な肥満者の人数は 1195 人中 574 人であった。

表５の数字を用いて危険因子と医療費に関する様々なシミュレーションを行うことが可能である。例えば保健指導後の有病率を 75%に設定すると(保健指導によって 25%有所見者が減少した場合)、期待される医療費減少割合(%)は男性で 2.0%、女性で 2.9%と考えられた。またそのために保健指導で改善が必要な肥満者の人数は 1195 人中 287 人であった。医療制度改革大綱における政策目標は生活習慣病有病者を 25%減少させることとしているが、このシミュレーションではその効果をある程度予測していると考えられる。この目標達成のために改善しなければならない人数は肥満者全体の 24%（287 人）であり、保健指導による改善率を 50%と見積もると、約 600 人の対象者に保健指導を行う必要がある。また肥満のみを情報提供レベル、肥満＋危険因子１個を動機づけ支援レベル、肥満＋危険因子２個を積極支援レベルの対象者とすると、支援

レベル別の効果を予測することもできる。例えば動機付け支援レベルの保健指導後の有病率を85%（15%減少)、積極支援レベルの保健指導後の有病率を60%（40%減少）とすると、期待される医療費減少割合(%)は男性で2.9%、女性で4.1%と考えられる。なお本解析では標準的な健診・保健指導プログラムの手順に従って、肥満のある者に対する保健指導による医療費適正化効果を求めたが、実際は非肥満かつ危険因子ありから発生している過剰医療費割合が男性では15%、女性では20%あることを銘記しておくべきである。特定保健指導以外にもこれらの「やせた危険因子保有者」に対する対策が必要である。

なお表１－５の対象者数と保健指導後の有病率（%)にいろんな数字を入力することによって、医療費適正化の効果（期待される医療費減少割合)を予測することが可能である。なお実際の医療費は構成員の平均年齢の上昇や診療報酬の改定等の影響を受けるため、必ずしもこのシミュレーションの予測通りに行かないこともあり得るが、本結果は実際のデータ（エビデンス）に基づいた科学的な推計と考えられ、その意義は大きい。なお今後の検討課題として、検診所見の変化と医療の推移の関連を見る必要がある。すなわち、実際に検査所見が改善したりメタボリックシンドロームが改善したりした人の医療費の推移を検討する必要があると思われる。

結論

男女ともに肥満、高血圧、高血糖を有する者で医療費総額は高く、また肥満の有無に関らず危険因子の数が増加するに従い総医療費は高くなる傾向にあった。肥満による過剰医療費は医療費総額において男性2.3%、女性6.4%であった。これは滋賀県下の市町での解析結果とほぼ同様であった。特定保健指導対象者の指導後の有病率を50%と設定すると、期待される医療費総額の減少割合は4～6%であった。高血圧・高血糖の過剰医療費割合が高く、また非肥満で危険因子ありから発生している過剰医療費割合が15～20%あることから、特定保健指導一巡後は、次の課題としてやせた危険因子保有者に対する対策が必要である。

図1　　肥満と平均年間医療費(総額)

