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Original Article

The Relation between Insulin Resistance and Lifestyle in Japanese Female University Students

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Using the homeostasis model assessment (HOMA) index, we investigated the link between insulin resistance and lifestyle in Japanese female university students. We used data for 57 Japanese female university students (21.0 ± 0.8 years) who were enrolled in a cross-sectional investigation study. We performed full blood examinations, and anthropometric parameters, nutrient oral intake and daily step counts were measured. The mean HOMA index for the subjects was 1.3 ± 0.6, and 12 subjects were over the level of 1.6, which is considered to indicate insulin resistance in Japan. The HOMA index was positively correlated with abdominal circumference ($r = 0.542$, $p < 0.0001$), triglycerides, low density lipoprotein (LDL) cholesterol and systolic blood pressure. In addition, the HOMA index was negatively correlated with n-3 fatty acid and positively correlated with the n-6/n-3 fatty acid ratio ($r = 0.304$, $p = 0.0216$). Daily step count was negatively correlated with the HOMA index, but not at a significant level ($r = -0.237$, $p = 0.0809$). Higher HOMA index in some Japanese female university students was noted, and that was associated with lifestyle, especially n-6/n-3 fatty acid ratio of nutrient oral intake.

Key words: the homeostasis model assessment (HOMA) index, lifestyle, n-6/n-3 fatty acid ratio, female university students

Advances in our understanding of the pathophysiology of obesity convince us that intra-abdominal or visceral adipose tissue accumulation is closely related to insulin resistance and the development of atherosclerosis [1, 2]. In addition, the modern lifestyle of a high-calorie diet and reduced physical activities is closely related to the increasing population of obese subjects. Therefore, a useful method of preventing future lifestyle-related disease is urgently needed. Improving body composition and promoting proper diet and exercise habits are considered useful ways to improve each component of metabolic syndrome in adults [3-7]. However, in Japanese university students, the link between insulin resistance and clinical parameters, *i.e.*, anthropometric, diet and exercise parameters, remains to be investigated.

In this study, we measured insulin resistance using the homeostasis model assessment (HOMA) index [8] in Japanese female university students, and we investigated the link between the HOMA index and clinical parameters such as anthropometric measurements, diet and daily step counts.

Subjects and Methods

Subjects. We used data for 57 Japanese female university students, aged 21.0 ± 0.8 years, who had received no medications for diabetes, hypertension and/or dyslipidemia, and who provided written informed consent for study participation (Table 1).

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Table 1 Clinical profiles of enrolled subjects

	Mean ± SD	Minimum	Maximum
Number of subjects (n = 57)			
Age	21.0 ± 0.8	18	23
Height (cm)	158.0 ± 4.7	141.2	165.3
Body weight (kg)	51.5 ± 6.0	38.6	66.9
Body mass index (kg/m²)	20.6 ± 2.1	16.1	26.4
Abdominal circumference (cm)	70.2 ± 6.7	57.8	88.0
Body fat percentage (%)	27.7 ± 4.6	16.7	39.3
Triglyceride (mg/dl)	69.4 ± 34.1	28.0	184.0
HDLcholesterol (mg/dl)	68.8 ± 13.7	47.0	116.0
LDLcholesterol (mg/dl)	106.1 ± 33.6	53.0	219.0
Plasma glucose (mg/dl)	82.7 ± 5.7	68.0	95.0
Insulin (μU/ml)	6.1 ± 3.0	2.0	18.0
HOMA index	1.3 ± 0.6	0.3	3.6
HbA1c (%)	4.7 ± 0.2	4.3	5.4
Systolic blood pressure (mmHg)	106.3 ± 6.5	96.0	121.0
Diastolic blood pressure (mmHg)	61.7 ± 7.7	48.0	82.0
Total energy intake (kcal/day)	1,693.0 ± 356.8	849.6	3,463.7
Protein (g/day)	59.0 ± 15.9	31.8	135.3
Fat (g/day)	61.6 ± 16.9	36.0	146.5
Carbohydorate (g/day)	218.0 ± 46.8	91.1	386.9
Saturated fatty acid (g/day)	20.1 ± 6.3	10.7	50.6
Monounsaturated fatty acid (g/day)	22.1 ± 6.7	10.5	55.6
Polyunsaturated fatty acid (g/day)	11.3 ± 3.2	6.9	22.5
n-3 fatty acid (g/day)	1.9 ± 0.7	1.0	4.4
n-6 fatty acid (g/day)	9.4 ± 2.6	10.2	19.0
n-6/n-3 fatty acid ratio	5.3 ± 1.0	2.8	7.3
Protein (%)	13.9 ± 1.8	10.2	19.0
Fat (%)	32.7 ± 4.5	25.2	53.2
Carbohydorate (%)	53.5 ± 5.5	29.0	62.2
Food fiber (solution) (g/day)	2.6 ± 0.6	1.6	4.2
Food fiber (Insolution) (g/day)	7.7 ± 1.9	4.9	13.0
Total food fiber (g/day)	10.6 ± 2.6	6.9	17.9
Mean of weekday step counts (steps/day)	7,901.7 ± 2,931.2	2,888.2	13,944.0
Mean of holiday step counts (steps/day)	5,735.1 ± 2,929.6	663.0	12,639.0
Mean of daily step counts (steps/day)	7,282.7 ± 2,457.0	2,328.4	11,966.0

