

Factors associated with basal insulin dose in Japanese children and young adult type 1 diabetics

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ABSTRACT

Aims/Introduction: The daily basal insulin doses/body weight and the daily basal insulin doses/total daily insulin doses of Japanese type 1 diabetes mellitus patients are less than those of Western type 1 diabetes mellitus patients. It is known that Western meals are richer in fat than Japanese meals. We speculated that fat intake might be associated with basal insulin dose in type 1 diabetes mellitus patients.

Materials and Methods: Forty-one outpatients with type 1 diabetes mellitus (20 males, 21 females, mean age 15.9) were enrolled. Variables investigated included: gender, SDS-BMI, HbA1c, duration of diabetes, therapy (MDI or CSII), insulin doses and meal contents. Meal contents were recorded for 3 days using a digital camera. Correlation and multiple regression analyses were performed for all subjects and each age group.

Results: The mean daily basal insulin doses/total daily insulin doses was 0.35. In the multiple regression analysis among all subjects, when daily basal insulin doses/body weight was used as a dependent variable, fat energy ratio of the meal was obtained as an entered variable ($P = 0.001$). This tendency was particularly strong among the patients aged 14 or above ($P < 0.001$, standardized coefficient $\beta = 0.683$).

Conclusions: In the type 1 diabetes patients who are aged 14 or above, an association between daily basal insulin doses/body weight and fat energy ratio of meal was suggested. This may explain the aforementioned expectation of increased fat intakes making higher basal insulin doses. (*J Diabetes Invest*, doi: 10.1111/j.2040-1124.2011.00171.x, 2012)

KEY WORDS: Basal insulin, Dietary fats, Type 1 diabetes mellitus

INTRODUCTION

Currently, basal-bolus insulin therapy is used to provide the insulin secretory patterns most physiologically similar to normal. Basal-bolus therapy includes multiple daily injection (MDI) and continuous subcutaneous insulin infusion (CSII) therapies. The recent advent of rapid-acting insulin analogs and long-acting insulin analogs, and the development of CSII therapy using rapid-acting insulin have clarified the role of basal and bolus insulin. Bolus insulin doses are determined based on carbohydrate counting.

Few studies, however, have focused on factors associated with basal insulin doses. Although basal insulin doses for Japanese patients with type 1 diabetes mellitus were reported to be lower than those of type 1 diabetes mellitus patients in Europe and the US¹⁻³, the reasons for this have not been clarified.

One of the differences between Japanese and Western societies is meal content. Japanese meals are known to have a higher carbohydrate energy ratio of meal (CER) and a lower fat energy ratio of meal (FER) than Western meals. According to the statistics of the United Nations, based on the amounts supplied, the FER in Japan is 28% while those in Western countries exceed 35% or even 40%. We speculated that differences in meal contents might be responsible for the differing basal insulin doses.

To investigate determinants of basal insulin doses for basal-bolus therapy in Japanese patients with type 1 diabetes mellitus, we examined associations of potential factors, including age, SDS-BMI (standard deviation score of body mass index), HbA1c levels and meal contents based on meal records, with basal insulin doses.

MATERIALS AND METHODS

Subjects

Forty-one outpatients with type 1 diabetes mellitus between the ages of 3 and 26 (20 males and 21 females, mean age 15.9) were enrolled. Patients with a duration of diabetes of <2 years, HbA1c levels of 9.0% or more, diabetic complications, or who

