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Impact of obesity on annual medical expenditures and diabetes care in Japanese patients with type 2 diabetes mellitus

Chisato Kusunoki-Tsuji[1], Shin-ichi Araki[1]*, Shinji Kume[1], Masami Chin-Kanasaki[1], Norihisa Osawa[1], Katsutaro Morino[1], Osamu Sekine[1], Satoshi Ugi[1], Atsunori Kashiwagi[2], Hiroshi Maegawa[1]

[1]Department of Medicine, Shiga University of Medical Science, Otsu, and [2]Kusatsu General Hospital, Kusatsu, Shiga, Japan

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***Correspondence**
Shin-ichi Araki
Tel.: +81-77-548-2222
Fax: +81-77-543-3858
E-mail address:
araki@belle.shiga-med.ac.jp

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ABSTRACT

Aims/Introduction: Diabetes and obesity are important health and economic concerns. We investigated the influence of obesity on diabetes control, the annual medical expenditures and medications in Japanese patients with type 2 diabetes who were relatively lean in comparison with those in Western countries.

Materials and Methods: A total of 402 Japanese patients with type 2 diabetes were enrolled and their annual medical expenditures investigated. Obesity was defined as body mass index ≥25 kg/m^2, according to the obesity classifications from the Japan Society for the Study of Obesity.

Results: A total of 165 patients (41.0%) were classified as obese. The obese group was younger, had poor glycemic control and higher frequency of hypertension than the non-obese group. The median total annual medical expenditures for all participants was ¥269,333 (interquartile range ¥169,664–437,437), which was equivalent to approximately $US2,450. The annual medical expenditure was significantly higher in patients with obesity than in non-obese patients ($P < 0.001$). This difference was mainly attributed to the annual expenditures for medication and hospitalization. In particular, the medication expenditures and the average number of drug classes for hyperglycemia and hypertension were significantly higher in the obese group.

Conclusions: Japanese patients with type 2 diabetes and obesity had higher annual medical expenditures and a larger number of medications, but their diabetes control care was insufficient in comparison with those without obesity. Further studies are required to assess the effect of reducing bodyweight on diabetes control and costs.

INTRODUCTION

The prevalence of diabetes and obesity has continuously increased worldwide in recent decades. These pandemics are mainly attributed to population growth, aging and lifestyle changes. Diabetes and obesity are well recognized as risk factors for cardiovascular disease and mortality. Correspondingly, patients with both diabetes and obesity tend to have immense medical expenditures and to take more medications in order to maintain their quality of life and longevity. In the USA, the annual per capita medical spending for patients with diabetes was estimated to be more than twice that of patients without diabetes[1], and the managing expenses for diabetes have also increased[2]. According to the International Diabetes Federation, diabetes already accounts for 5–10% of the total healthcare budget in many countries[3]. In addition, the association between high medical expenditures and obesity was reported in the USA and UK[4]. Thus, these pandemics are not only a public health concern, but also a social economic issue.

Although these changes are taking place worldwide, the increase in the prevalence of diabetes is estimated to be particularly high in Asian countries, including Japan[5,6]. In addition, the clinical characteristics of type 2 diabetes are somewhat different between Japanese and Caucasian populations. In particular, the average body mass index (BMI) in Japanese patients with diabetes is relatively lower than that in people in Western countries, even though their average BMI is increasing

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annually[7]. In particular, the proportion of patients with BMI ≥ 30 kg/m^2, which is defined as obesity by the World Health Organization, is much lower in Japan than that in Western countries[8]. Thus, obesity in Japan[9] is defined as BMI ≥ 25 kg/m^2, which is considered overweight by the World Health Organization. Several studies using data from the Japanese health insurance system to estimate the medical expenditures reported the association between the medical expenditures and diabetes[10,11] or obesity[12,13] in the Japanese population. However, using this approach, it is difficult to simultaneously evaluate the influence of obesity on medical expenditures and clinical characteristics. Thus, the influence of obesity on diabetes care, medical expenditures and medications in relatively lean Japanese diabetes patients remains unclear. Clarification and identification of these associations are important for exploring measures to improve diabetes care and reduce medical costs. Thus, we carried out a cross-sectional study to investigate the influence of obesity on these medical concerns, particularly annual medical expenditures, in Japanese patients with type 2 diabetes.