Ethical approval for the study was obtained from the Ethical Committee of Notre Dame Seishin University.

Anthropometric and body composition measurements. The anthropometric parameters we measured were the height, body weight and abdominal circumference. Body mass index (BMI) was calculated by weight/[height]^2 (kg/m^2). Abdominal circumference was measured at the umbilical level [9]. Body fat percentage was measured by using the impedance method (Inner Scan BC-611, TANITA, Tokyo, Japan)

Blood sampling and assays. After subjects fasted overnight for 10 to 12 h, we collected blood samples to determine the levels of high-density lipoprotein (HDL) cholesterol, triglycerides (L Type Wako Triglyceride・H, Wako Chemical, Osaka, Japan), low-density lipoprotein (LDL) cholesterol, insulin, plasma glucose and hemoglobin A1c (HbA1c). Serum insulin was measured by immunoradiometric assay (IRMA) using Insulin Riabeads (Dainabot, Tokyo, Japan). Plasma glucose was measured by using the glucose-oxidant method. The insulin resistance was evaluated using the HOMA index [fasting plasma glucose (mg/dl)×fasting serum insulin (μU/

ml)/405], according to the method developed by Matthews *et al.* [8].

Blood pressure measurements. Resting systolic and diastolic blood pressures were measured indirectly using a mercury sphygmomanometer placed on the right arm of the seated participant after at least 15 min of rest.

Measurements of diet and daily step counts. Nutrients oral intake was determined for all subjects using a frequency survey (Food Frequency Questionnaire Based on Food Groups: FFQg) [10]. The FFQg is based on 29 food groups and 10 kinds of cookery, and we used it to estimate the energy and nutrient intakes of individual subjects for the previous one to two months before the study started. The correlation coefficients between the FFQg and the records for 7 continuous days for energy, protein, fat, carbohydrate and calcium intakes were 0.47, 0.42, 0.39, 0.49 and 0.41, respectively [10]. Daily step counts were also measured by pedometer (AM-120, TANITA, Tokyo, Japan).

Statistical analysis. Data are expressed as mean ± standard deviation (SD) values. Pearson's correlation coefficients were calculated and used to test the significance of the linear relationship among continuous variables. Stepwise multiple regression analysis was also used to identify the most independent determinant factor of the HOMA index.

Results

Clinical profiles are summarized in Table 1. The mean HOMA index for all subjects was 1.3 ± 0.6, and 12 subjects were over the level of 1.6, which is considered by the Japan Diabetes Society to indicate insulin resistance [11].

We evaluated the relationship between the HOMA index and anthropometric parameters (Table 2, Fig. 1) and found that the HOMA index was positively correlated with body weight, BMI, abdominal circumference and body fat percentage. The coefficient rate between the HOMA index and abdominal circumference was the highest among the variables ($r = 0.542$, $p < 0.0001$). We also used stepwise multiple regression analysis to evaluate the effect of anthropometric parameters, *i.e.*, height, weight, BMI, abdominal circumference and body fat percentage, on the HOMA index and found that only abdominal circumference was significant (the HOMA index $= -2.348 + 0.051$ (abdominal circumference), $r^2 = 0.294$, $p < 0.0001$).