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were pregnant and/or had other diseases were excluded. The study period was from April to October of 2008. The following variables were examined: gender, age, height, weight, SDS-BMI⁴, HbA1c level, duration of diabetes, insulin administration method (MDI or CSII), daily bolus insulin doses (BOD), daily basal insulin doses (BAD), total daily insulin doses (TDD), BAD/TDD (BT ratio), the value obtained by dividing BAD by BW (BAD/BW) and meal contents. In order to calculate the SDS-BMI for the 12 patients aged 19 or over (for which there is no recorded data in Japan), each age used the data of 18.5 years old. The value for HbA1c (%) is estimated as a National Glycohemoglobin Standardization Program (NGSP) equivalent value (%) calculated by the formula $\text{HbA1c (\%)} = \text{HbA1c (JDS: Japan Diabetes Society) (\%)} + 0.4\%$, considering the relational expression of HbA1c (JDS) (%) measured by the previous Japanese standard substance and measurement methods and HbA1c (NGSP)⁵. Insulin doses for MDI therapy were obtained from the patients themselves or from medical records. Insulin doses for CSII therapy were obtained by reading the records on the pump used via the ComStation (MMT-7301U) (Medtronic Diabetes, Northridge, CA, USA). The doses of daily bolus insulin and daily basal insulin were checked every day for 3 days when the patients took pictures of their meals as described in detail below and the average values of three data were used for analysis. The other variables were obtained from medical records. All subjects were treated with either MDI or CSII employing basal-bolus therapy. As to rapid-acting insulin analogs, either lispro or aspart was used. Glargine was used as the basal insulin in all patients treated with MDI. Patients given CSII were received a bolus of normal type for bolus insulin dosing, during the study period. None used either a dual-wave or a square bolus. Patients were instructed to adjust the basal insulin dose to keep blood glucose levels stable while they were not eating or not receiving the additional insulin. Normal eating was allowed, and no limitations were set. BOD was determined based on the results of carbohydrate counting in all cases. Instructions of carbohydrate counting were provided at outpatient visits by a physician or by a dietitian working in our hospital.

Meal Contents

All patients were asked to photograph all of their meals for 3 days. The photographs were taken with a digital camera or a mobile phone equipped with a camera. The meals included all breakfasts, lunches, dinners, and snacks, as well as supplemental food consumed at the time of hypoglycemia attacks. When the photographs were taken, something (e.g., a coin) was placed beside the food to provide a size marker for length assessment. Photographs were taken from above diagonally to allow estimation of depth. Photographs of meals obtained from patients were checked by three registered dietitians. The dietitians estimated all ingredients and their weights from the photographs and calculated the ingested amounts (in grams) of protein, fat, and carbohydrate. They entered data for each ingredient using the computer software program Excel Eiyō-kun, version 4.0

(Kenpaku Co. Ltd., Tokyo, Japan). Excel Eiyō-kun is a program designed to calculate amounts of protein, fat, and carbohydrate by entering the name and weight of a meal ingredient⁶. The mean ingested amount of each nutrient (daily protein, fat, and carbohydrate intakes) as determined by the three dietitians was used for the analysis. The protein energy ratio of meal (PER) was calculated by the following equation: $\text{daily protein intake (g)} \times 4 / \text{daily total energy (kcal)}$. The fat energy ratio of meal (FER) was calculated by the following equation: $\text{daily fat intake (g)} \times 9 / \text{daily total energy (kcal)}$. The carbohydrate energy ratio of meal (CER) was calculated by the following equation: $\text{daily carbohydrate intake (g)} \times 4 / \text{daily total energy (kcal)}$. The ethics committee of Osaka City University Institutional Review Board, Osaka, Japan, approved this protocol.

Statistical Analysis

Data were expressed as mean \pm standard deviation without any explanation. Inter-group comparisons were performed for age, SDS-BMI, HbA1c levels, duration of diabetes, BT ratio, BAD/BW and meal contents, according to gender and therapy (MDI or CSII), using the *t*-test or the Mann-Whitney *U*-test. Subsequently, to evaluate simple correlations with basal insulin doses, associations of the BT ratio or BAD/BW with age, SDS-BMI, HbA1c levels, duration of diabetes and each meal content variable were examined using Pearson's product-moment correlations. Next, multiple regression analysis was performed for all subjects and for each age group to evaluate factors influencing BAD without interactions among the variables examined. The dependent variable selected was BAD/BW. The independent variables selected were: gender (female = 0, male = 1), age, SDS-BMI, HbA1c levels, therapy (MDI = 0, CSII = 1), and fat energy ratio.

For the analysis of age effect, patients were divided into four age groups. Patients aged 9 or younger were age group 1, patients between the age of 10 and 13 were age group 2, patients between the age of 14 and 18 were age group 3, and patients aged 19 or above were age group 4. Then patients were divided by sex (male and female group) and HbA1c levels (good <7% and poorly controlled >7% group).