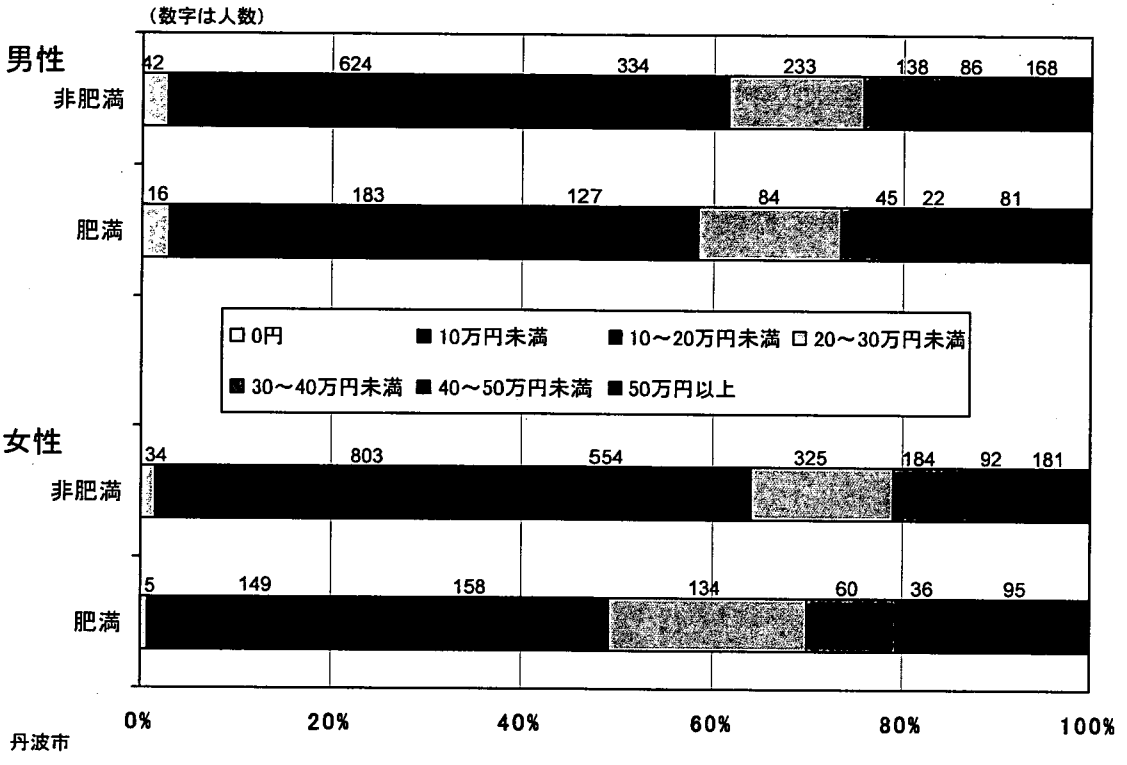

図2 高コレステロール血症を除いた脂質異常症と平均年間医療費(総額)