METHODS

Participants and measurements

The participants in the present study were enrolled from among those with type 2 diabetes who registered in the ongoing Shiga Prospective Observational Follow-up Study[14,15], and who underwent the annual medical examination for this follow-up study in fiscal year 2011 and fiscal year 2012 (from April 2011 to March 2013). This study was carried out with adherence to the principles of the Declaration of Helsinki. The study protocol and informed consent procedure were approved by the ethics committee of Shiga University of Medical Science. Patients with cancer, chronic infectious disease or collagen disease were excluded from the present study because of their high medical costs unrelated to diabetes and obesity. Those with Japanese livelihood protection were also excluded. Finally, 402 patients were enrolled in the present study. After obtaining written informed consent, each participant underwent an annual medical examination including the standard physical examination, and sampling of fasting blood and the first-morning urine. BMI was calculated as weight divided by the square of height (kg/m^2). In the present study, obesity was defined as BMI ≥ 25 kg/m^2 according to the obesity classifications of the Japan Society for the Study of Obesity[9]. The serum and urine samples were immediately used to measure all laboratory variables at the Shiga University of Medical Science Hospital. Hemoglobin A1c (HbA1c) levels were presented as National Glycohemoglobin Standardization Program values, according to the recommendations of the Japanese Diabetes Society[16]. Hypertension was defined as blood pressure (BP) ≥ 140/90 mmHg or current use of antihypertensive drugs. Estimated glomerular filtration rate was calculated using the simplified prediction equation proposed by the Japanese Society of Nephrology[17]: estimated glomerular filtration rate (mL/min/1.73 m^2) = 194 × (age [years])$^{-0.287}$ × (serum creatinine [mg/dL])$^{-1.094}$ × 0.739 (for women). Albuminuria was defined as ≥30 mg/g creatinine of urinary albumin-to-creatinine ratio in the first-morning urine. The diagnosis of diabetic retinopathy was made by an ophthalmologist. Diabetic retinopathy was defined as background or more stage.

To calculate the annual medical expenditure for each individual, we investigated the participants' payment bills, burden of insurance and prescription medicine record in our hospital for 1 year from the day of the annual medical examination. The annual medical expenditures were the total healthcare costs, including fees for outpatient services (physician consulting fees, medical supervision charges, testing fees etc.), medications (prescription fees and medicine costs) and hospitalization expenses, which also included the treatment costs for diabetes-unrelated disease that occurred during the 1-year period. Several participants received medications in other clinics. In those cases, the medical expenditures were estimated based on patient reporting. The annual medical expenditures were presented in Japanese yen (¥) per year (¥100 = $US0.91). In addition, the prescriptions were reviewed to identify the classes of drugs used for the treatment of hyperglycemia, hypertension and hyperlipidemia during the 1-year observation period; the numbers of classes of medications for each category were calculated for each participant. This counting included only medications used for at least 1 month. In the present study, the drug classes for a glucose-lowering therapy included biguanides, sulfonylureas, glinides, thiazolidines, α-glucosidase inhibitors, incretin-related agents (dipeptidyl peptidase 4 inhibitors and glucagon-like peptide 1 receptor agonists) and insulins. Sodium–glucose cotransporter 2 (SGLT2) inhibitors were not commercially available in Japan during the study period. The categories for hypertension included calcium channel blockers, renin–angiotensin system inhibitors (angiotensin receptor blockers and angiotensin-converting enzyme inhibitors), diuretics and others. Those for dyslipidemia included statins and others. We counted as one drug class if patients took two or more agents, which were categorized in the same drug class (e.g., rapid-acting insulin and long-acting insulin).

Statistical analysis

Data are expressed as mean ± standard deviation or medians (interquartile range), as appropriate. In comparing the two groups, χ^2-tests were used for categorical variables, whereas unpaired Student's *t*-tests were used for normally distributed variables, and the Mann–Whitney *U*-test for variables with skewed distributions. In addition, we carried out the comparison between the two groups by using independent *t*-test, instead of the Mann–Whitney *U*-test, according to the central limit theorem. All analyses were carried out using IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, New York, USA). Two-sided *P*-values <0.05 were considered statistically significant.

RESULTS

Clinical characteristics

The clinical characteristics of 402 patients and two subgroups stratified by obesity status are presented in Table 1. A total of 165 patients (41.0%) were classified as obese (BMI ≥ 25 kg/m^2). Just 8.7% of this study population had a BMI ≥ 30 kg/m^2. The patients with obesity were younger, and had higher mean levels of waist circumference, HbA1c, diastolic BP, total cholesterol and triglycerides, and frequency of hypertension compared with those without obesity. In contrast, the mean level of high-density lipoprotein cholesterol was lower in patients with obesity than in those without. During the 1-year observation period, 13% were hospitalized for any medical reasons. The total number of hospitalizations in 1 year did not differ significantly between the subgroups. The average rate of outpatient visits for 1 year also did not differ between the groups. No participants died during the 1-year period.