Differences with $P < 0.05$ were considered to be statistically significant. For multiple regression analysis, the stepwise method was used with the following criteria: probability of entering $F: \leq 0.050$ and probability of removing $F: \geq 0.100$. Statistical analyses were performed with SPSS version 11.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

The characteristics of the patients are shown in Table 1. Twenty-four patients were treated with MDI, 17 with CSII. The averages of key characteristics were as follows: age, 15.9 ± 5.4 years; SDS-BMI, 0.86 ± 0.83 ; duration of diabetes, 9.8 ± 5.7 years; HbA1c levels $7.2 \pm 0.7\%$; BT ratio, 0.35 ± 0.09 (MDI: 0.33, CSII: 0.37); and BAD/BW, 0.35 ± 0.12 U/kg (MDI: 0.36 CSII: 0.34 U/kg). The average of differences for 3 days in FER was $6 \pm 3\%$.

Table 1 | Characteristics of patients

N = 41	Mean	Median	SD	Minimum	Maximum
Age (years)	15.9	16.1	5.4	3.3	26.9
Weight (kg)	52.9	54.2	15.9	14.6	83.0
SDS-BMI	0.86	1.06	0.83	-1.32	2.50
Disease duration (years)	9.8	7.8	5.7	2.0	24.0
HbA1c (%)	7.2	7.2	0.72	6.1	8.9
TDD (U)	55.7	48.8	25.1	9.8	131
BT ratio	0.35	0.35	0.10	0.16	0.51
BAD/BW (U/kg)	0.35	0.33	0.12	0.13	0.71
TDD/BW (U/kg)	1.04	0.97	0.36	0.47	2.36
PER	0.16	0.16	0.024	0.11	0.23
FER	0.30	0.30	0.045	0.20	0.39
CER	0.52	0.53	0.055	0.34	0.61
Energy (kcal/day)	1761	1758	412	793	2800

TDD, total daily insulin doses; BT ratio, daily basal insulin doses/total daily insulin doses; BAD/BW, daily basal insulin doses/body weight; TDD/BW, total daily insulin doses/body weight; PER, protein energy ratio of meal; FER, fat energy ratio of meal; CER, carbohydrate energy ratio of meal; Energy, total energy intake.

An example meal photograph is presented in Figure 1. Based on the assessments made by the three experienced dietitians, the mean PER was 0.16, the mean FER was 0.30, and the mean CER was 0.52 in 41 patients.

In inter-group comparisons, regardless of gender or insulin administration method (MDI or CSII), there were no inter-group statistical differences in SDS-BMI, BAD/BW, BT ratio and FER. However, age and duration of diabetes of the MDI group were significantly higher than that of the CSII group, and HbA1c levels of the CSII group were significantly higher than that of the MDI group.

Simple correlations of the BT ratio or BAD/BW with age, SDS-BMI, HbA1c level and each meal content variable are given in Table 2. In all subjects, there was a positive correlation between age and TDD ($r = 0.452$, $P = 0.003$) or SDS-BMI and TDD ($r = 0.320$, $P = 0.041$). Additionally, there was a positive correlation between BAD/BW and FER ($r = 0.493$, $P = 0.001$) and a negative correlation between BAD/BW and CER ($r = -0.541$, $P < 0.001$). The BOD/BW tended to correlate negatively with HbA1c level ($r = -0.281$, $P = 0.075$). Among patients under 19 years old (age groups 1, 2 and 3), there was a positive correlation between BAD/BW and SDS-BMI ($r = 0.472$, $P = 0.010$) or BAD/BW and FER ($r = 0.452$, $P = 0.014$).

Multiple regression analyses are shown in Table 3. In all subjects, when BAD/BW was selected as the dependent variable, FER was obtained as an entered variable ($P = 0.001$). The standardized coefficient β was 0.493, and the adjusted R^2 was 0.223. In age group 1 or age group 2, no value was obtained as an entered variable. In age group 3, FER was obtained as an entered

