原著:

Relationship between Serum γ -Glutamyl Transpeptidase Fraction Pattern and the Pattern of Food Intake

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The effects of the food intake pattern on the activity and fraction pattern of serum γ -glutamyl transpeptidase (γ -GTP) were examined in 257 healthy Japanese men.

Applying the technique of factor analysis to the food intake data, the following three factors were extracted. The first factor (F1): meats, eggs, and vegetables had a highly positive factor loading. The second factor (F2): wheat had a highly positive factor loading, while rice had a highly negative factor loading. This factor was considered to be a "wheat versus rice factor". The third factor (F3) could not be explained simply in terms of its factor. The scores of the first two factors for the 257 subjects were calculated.

Significantly negative correlations were observed between the percentage of GT_1 fraction and the factor score of F1 ($r = -0.230$, $p < 0.01$), between the percentage of GT_1 fraction and the factor score of F2 ($r = -0.187$, $p < 0.01$). The total serum γ -GTP activity was not correlated with the factor score. These results suggested that the percentage of GT_1 fraction is influenced by the pattern of food intake.

① serum γ -GTP activity ② serum GT_1 fraction ③ pattern of food intake ④ multivariate analysis

1. Introduction

Health screening for alcoholism occupies an important place in rural medicine, and there have been many reported on the alcohol intake in rural inhabitants¹⁻³). The activity of serum γ -GTP has been widely used as a diagnostic tool for alcoholic liver diseases. However, there have been no published reports on the correlation between its activity and fraction pattern with the intake of nutrients in healthy people. In previous studies⁴⁻⁵), the percentage of GT_1 fraction showed a close correlation with the intake of carbohydrates⁴), proteins and vitamin C⁵). Then, we examined the relation between both activity and fraction pattern of serum γ -GTP to the pattern of food intake in healthy young Japanese men applying the statistical technique of multivar-

iate analysis which is widely used in the field of public health.

2. Methods

1) Subject

The subjects studied were 257 healthy Japanese men. They were university students, and followed a normal daily routine. They were healthy as judged from their detailed medical histories, physical examinations, urinalyses and hematological and serum biochemical analyses. The physical characteristics of the subjects are given in Table 1. Their conditions were as follows: a) None had any disease which required hospital treatment. b) None had any disease of the hepatobiliary system. c) None had chronic diseases of the heart or diabetes mellitus. d) Liver function tests were within the

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Table 1. Characteristics of subjects

Items	Mean	S.D.	Max.	Min.
Age	23.1	3.4	28	21
Height (cm)	170.7	5.4	190.0	153.0
Weight (kg)	63.0	8.0	85.0	49.0
Broca index	89.2	9.9	118.2	68.3

Number of subjects: 257 men

Broca index: $[\text{Weight}/(\text{Height}-100)] \times 100$

normal range. e) None had hyperlipidemia. f) None drank habitually.

2) Diets

The subjects recorded their food intake after each meal or snack. All food eaten by the subjects in a 2-day period before the test was weighed, and the intake of each of 15 food was calculated, using the standard tables of food composition in Japan (4th revised edition⁶⁾).

3) Blood samples

Venous blood samples were obtained from subjects after they underwent overnight fasting for at least 12 hours. The serum was separated and stored at 4°C for analysis. Serum γ -GTP activity and the percentage of the γ -GTP fraction were measured on the day that blood was taken. Serum γ -GTP activity⁷⁾ was determined with a γ -GTP Test Kit (Wako Pure Chemical Industries). Serum γ -GTP fractions⁵⁾ were separated by electrophoresis on agarose film. Two γ -GTP fractions were obtained, one with mobility at a level between those of albumin and $\alpha(1)$ -globulin(GT₁), and the other with the same mobility as that of the lowest part of $\alpha(2)$ -globulin(GT₂). The serum γ -GTP activity and percentage of the γ -GTP fraction were measured three times for each sample and the mean values for each sample were calculated. The pooled serum prepared in our department was used as the control.

4) Analyses

Data were processed by a NEC PC9801VX computer. Factor analysis, a multivariate analysis, was applied to intakes of 15 group of foods in all subjects. The 15 groups of foods examined are listed in Table 2. Factor scores were calculated for the 4855 (257X15) data with factor loadings used for weight.

Fig. 1. Distribution of serum γ -GTP activity Fig. 2. Distribution of fraction ratio of GT₁

3. Results

1) Distribution of serum γ -GTP activity and fraction pattern

Fig. 1 show the distribution of serum γ -GTP activity in the 257 subjects. Their values leaned forward a higher concentration with a peak at 5 mU/mL. The mean serum γ -GTP activity was 6.1 ± 4.3 mU/mL (0.8~14.4 mU/ml). The distribution of serum γ -GTP fraction pattern in the 257 subjects as shown in Fig. 2. The mean percentage of γ -GT₁ fraction was $54.4 \pm 2.7\%$ (43.6~63.5 %).