Effect of obesity on annual medical expenditures

We first calculated and compared the total annual medical expenditure (Table 2). The median total annual medical expenditures for all participants was ¥269,333 (interquartile range ¥169,664–437,437, maximum ¥2,708,081). This was equivalent to approximately $US2,450. In subgroup analysis stratified by obesity status, the total annual medical expenditure was significantly higher in patients with obesity than in those who were not obese ($P < 0.001$). When we carried out the comparison between them by using independent *t*-test instead of the Mann–Whitney *U*-test, the significant difference was similarly observed ($P = 0.007$). Next, we separately compared the effect of obesity on each annual expenditure for outpatient services, medication and hospitalization (Table 2). The annual expenditures for all outpatient services were significantly higher in those with obesity than in those without it, whereas the annual expenses for only outpatient services except for medications did not differ significantly. In particular, the medication expenditures for hyperglycemia, hypertension and dyslipidemia were significantly higher in those with obesity than in those without. Comparison of only hospitalization expenses showed similar significant differences.

Effect of obesity on medication

The ratio of patients who took any medications for hyperglycemia in the 1-year observation period was significantly

Table 1 | Clinical characteristics of all patients and of two subgroups stratified by obesity status

Variable	All	BMI (kg/m^2)		*P*-value[†]
		<25	≥25	
n	402	237	165	
Male (%)	66.2	66.7	60.6	NS
Age (years)	66 ± 11	68 ± 9	63 ± 12	<0.001
BMI (kg/m^2)	24.7 ± 4.1	22.1 ± 2.0	28.4 ± 3.4	<0.001
Known diabetes duration (years)	17 ± 10	17 ± 10	15 ± 10	<0.05
Waist circumference (cm)	89 ± 11	83 ± 8	98 ± 9	<0.001
HbA1c (%)	7.3 ± 1.0	7.2 ± 0.9	7.5 ± 1.1	0.001
Total cholesterol (mg/dL)	191 ± 32	191 ± 31	191 ± 33	NS
HDL cholesterol (mg/dL)	54 (44–61)	56 (47–66)	52 (43–62)	<0.001
Triglycerides (mg/dL)	93 (69–144)	96 (70–147)	112 (81–155)	0.01
LDL cholesterol (mg/dL)	104 ± 26	103 ± 26	107 ± 26	NS
Systolic BP (mmHg)	136 ± 17	135 ± 18	137 ± 17	NS
Diastolic BP (mmHg)	74 ± 11	73 ± 11	75 ± 12	<0.05
Hypertension (%)	75.1	70.5	81.8	0.01
Retinopathy (%)	20.6	20.3	21.2	NS
Urinary albumin-to-creatinine ratio (mg/g Cr)	11 (5–27)	10 (6–23)	12 (5–28)	NS
Albuminuria (%)	22.5	21.9	23.4	NS
eGFR (mL/min per 1.73 m^2)	74 ± 23	73 ± 22	74 ± 25	NS
Current smoking (%)	17.4	17.7	17.0	NS
Past history of CVD (%)	19.4	20.7	17.6	NS
Hospitalization (*n*)	54	31	23	NS
Outpatient visits (times per year)	9.0 ± 3.6	8.7 ± 3.5	9.4 ± 3.8	NS

Data are expressed as mean ± standard deviation for normally distributed continuous variables or medians (interquartile range) for skewed continuous variables. Obesity categorized by body mass index (BMI) ≥ 25 kg/m^2. [†]Differences between the two subgroups were compared using a χ^2-test for categorical variables, Student's *t*-test for normally distributed continuous variables and the Mann–Whitney *U*-test for skewed continuous variables. BP, blood pressure; Cr, creatinine; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; HbA1c, hemoglobin A1c; HDL, high-density lipoprotein; LDL, low-density lipoprotein; NS, not significant.