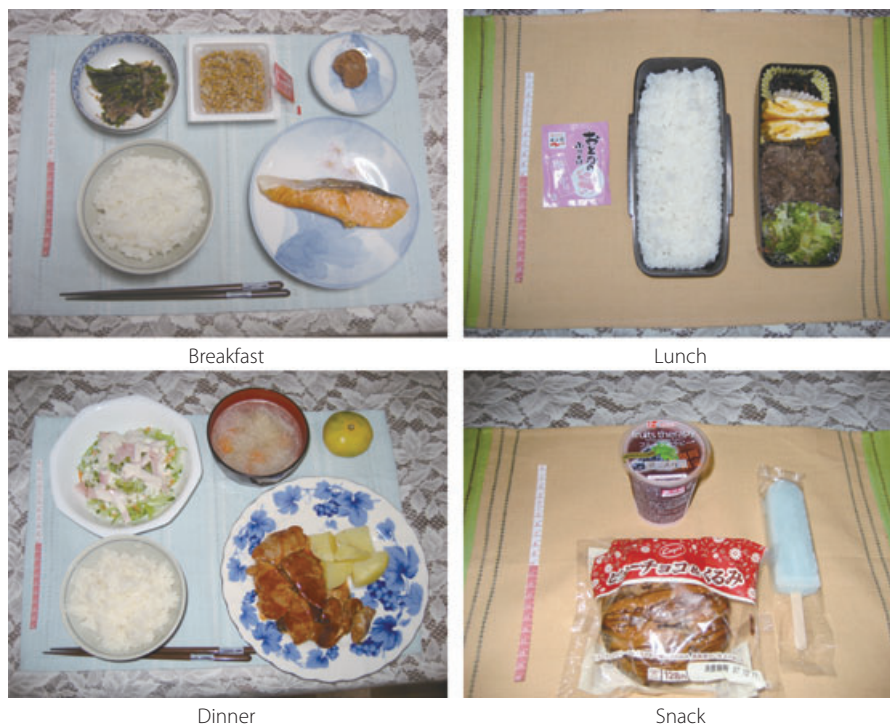


Figure 1 | Sample photographs of meals for 1 day. All patients were asked to photograph all of their meals for 3 days. Photographs of meals were checked by three registered dietitians. The total daily energy intake estimated from the meals pictured was 2625 kcal. The total daily grams of protein, fat, and carbohydrate were 107, 76, and 359 g, respectively. Protein energy, fat energy, and carbohydrate energy ratios were 0.16, 0.26, and 0.55, respectively.

Table 2 | Correlations between variables

N = 41	Age	SDS-BMI	HbA1c	Duration	TDD	BT ratio	BOD/BW	BAD/BW	TDD/BW	PER	FER	CER
Age (years)	–	0.249	–0.187	0.743**	0.452**	0.146	–0.056	0.113	–0.013	0.323*	–0.063	–0.137
SDS-BMI	0.249	–	–0.075	0.166	0.320*	0.145	0.059	0.257	0.132	0.255	0.183	–0.259
HbA1c (%)	–0.187	–0.075	–	–0.071	–0.339*	0.232	–0.281	0.033	–0.232	–0.081	0.149	–0.081
Duration (years)	0.743**	0.166	–0.071	–	0.261	0.111	–0.130	0.085	–0.085	0.163	0.068	–0.118
TDD (U)	0.452**	0.320*	–0.339*	0.261	–	–0.291	0.776**	0.462**	0.825**	0.133	0.157	–0.196
BT ratio	0.146	0.145	0.232	0.111	–0.291	–	–0.650**	0.497**	–0.410**	0.209	0.119	–0.209
BOD/BW (U/kg)	–0.056	0.059	–0.281	–0.130	0.776**	–0.650**	–	0.248	0.952**	0.002	0.149	–0.115
BAD/BW (U/kg)	0.113	0.257	0.033	0.085	0.462**	0.497**	0.248	–	0.534**	0.304	0.493**	–0.541**
TDD/BW (U/kg)	–0.013	0.132	–0.232	–0.085	0.825**	–0.410**	0.952**	0.534**	–	0.100	0.287	–0.273
PER	0.323*	0.255	–0.081	0.163	0.133	0.209	0.002	0.304	0.100	–	0.100	–0.565**
FER	–0.063	0.183	0.149	0.068	0.157	0.119	0.149	0.493**	0.287	0.100	–	–0.862**
CER	–0.137	–0.259	–0.081	–0.118	–0.196	–0.209	–0.115	–0.541**	–0.273	–0.565**	–0.862**	–

Correlations between the dose of insulin and age, SDS-BMI, HbA1c levels, duration of diabetes or each meal content variable using Pearson's product-moment correlations. Each value in the table is correlation coefficient.