Table 2 Relationship between the HOMA index and anthropometric parameters

	r	*p*
Height (cm)	0.222	0.0973
Body weight (kg)	0.446	0.0005
Body mass index (kg/m²)	0.376	0.0039
Abdominal circumference (cm)	0.542	<0.0001
Body fat percentage (%)	0.421	0.0011

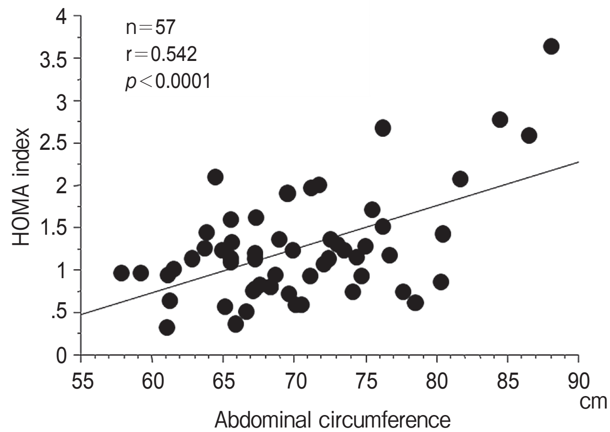

Fig. 1 Simple correlation analysis between the HOMA index and abdominal circumference.

We also evaluated the relationship between the HOMA index and the results of blood examinations and blood pressure, and the HOMA index was significantly correlated with triglycerides, LDL cholesterol and systolic blood pressure (Table 3, Fig. 2).

In evaluating the effect of diet and exercise habits on the HOMA index in Japanese female university students, we found that n-3 fatty acid was negatively correlated with the HOMA index and that the n-6/n-3 fatty acid ratio was positively and weakly correlated with the HOMA index (Table 4, Fig. 3). The Daily step count was negatively and weakly correlated with the HOMA index, but not at a significant level ($r = -0.237$, $p = 0.0809$). We also used stepwise multiple regression analysis to evaluate the effect of diet and daily step count, and found that only the n-6/n-3 fatty acid ratio was significant (the HOMA index $= 0.166 + 0.208$ (n-6/n-3 fatty acid ratio), $r^2 = 0.097$, $p = 0.0206$). We found no significant relationship between

Table 3 Relationship between the HOMA index and blood examination results and blood pressure

	r	*p*
Triglyceride (mg/dl)	0.519	<0.0001
HDLcholesterol (mg/dl)	0.034	0.8021
LDLcholesterol (mg/dl)	0.280	0.0348
Plasma glucose (mg/dl)	0.396	0.0023
HbA1c (%)	0.084	0.5336
Systolic blood pressure (mmHg)	0.309	0.0194
Diastolic blood pressure (mmHg)	0.085	0.5290

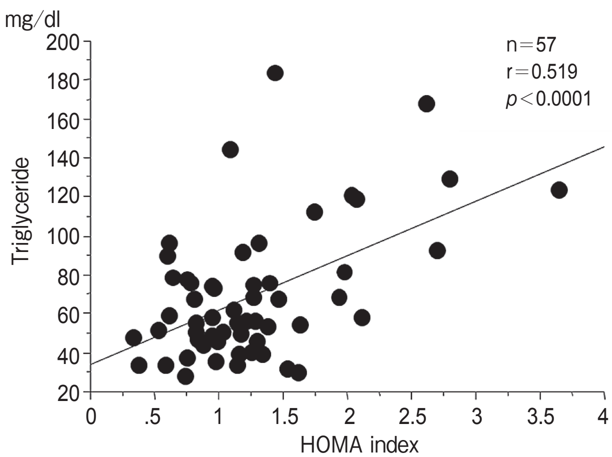

Fig. 2 Simple correlation analysis between the HOMA index and the triglycerides level.

triglycerides and n-6/n-3 fatty acid ($r = 0.204$, $p = 0.1283$).

Discussion

The main finding of this study was that the HOMA index was positively correlated with anthropometric parameters, blood examination results and nutrient oral intake, especially the n-6/n-3 fatty acid ratio.

Generally, young adults are considered to be the most healthy, to be in the best physical condition and to require the least medical care of any Japanese age cohort. Especially in their 20s, only 4.0% of men and 1.5% of women were diagnosed as having metabolic syndrome on the National Nutrition Survey (http://www.mhlw.go.jp/houdou/2009/11/dl/h1109-1b.pdf, accessed on Aug 19, 2010). However, higher brachial-ankle pulse wave velocity (baPWV) was noted in some Japanese female university students, and that

Table 4 Relationship between the HOMA index and diet and exercise habits

	r	*p*
Total energy intake (kcal/day)	−0.015	0.9121
Protein (g/day)	−0.056	0.6768
Fat (g/day)	−0.068	0.6144
Carbohydorate (g/day)	0.053	0.6966
Saturated fatty acid (g/day)	0.006	0.9616
Monounsaturated fatty acid (g/day)	−0.066	0.6276
Polyunsaturated fatty acid (g/day)	−0.212	0.1129
n-3 fatty acid (g/day)	−0.262	0.0486
n-6 fatty acid (g/day)	−0.193	0.1506
n-6/n-3 fatty acid ratio	0.304	0.0216
Protein (%)	−0.095	0.4815
Fat (%)	−0.092	0.4940
Carbohydorate (%)	0.106	0.4326
Food fiber (solution) (g/day)	−0.072	0.5931
Food fiber (Insolution) (g/day)	−0.048	0.7205
Total food fiber (g/day)	−0.042	0.7569
Mean of weekday step counts (steps/day)	−0.187	0.1728
Mean of holiday step counts (steps/day)	−0.230	0.0905
Mean of daily step counts (steps/day)	−0.237	0.0809