2) Food intakes of subjects

The means and standard deviations of food intakes of the subjects are shown in Table 2. All the subjects were well nourished, and apparently in

Table 2. Food intake

Items	Mean	S.D.	Max.	Min.
1. Rice	253.2	79.4	510.1	70.0
2. Wheat	107.2	64.9	440.1	11.3
3. Potatoes	45.0	46.8	170.0	0.0
4. Sugar	8.4	9.8	84.0	1.0
5. Nuts and Seeds	1.8	10.5	74.3	0.0
6. Fats and Oils	23.5	13.4	54.1	5.0
7. Pulses	72.3	84.1	301.0	0.0
8. Fishes	62.2	59.6	240.5	0.0
9. Meats	128.5	75.4	302.0	0.0
10. Eggs	62.8	62.8	180.0	0.0
11. Milks	156.1	147.3	740.0	0.0
12. Vegetables	211.1	108.5	676.2	41.2
13. Fruits	60.8	94.5	540.0	0.0
14. Algae	2.3	7.0	17.0	0.0
15. Confectioneries	27.4	45.5	220.0	0.0

good health.

3) Statistical analysis

Applying the technique of factor analysis to the food intake data, we extracted three factors. The factor loadings of 15 food groups are shown in Table 3. The contribution ratios of the first, and second factors were 44.7 %, and 22.5 %, respectively.

The first factor (F1): meats, eggs, and vegetables had highly positive factor loadings. The second factor (F2): wheat had a highly positive factor loading, while rice had a highly negative factor loading. This factor was considered to be a "wheat versus rice factor". The third factor (F3) could not be explained simply in terms of its factor. The scores of the two factors for the 257 subjects were calculated. Table 4 shows the correlation coefficient between serum γ -GTP activity, percentage of GT₁ fraction and factor scores. Significantly negative correlations were observed between the percentage of GT₁ fraction and factor scores of F1 ($r = -0.230$, $p < 0.01$), between the percentage of GT₁ fraction and factor scores of F2 ($r = -0.187$, $p < 0.01$). The serum total γ -GTP activity was not correlated with factor scores.

Table 3. Factor loadings

Items	Factor loadings			Communality
	F1	F2	F3	
1. Rice	-0.062	-0.770	0.264	0.528
2. Wheat	0.057	0.808	0.083	0.527
3. Potatoes	-0.066	-0.101	0.406	0.191
4. Sugar	-0.047	0.064	0.312	0.104
5. Nuts and Seeds	-0.054	-0.051	0.080	0.065
6. Fats and Oils	0.191	-0.038	0.282	0.130
7. Pulses	-0.172	-0.313	0.235	0.213
8. Fishes	0.225	-0.028	-0.143	0.357
9. Meats	0.753	0.093	-0.106	0.591
10. Eggs	0.711	0.155	-0.103	0.603
11. Milks	0.247	0.679	-0.045	0.582
12. Vegetables	0.741	-0.049	0.079	0.425
13. Fruits	-0.083	0.178	0.111	0.121
14. Algae	0.283	0.046	0.018	0.084
15. Confectioneries	0.047	-0.130	0.303	0.282
Eigen value	2.397	1.207	0.763	
Proportion (%)	44.7	22.5	14.2	

F1: Factor 1, F2: Factor 2, F3: Factor 3

Table 4. The correlation coefficient between serum total γ -GTP activity, percentage of GT₁ fraction and factor scores

Item	Factor 1	Factor 2
γ -GTP(T)	0.101	0.088
GT ₁	-0.230**	-0.187**

** : $P < 0.01$

γ -GTP(T): Total serum γ -GTP activity

GT₁ : Percentage of GT₁ fraction

4. Discussion

Multiphasic health screening for chronic diseases occupies an important place in periodic examinations. Measurements of γ -GTP in serum are frequently used as an indicator of hepatobiliary diseases, including alcohol- or drug-induced liver damage.

Previously⁹⁾, we reported the relations between its activity and fraction pattern and the intakes of nutrients. In the present study, we investigated the effect of the pattern of food intake on serum γ -GTP activity and fraction in healthy young men. When diets of groups are examined, the intakes of individ-

ual food items or nutrient intakes are not independent of each other but show synergistic or antagonistic relations with other food items or nutrient intakes. Thus, the relation constitutes what is generally called a pattern of food intake¹⁰⁾.