TDD, total daily insulin doses; BT ratio, daily basal insulin doses/total daily insulin doses; BOD/BW, daily bolus insulin doses/body weight; BAD/BW, daily basal insulin doses/body weight; TDD/BW, total daily insulin doses/BW; PER, protein energy ratio of meal; FER, fat energy ratio of meal; CER, carbohydrate energy ratio of meal.

* $P < 0.05$, ** $P < 0.01$.

Table 3 | Multiple regression analyses among the variables

Dependent variable		Entered variable	R^2	Adjusted R^2	The standardized coefficient β	P
BAD/BW						
All subjects	$N = 41$	FER	0.243	0.223	0.493	0.001
Age group 1						
3–9 years	$N = 5$	None	–	–	–	–
Age group 2						
10–13 years	$N = 11$	None	–	–	–	–
Age group 3						
14–18 years	$N = 13$	FER	0.712	0.686	0.844	<0.001
Age group 4						
19–26 years	$N = 12$	FER	0.337	0.270	0.580	0.048
Age group 3 and 4						
14–26 years	$N = 25$	FER	0.466	0.443	0.683	<0.001
Male group	$N = 20$	None				
Female group	$N = 21$	None				
Well controlled group	$N = 20$	FER	0.399	0.365	0.631	0.003
Poorly controlled group	$N = 21$	None				

The stepwise method was used. Independent variables were: gender, age, SDS-BMI, HbA1c levels, therapy (MDI or CSII), and fat energy ratio. In all subjects, age group 3, age group 4, age group 3 and 4 or well controlled group, when BAD/BW was selected as the dependent variable, FER was obtained as an entered variable. BAD/BW, daily basal insulin doses/body weight; FER, fat energy ratio of meal; well controlled group, HbA1c < 7.0; poorly controlled group, HbA1c > 7.0.

variable ($P < 0.001$, standardized coefficient $\beta = 0.844$, adjusted $R^2 = 0.686$). In age group 4, FER was also obtained as an entered variable ($P = 0.048$, standardized coefficient $\beta = 0.580$, adjusted $R^2 = 0.270$). Among patients aged 14 or above (age groups 3 and 4), FER was obtained similarly ($P < 0.001$, standardized coefficient $\beta = 0.683$, adjusted $R^2 = 0.443$). The correlation between FER and BAD/BW in age group 3 and 4 ($n = 25$) is shown in Figure 2. In the male group or female group, no value

was obtained as an entered variable. In the well controlled group, FER was obtained as an entered variable ($P = 0.003$, standardized coefficient $\beta = 0.631$, adjusted $R^2 = 0.365$) while none was obtained in the poorly controlled group.

DISCUSSION

In this study, estimation of meal ingredients from photographs taken by patients was chosen as the method for examining meal

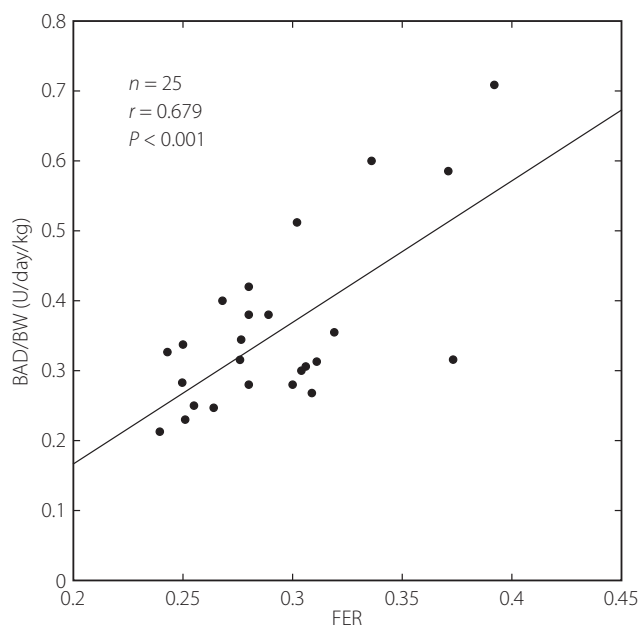


Figure 2 | The correlation between FER and BAD/BW. Among patients aged 14 or above (age group 3 and 4), the correlation between FER and BAD/BW was particularly strong. FER: fat energy ratio of meal, BAD/BW: daily basal insulin doses/body weight.