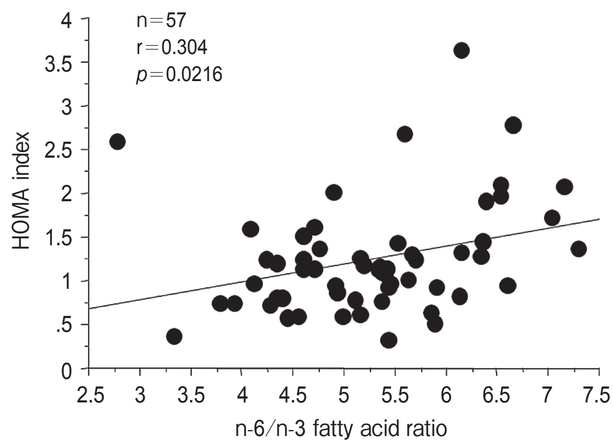

Fig. 3 Simple correlation analysis between the HOMA index and the n-6/n-3 fatty acid ratio.

was weakly correlated with body fat percentage and exercise capacity in a previous report [12]. We also found that a higher HOMA index was noted in some Japanese female university students. The coefficient rate between the HOMA index and abdominal circumference was the highest among parameters. Although there was no significant link between the HOMA index and HbA1c, abdominal circumference and triglycerides level were closely associated with the HOMA index, indicating that the HOMA index may reflect insulin resistance. Tobe *et al.* investigated 3,675 university graduates aged 26–62 years in whom BMI was determined at the time of university enrollment and found that maintenance of BMI at the late adolescence level was an important factor in preventing future disease [13]. Miyatake *et al.* also showed that reducing waist circumference by at least 3 cm was useful for improving metabolic syndrome in obese Japanese men [14]. Therefore, it is reasonable that lifestyle modification is recommended to prevent future lifestyle-related disease in Japanese university students.

Two longitudinal studies [15, 16] and a cross-sectional study from Alaska of an Inuit population [17] have linked fish intake with protection against glucose intolerance. An investigation study among the Inuit in the Alaska Siberia project showed that an increased consumption of traditional foods rich in n-3 fatty acids resulted in a decrease in plasma glucose [18]. Thorseng *et al.* reported that they measured the contents of n-3 fatty acids and the n-6/n-3 fatty acid ratio in the erythrocyte membrane phospholipids and found that some types of n-3 fatty acids had a protective effect against insulin resistance [19]. In this study, we also found that the n-3 fatty acid was negatively correlated with the HOMA index and that the n-6/n-3 fatty acid ratio was positively correlated with the HOMA index. In addition, the daily step count was negatively and weakly correlated with the HOMA index, but not at a significant level. By stepwise regression analysis, only the n-6/n-3 fatty acid ratio was a significant factor on the HOMA index. The FFQg/7 continuous-days records ratios (%) in n-6 fatty acid and n-3 fatty acid were reported to be 115.9 and 102.3, respectively [10]. In the National Nutrition Survey in Japan, only 16.5% of women in their 20s exercised habitually, and 26.2% of women in their 20s reported not eating a regular breakfast (http://www.mhlw.go.jp/houdou/2009/11/dl/h1109-1b.pdf, accessed on Nov 22, 2010). Taken together, the clinical impact of these parameters on the HOMA index may be having an important effect on insulin resistance in Japanese female university students.

Our study has potential limitations. First, our study was a cross-sectional and not a longitudinal study. Second, we could not accurately prove the mechanism between the HOMA index and the n-6/n-3 fatty acid ratio. Third, the small sample size may also make it difficult to prove the link between the HOMA index and lifestyle parameters. Fourth, we did not evaluate male university students, in whom the coefficient rate between visceral adipose tissue accumulation and biochemical tests was higher than that in female university students [20]. In conclusion, anthropometric parameters and the n-6/n-3 fatty acid ratio were closely associated with the HOMA index. Japanese female university students must improve their anthropometric parameters and practice proper diet habits to prevent lifestyle-related disease. Further prospective studies are needed in Japanese young adults, especially men.

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