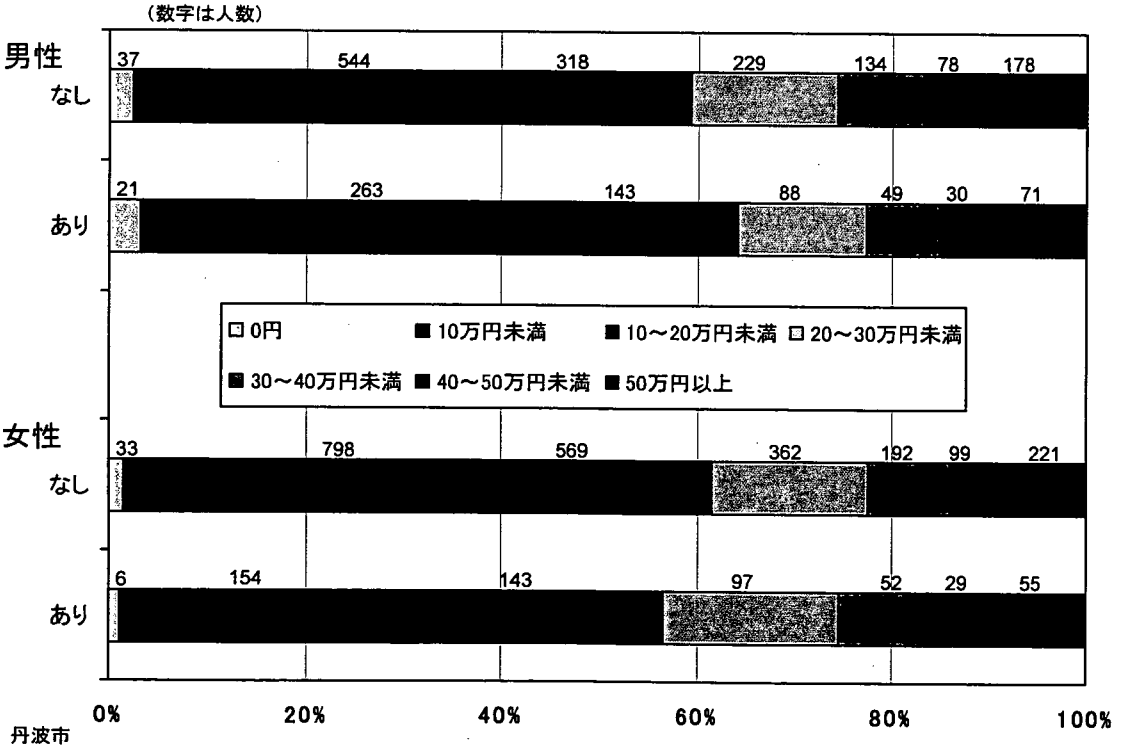

図3 高血圧と平均年間医療費(総額)

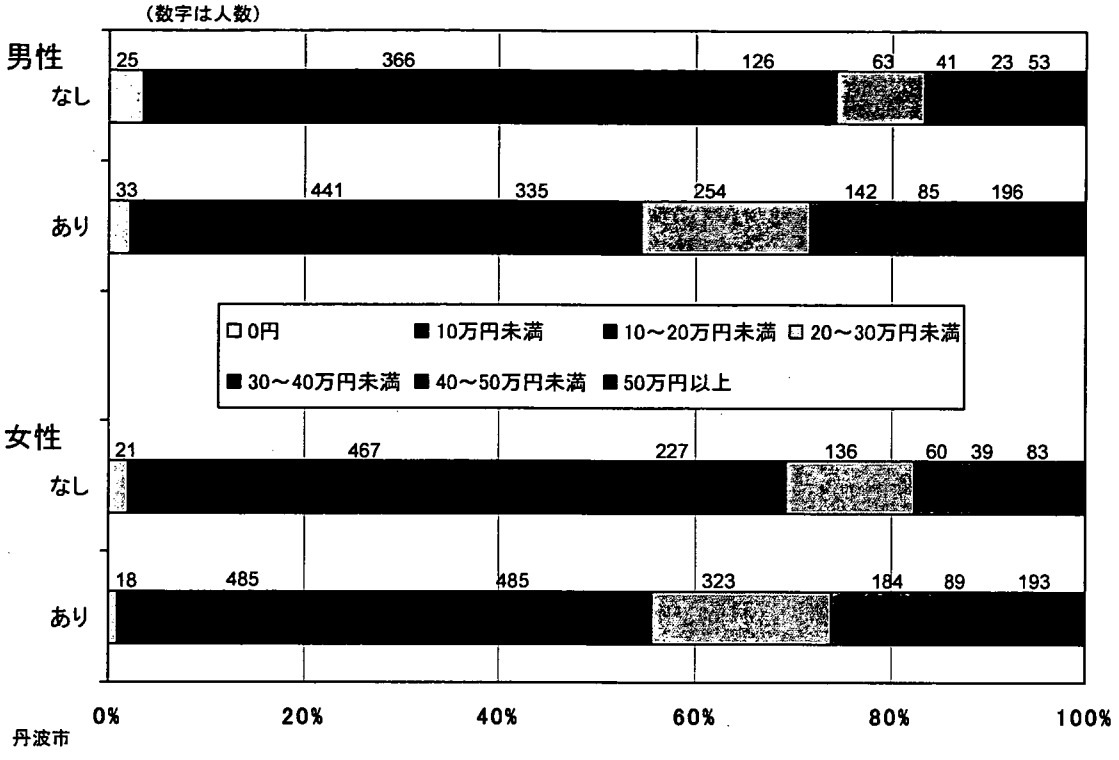

図4 高血糖と平均年間医療費(総額)