contents. The validity of this method has been evaluated in other studies. Williamson *et al.*⁷ reported that estimates of portion sizes related to food selections, plate waste, and food intake correlated highly with actual food weights by both the digital photography and the direct visual estimation method. The correlation coefficient between the estimated amounts of whole meals using digital photography and the actual amounts of meals ranged from 0.89 to 0.94, indicating a high correlation. Matsuzaki *et al.*⁸ reported that a person with considerable knowledge of nutrition, such as a senior nutritionist at a university, could assess nutrient intakes using digital images and that the results of these assessments were accurate. In the present study, three experienced registered dietitians assessed digital images, and their evaluation results were combined to obtain mean values. All three dietitians had knowledge of carbohydrate counting and extensive clinical experience. Therefore, given the previous reports, the method used in the present study was considered to be appropriate and to have yielded valid results. Furthermore, we asked the subjects to take pictures of food during normal daily life. The nutritional data obtained from the 3 days of food photographs was not so variable day by day. The data of insulin dosage used in this study was also obtained from the same 3 days as the food pictures. Therefore, the relationships between the nutritional data and basal insulin dose seems to be reliable.

Many investigators have reported BT ratios in various countries and facilities. Danne *et al.*⁹ reported that in the PPSG (the Pediatric Pump Study Group) study conducted in 23 facilities in

9 European countries and Israel, the mean BT ratio was 0.48 in 377 patients, with a mean age of 12.9 years, receiving CSII therapy and that there were differences among facilities. Doyle *et al.*¹⁰ reported that the mean BT ratio was 0.67 in children with type 1 diabetes mellitus receiving CSII therapy in the USA. Studies in Europe and the USA have often found the BT ratio to be at least 0.50¹¹. Studies in Japan, on the other hand, have demonstrated BT ratios tending to be lower than those in Europe and the USA. The BT ratios were usually below 0.50 in patients receiving basal-bolus therapy (CSII or MDI), regardless of age, at many Japanese facilities^{1,2}. Particularly, Kuroda reported <0.30 of BT ratio in Japanese type 1 diabetes using CSII therapy as inpatients with 50–60% CER meals³. The BT ratios in Europe and the USA, however, are not always high. Pankowska *et al.*¹² reported the mean BT ratio to be 0.28 in children with type 1 diabetes mellitus receiving CSII therapy in Warsaw. Therefore, BT ratios are not consistently high in European patients, such that factors other than race and ethnicity are thus considered to be involved.

Various factors reportedly affect BT ratios. Pankowska *et al.* reported BT ratios to correlate positively with age and diabetes duration and to correlate negatively with blood concentrations of C-peptide in type 1 diabetes mellitus patients under 19 years of age in Poland¹¹. In the present study, however, the BT ratio showed no association with age or disease duration. Blood concentrations of C-peptide were not examined in this study, and this relationship thus remains unclear. Disease duration and endogenous insulin were thought not to influence BT ratios significantly because patients with disease durations of <2 years were excluded from this study.

Many studies worldwide have reported BT ratios, but few have examined associations between BAD/BW and other factors. The results of our studies show BAD/BW is likely to be associated with SDS-BMI in type 1 diabetes mellitus patients of <19 years of age. This suggests that obesity increases insulin resistance in pediatric type 1 diabetes mellitus patients, as has been observed in other general populations. On the other hand, HbA1c levels were not associated with either SDS-BMI or BAD/BW.

Arai *et al.*¹³ reported that in 1486 Japanese patients with type 1 diabetes mellitus between 16 and 90 years of age, those with higher BMI had higher TDD/BW. Although it must be recognized that BAD/BW is different from TDD/BW, their results were similar to ours. As to insulin resistance and obesity, Reinhr *et al.*¹⁴ reported that TDD/body surface area and TDD/ideal body weight correlated more with SDS-BMI than TDD/BW in 4124 German patients with type 1 diabetes mellitus. They proposed that glucose uptake occurring mainly in the lean body mass was one of the explanations for this finding, and SDS-BMI was associated with a decrease in TDD/BW and an increase in TDD/body surface area and TDD/ideal body weight.