We used multivariate analysis (factor analysis) to analyze the data on food intake of the subjects. According to the method, common factor of $f_1, f_2, \dots$ and f_m are linear components given as follows:

$$x_1 = a_{11}f_1 + a_{12}f_2 + \dots + a_{1m}f_m + \varepsilon_1$$

$$x_2 = a_{21}f_1 + a_{22}f_2 + \dots + a_{2m}f_m + \varepsilon_2$$

.....

$$x_p = a_{p1}f_1 + a_{p2}f_2 + \dots + a_{pm}f_m + \varepsilon_p$$

a_{pm} is the factor loading. Thus the factor analysis might be said to summarize the information contained in the total number of variables into a smaller number of independent factors, which are linear functions of the original variable. This method allowed analysis of the patterns of food intake of the subjects. The results obtained were as follows: the first factor might be interpreted as a factor determining the relative degree of importance of meats, eggs and vegetables in the diet. In this study, significantly negative correlations were observed between the percentage of GT₁ fraction and the factor score of F_1 : in other words, although the percentage of GT₁ fraction remained within the normal range, they tended to increase with the decrease in intake of meats, eggs and vegetables.

The second factor is supposed to be a factor indicating degrees of importance of wheat and rice; that is, a factor related to the nature of the main constituent of the food. A significantly negative correlation was observed between the percentage of GT₁ fraction and the factor score of F_2 : the percentage of GT₁ fraction tended to increase with the decrease in wheat intake and increase in rice intake. In other words, the percentage of GT₁ fraction was high in subjects who ate traditional Japanese food with rice as the main constituent. With respect to the relationship between the percentage of GT₁ fraction and nutrient intakes, Antener et al.¹¹⁻¹²⁾ observed that in patients with malnutrition, the percentage of GT₁ fraction is lowered by improvement of the nutritional state such as by increased intakes of an energy source, protein, vitamins and

minerals. We observed that the percentage of GT₁ fraction increased significantly in eight healthy young volunteers who received a low protein diet for 21 days, and in four healthy young volunteers who received a high carbohydrate¹⁾ diet for 21 days. We also observed that after 10 days of oral administration with 1 and 10 g/day of vitamin C to six normal subjects, their percentage of GT₁ fraction was lower than that before administration⁵⁾.

The mechanism of increase in the percentage of the GT₁ fraction is unknown. However, Koike et al.¹³⁾ reported that a low protein intake, low vitamin C intake and imbalanced diet caused metabolic stress. The data in these papers also suggested that the percentage of GT₁ fraction increased in certain individuals in response to metabolic stress induced by an imbalanced pattern of food intake, and that its fraction passed from the liver into the blood stream due to slight fatty degeneration of the liver. The present study indicated that the levels tended to increase with high intake of meats, eggs and vegetables, and that, with intake of modern food sources with wheat as the main constituent, the levels of the percentage of GT₁ fraction were low. With respect to the relations of the serum γ -GTP activity and nutrient intake, Antener et al.¹¹⁻¹²⁾ reported that patients with malnutrition have abnormally higher levels of serum γ -GTP and that the level is normalized when the nutritional state is improved. Fujisawa et al.¹⁴⁾ reported that in healthy subjects the daily variation in serum γ -GTP activity is small and is not affected by daily meals. In the present study, we found that the pattern of food intake did not affect serum γ -GTP activity.

In general, the nutritional status of a subject depends on his social, economic, personal and family background. Our results suggested that the low GT₁ subjects had a good food intake pattern which prevents chronic diseases from occurring. It is worthy of attention how the food intake pattern of rural people will change in future from the viewpoint of the possibility of change which will be recognized in the national health status. Therefore, we think that measurement of GT₁ is important in rural medicine.

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血清 γ -Glutamyl Transpeptidase 分画と 食物摂取パターンとの関連性について

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血清 γ -GTP 分画と食物摂取パターンの関連性について、健康な日本人青年257名を対象に以下の疫学的調査を実施した。対象者の食物摂取データを用いて、因子分析法により食物摂取パターンの三つの因子を抽出した。第1因子は、肉類、卵類、野菜類に正の高い因子負荷量があり肉類、卵類、野菜類を多食するパターンである。第2因子は小麦類が正の高い因子負荷量、米類は負の高い因子負荷量を示し、「パン食対米食」因子である。つまり負の因子得点の対象は米食中心の食パターンである。第3因子は十分に説明できなかった。

これらの因子と血清 γ -GTP 活性値との関連性を解析すると、統計的に有意な負の相関が GT₁ 分画比と第1因子 ($r = -0.230$, $p < 0.01$), 第2因子 ($r = -0.187$, $p < 0.01$) に認められた。しかし総血清 γ -GTP 活性値とは有意な関係は認められなかった。以上の結果より、食物摂取パターンが γ -GTP 分画比に影響を与えていることが疫学的に認められた。

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