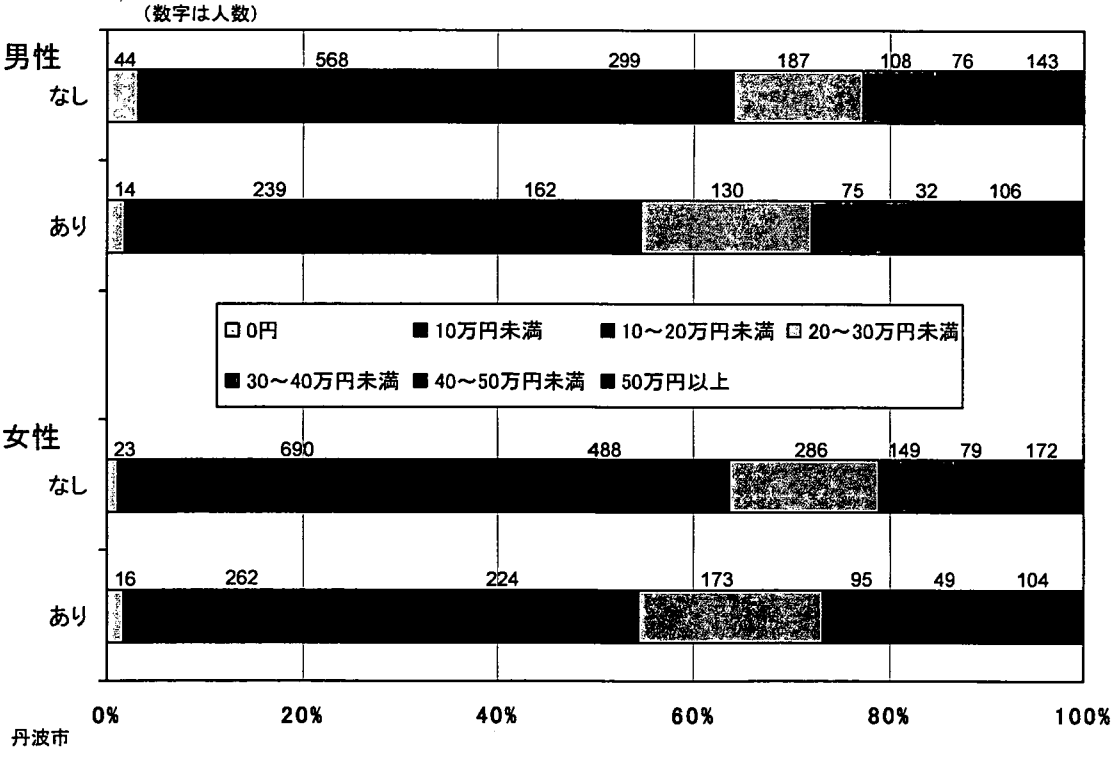

図5 高コレステロールと平均年間医療費(総額)