Table 2 | Annual medical expenditures of all patients and of two subgroups stratified by obesity status

Variable	All	Body mass index (kg/m^2)		*P*-value[†]
		<25	≥25	
Total	¥269,333 (¥169,664–437,437)	¥252,263 (¥153,218–389,635)	¥294,548 (¥183,090–488,909)	0.004
All outpatient services[‡]	¥260,111 (¥163,671–400,038)	¥242,082 (¥151,866–356,663)	¥293,792 (¥181,923–448,031)	0.001
Outpatient services except for medications	¥95,900 (¥54,630–187,061)	¥92,490 (¥53,775–182,850)	¥100,650 (¥57,120–18,895)	0.22
Medications	¥133,183 (¥82,120–212,902)	¥120,663 (¥72,994–176,934)	¥161,931 (¥101,719–247,644)	<0.001
Hyperglycemia	¥67,127 (¥26,704–107,071)	¥60,439 (¥19,107–99,800)	¥79,647 (¥39,824–132,399)	<0.001
Hypertension	¥26,748 (¥0–60,996)	¥19,893 (¥0–53,338)	¥44,895 (¥1,149–72,578)	0.001
Dyslipidemia	¥18,382 (¥0–39,303)	¥9,888 (¥0–36,849)	¥24,354 (¥0–41,930)	0.02
Hospitalization[§]	¥602,079 (¥284,913–1,030,000)	¥307,119 (¥247,845–599,400)	¥602,079 (¥284,913–1,030,000)	0.03

Data are expressed as medians of Japanese yen (interquartile range). Obesity categorized by body mass index (BMI) ≥25 kg/m^2. [†]Differences between subgroups were compared using Mann–Whitney *U*-tests for skewed continuous variables. [‡]All outpatient services = total medical expenditures – hospitalization costs. [§]Data were analyzed only in patients that were hospitalized (total 54 patients; 31 without and 23 with obesity).

higher in the obese group than in the non-obese group (Table 3). In addition, the average number of drug classes prescribed as medications for hyperglycemia was also significantly higher in the obese group than in the non-obese group (2.0 ± 1.1 vs 1.6 ± 1.0 per individual, $P < 0.001$). In particular, the prescription rates of biguanides and thiazolidines were significantly higher in the obese group. Similar trends were observed for medications for hypertension (Table 3). The percentages of patients who took any antihypertensive medications were 75.8 and 62.4% in the obese and non-obese groups, respectively ($P = 0.005$); the average numbers of drug classes prescribed for hypertension were 1.6 ± 1.3 and 1.1 ± 1.1 ($P < 0.001$), respectively. The ratios were not significantly different between groups for medications prescribed for dyslipidemia (61.8 vs 54.4% for obese and non-obese groups, respectively; $P = 0.15$).

DISCUSSION

The results of the present study showed that the annual medical expenditures were higher in Japanese type 2 diabetes patients with obesity (BMI ≥ 25 kg/m^2) than in those who were not obese. This difference was mainly attributed to medication expenditures and hospitalization costs. In addition, patients with obesity were younger, and had higher glycemic, diastolic BP and lipid levels, although they were prescribed a larger number of medications and had higher medication fees in comparison with those who were not obese. These results show that overweight in type 2 diabetes is an important clinical factor, which influences both the medical economy and diabetes care. Thus, the optimal reduction in bodyweight might be a therapeutic target not only for diabetes care, but also for medical economy.

Diabetes is expected to impose an increasing economic burden worldwide[3]. In the USA, adults with diabetes had higher health expenditures from 2002 to 2011 compared with those without diabetes; the bulk of the expenditures came from hospitalization and prescriptions[18]. Furthermore, the comorbidity of obesity, another worldwide health concern, in diabetes patients is associated with not only increased risk of mortality, but also excess medical expenditures in Western countries. Cawley *et al.*[19] reported that the predicted total annual medical expenditures of individuals with diabetes increased non-linearly with BMI, and that the relationship between BMI and medical expenditures was more pronounced than among those without diabetes. In Germany, obesity was associated with significant increases in healthcare costs in diabetes patients[20]. The results of the present study are consistent with those of studies from Western countries, although Japanese patients with type 2 diabetes are relatively lean in comparison with those in Western countries. Thus, overweight and obesity in diabetes patients should be considered a worldwide health and economic concern regardless of ethnicity.

The strength of the present study was that it simultaneously evaluated the influence of obesity on medical expenditures, clinical data and medication for diabetes care. Most previous reports used data from the health insurance system to estimate the medical expenditures. However, using this approach, it is difficult to simultaneously evaluate the influence of obesity on medical expenditures and clinical data. The present study investigated these factors simultaneously. We identified important clinical features of obesity in Japanese patients with type 2 diabetes, including the fact that they were relatively young and had insufficient diabetes control in comparison with those without obesity; they also took a larger number of medications and had higher medical expenses. In addition, the higher medical expenditures in patients with obesity mainly came from the medication expenditures. At present, a number of medications for diabetes care are available in clinical practice. In our population, >90% of those with obesity took at least one medication for glucose control. Furthermore, half of them were prescribed two or more agents to achieve good glycemic control. In particular, the prescription rates of biguanides and thiazolidines were higher in obese patients. However, despite these efforts, glycemic control in those with obesity was poor in comparison with