The utility of carbohydrate counting for dose adjustment of bolus insulin was recently confirmed, and our department also uses this method for patient education. Carbohydrate counting,

which allows determination of the doses of bolus insulin based on the amounts of carbohydrate contained in meals, provides very good glycemic control. However, the optimal insulin dosing method with carbohydrate counting when a large amount of protein or fat is ingested has not yet been clearly defined, and no method of achieving this goal has been established. In fact, various studies have focused on identifying an insulin dosing method which allows adjustments for protein and fat intake^{15,16}. According to the results of the National Health and Nutrition Survey conducted in Japan in 2008, the mean FER for the entire Japanese population was 0.25 and the mean FER by age group (1–6, 7–14, and 15–19 years of age) were 0.28–0.29¹⁷. The mean PER of all three age groups was 0.14 and the mean CER was 0.55–0.57. Therefore, the present study subjects had slightly higher PER and FER and lower CER readings than the mean values for the Japanese population as a whole.

Generally, when a high protein, high fat meal is consumed, blood glucose levels are elevated for at least 5 h afterwards. Since the blood glucose elevation due to intake of large amounts of protein and/or fat can be managed by increasing BAD, patients, who routinely consume large amounts of protein and fat, are expected to require higher BAD. Our study revealed that the BAD/BW tended to be higher in those with higher FER especially aged 14 or above. This may be considered to explain the aforementioned expectation of increased fat intakes making higher basal insulin doses. To our knowledge, so far, no other studies have shown associations between meal contents and BAD.

However, this tendency was not seen in the younger age groups. When subjects were divided into four age groups to consider the effect of age, the result of multiple regression analyses was different. While in age groups 1 and 2 (the age of 13 or younger) no variable was associated with BAD/BW, in age groups 3 and 4 (the age of 14 or above) the FER variable was associated with BAD/BW. The reason that this result differs among groups is speculated below. First, because the dose of basal insulin increased as patients grew up, the difference in the older group might easily become significant. Second, the number of subjects in the younger groups might be too small. Third, the variability of FER may have been too small in these groups. Generally, the meals of younger patients were managed by their parents. All of their parents have received nutritional instruction regarding calories and balanced nutrition at the onset of their child's type 1 diabetes mellitus. According to the guideline of Japanese Diabetes Association, a CER of 50–60%, an FER of approximately 30%, and PER of approximately 20% were recommended. Therefore, it was thought that in patients consuming balanced meals under the management of their parents, variability in CPF ratio (carbohydrate: protein: fat energy ratio) would be minimal. While among patients aged 14 or over, an association between BAD/BW and FER was shown in the multiple regression analysis. This might be because when the patients grow up and assume responsibility for their own meals, they made their BAD requirements adequately. In our study of the

multiple regression analysis, dividing the subjects into well and poorly controlled groups, an association between BAD/BW and FER was shown in only the well controlled group. This may be because the better controlled patients or their families administer suitable doses of insulin.

As described above, the contents of meals, especially carbohydrate amounts, which greatly influence blood glucose levels, and CPF ratio may be an important factor related to BT ratios of insulin doses in MDI. Meal contents vary between countries worldwide, and the possibility that the differences in reported BT ratios among facilities are attributable to meal contents cannot be ruled out. Thus, we calculated CPF ratio based on the report entitled 'daily food supply per person in a country' published by the FAO (Food and Agriculture Organization of the United Nations) in 2005, in order to obtain summaries of meal contents¹⁸. The supplied fat energy/supplied total energy ratios in Asian countries were 0.28 (Japan), 0.27 (China), and 0.25 (Korea). On the other hand, they were 0.30 in Poland, 0.36 in Germany, 0.41 in France, and 0.41 in the USA. This indicates that FER based on amounts supplied in Asian countries, including Japan, are lower than those in European countries and the USA. The supplied fat energy/supplied total energy ratio in Poland was 0.30, but, relatively similar to that in Japan. As reported by Pankowska¹¹, people in Poland have a lower BT ratio than those in other European countries. Therefore these data also support our speculation that FRR defined the basal insulin dose. However, since these results were calculated based on amounts of food supplied, surveying the meals consumed by each patient, as in our present study, may be necessary to obtain results allowing comparisons among countries.

In conclusion, this study demonstrated an association between BAD/BW and FER, in particular among the patients aged 14 or above. This may explain the expectation of increased fat intake causing higher basal insulin doses in type 1 diabetes mellitus patients.

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