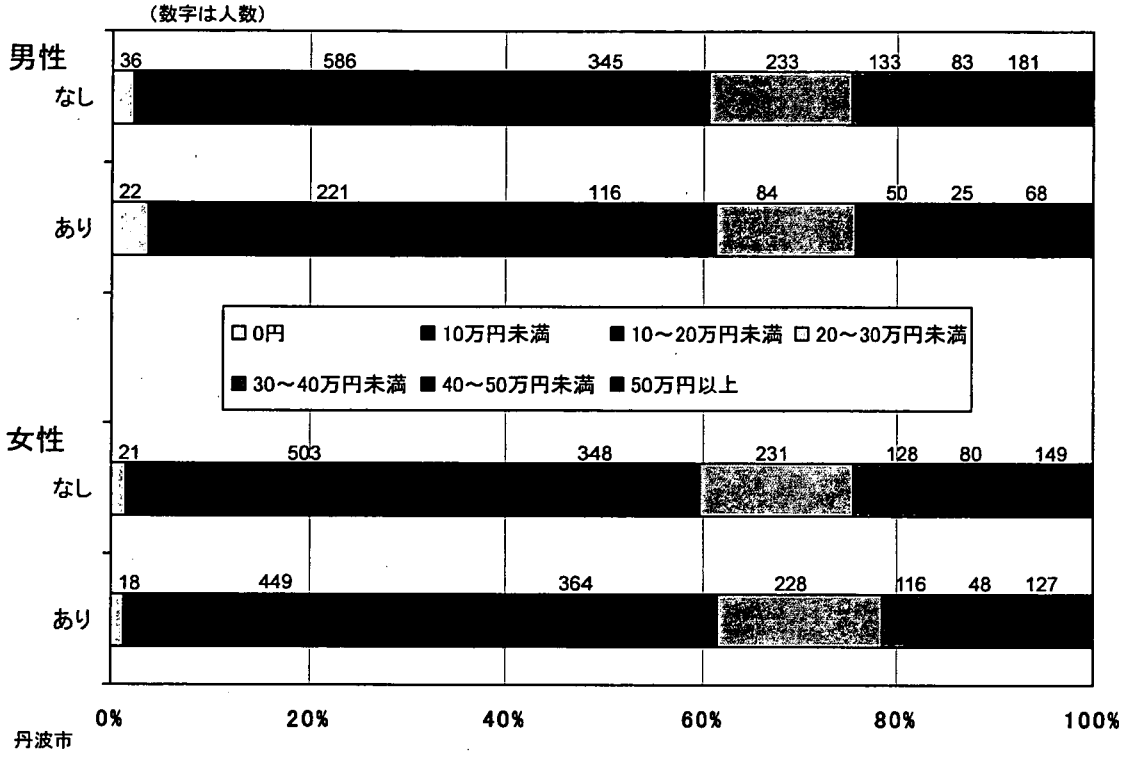

図6 喫煙と平均年間医療費(総額)