Table 3 | Prescription rates of antihyperglycemic, antihypertensive and antidyslipidemic drug classes

Disease categories and drug classes	Body mass index (kg/m^2)		*P*-value†
	<25 (*n* = 237)	≥25 (*n* = 165)	
Hyperglycemia			
Biguanides	27.8	46.1	<0.001
Sulfonylureas	36.7	37.0	NS
Glinides	6.7	6.8	NS
Thiazolidines	10.1	23.6	<0.001
α-Glucosidase inhibitors	24.9	21.2	NS
Incretin-related agents	21.1	27.9	NS
Insulins	35.7	40.6	NS
No. classes			
0	11.8	4.2	0.003
1	35.9	30.3	
2	33.8	33.3	
≥3	18.5	32.2	
Hypertension			
Calcium channel blockers	30.0	41.2	0.03
RAS inhibitors	54.0	61.8	NS
Diuretics	13.5	30.9	<0.001
Others	10.1	15.8	NS
No. classes			
0	37.6	24.2	0.002
1	28.3	25.4	
2	24.4	26.7	
≥3	9.7	23.7	
Dyslipidemia			
Statins	48.1	50.3	NS
Others	11.4	15.2	NS
No. classes			
0	45.6	38.2	NS
1	48.9	55.8	
≥2	5.5	6.0	

Data are expressed as the percentages in each subgroup (body mass index < 25 or ≥25). †Differences between subgroups were compared using χ^2-tests. NS, not significant; RAS, renin–angiotensin system.

those without obesity. A similar situation was observed for medications for hypertension. Obesity is associated with insulin resistance, which is closely related to poor glycemic and BP control. Thus, obesity disturbs glycemic and BP control, which results in increased medical expenditures. These results suggest that the optimal control of bodyweight, particularly in young type 2 diabetes patients, is important for improving diabetes care and reducing healthcare costs. These results suggest that the optimal control of bodyweight is important for improving diabetes care and saving healthcare costs.

The present study had several limitations. This study was a cross-sectional observation study carried out in a single center. The findings might not represent the majority of Japanese patients with type 2 diabetes mellitus, although the clinical characteristics of our study population were compatible with those of the general Japanese patients with type 2 diabetes[21]. Additionally, the clinical characteristics of these patients are somewhat different from those of Caucasian patients with type 2 diabetes. In particular, Japanese patients are relatively lean in comparison with Caucasian patients. In the present study, the mean BMI was 24.7 kg/m^2 and just 8.7% had a BMI ≥ 30 kg/m^2, similar to a recent report on a large-scale survey of Japanese patients with type 2 diabetes[22]. Thus, the findings of the present study require confirmation in other ethnic groups, particularly other Asian ethnic populations that are as lean as the Japanese population. In addition, we cannot assess whether reduced bodyweight could result in reduced medical expenditures and number of medications. Recently, a post-hoc analysis of the Action for Health in Diabetes (Look AHEAD) study reported lower healthcare costs and fewer medications after an intensive lifestyle intervention aimed at promoting long-term weight loss and increased physical activity[23]. However, the majority (85%) of participants in the Look AHEAD study had BMI ≥ 30 kg/m^2, which is different from that of Japanese patients with type 2 diabetes. A longitudinal study is required to investigate the effect of reducing bodyweight on lifetime medical expenditures in relatively lean patients with type 2 diabetes, such as those of Asian ethnicity. Finally, the present study was carried out before 2014, when SGLT2 inhibitors became commercially available in Japan. SGLT2 inhibitors reportedly have numerous beneficial medical effects on diabetes care, such as reduced hyperglycemia, hypertension and bodyweight[24,25]. In addition, the growing use of SGLT2 inhibitors might influence medical expenditures and the number of prescribed medications in obese patients with type 2 diabetes. Thus, future studies comparing this clinical aspect with the results of the current study are being planned.

In conclusion, the results of the present study showed that obesity in Japanese patients with type 2 diabetes mellitus was associated with high annual medical expenditures, mainly from medication expenditures and hospitalization costs, and an insufficient diabetes control despite their greater number of prescribed medications. Additional studies are necessary to determine whether reducing bodyweight in overweight patients is beneficial for reducing medical expenditures, and the number of medications and achieving optimal diabetes control.

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DISCLOSURE

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