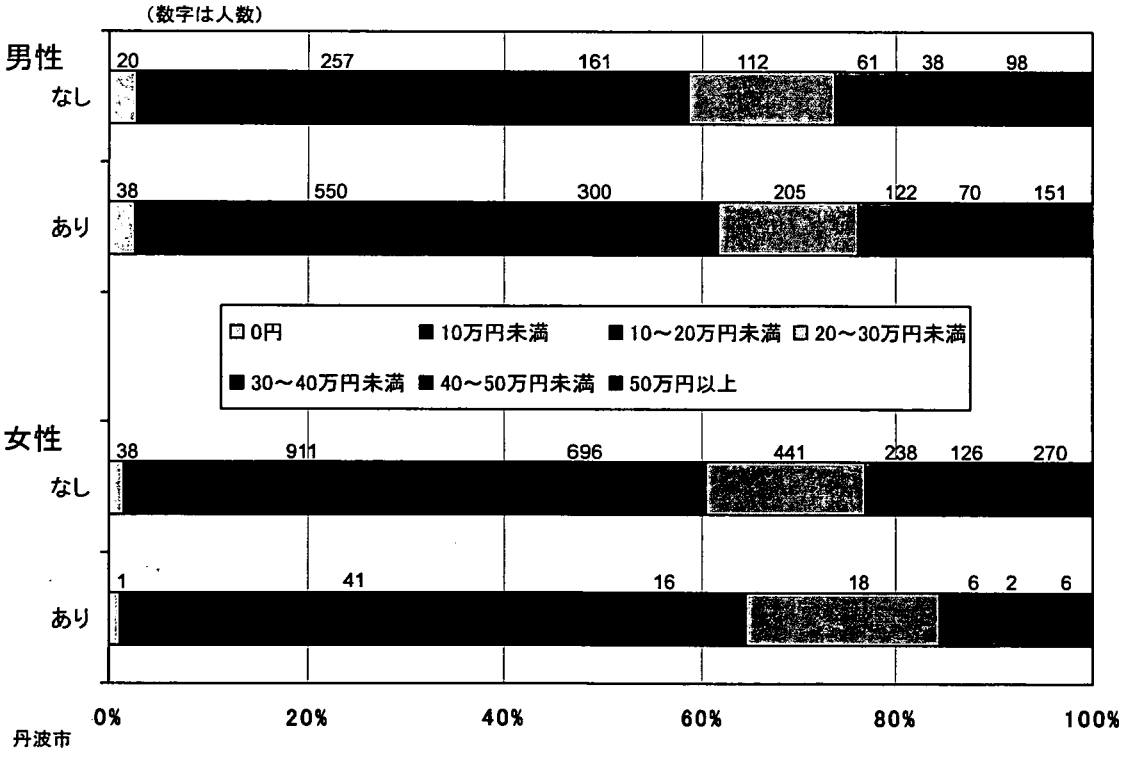

図7 危険因子の集積と平均年間医療費(総額):肥満なし

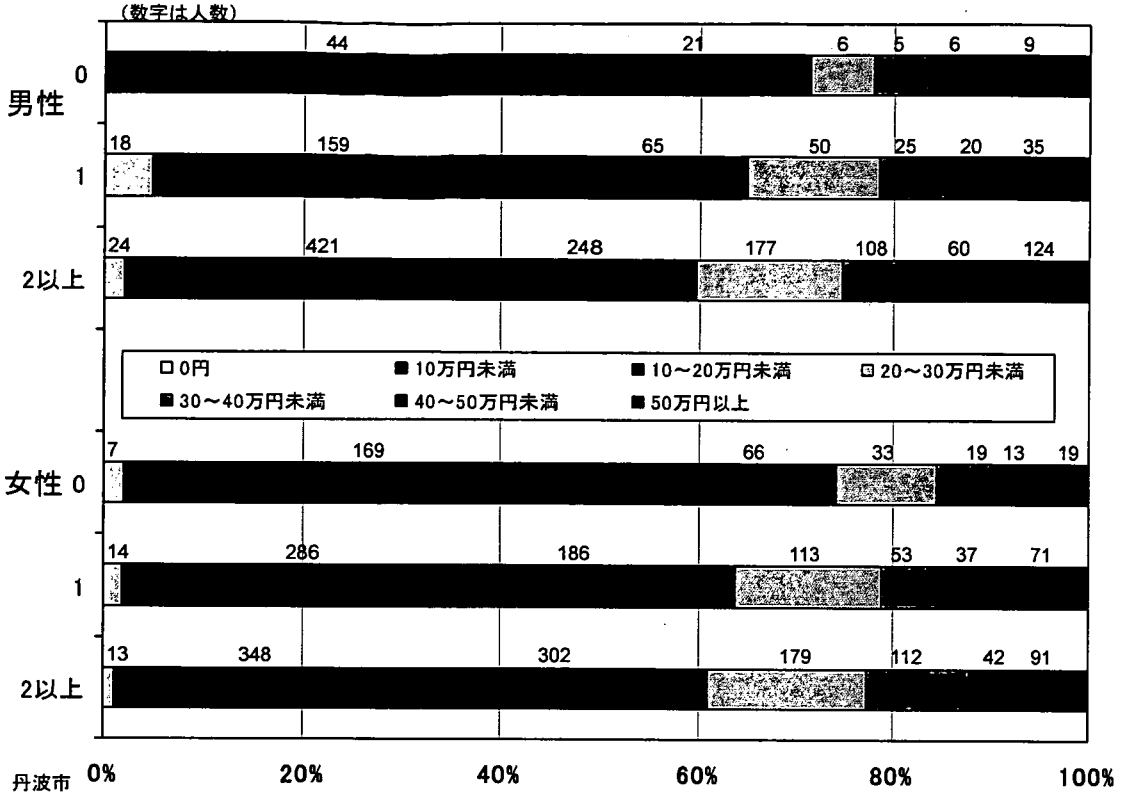

図8 危険因子の集積と平均年間医療費(総額):肥満あり