ACTA MED OKAYAMA 1999; 53(3): 119 122

Preferential Salivary-Type Hypoamylasemia in Obese Children

Hidetsugu MIZUUCHI* and Kazuhisa TAKETA

Department of Public Health, Okayama University Medical School, Okayama 700-8558, Japan

Serum levels of total amylase, pancreatic type (P-type) isoamylase, and salivary type (S-type) isoamylase were measured in obese children (153 subjects; mean age, 10.1 years old; 86 boys and 67 girls) before and after weight reduction therapy. Serum amylase activities were determined using p-nitrophenylmaltoheptaoside as a substrate, with or without an antibody added to inhibit the S-type isoamylase. Serum levels of total amylase, P-type isoamylase and S-type isoamylase activities were significantly decreased in obese children with an obesity index more than 50%. S-type and P-type isoamylases showed negative correlation with the obesity index, the correlation coefficient being slightly larger in S-type than in P-type isoamylase. Analysis of the serum amylase activities in obese children who underwent weight reduction treatments showed a negative correlation only between the differences in S-type isoamylase activity and the differences in the obesity index. It may be concluded that the S-type isoamylase activity in serum of obese children is decreased and that it can be increased by reducing their body weight.

Key words: salivary-type hypoamylasemia, obese children, weight reduction

Hyperamylasemia has been observed in eating disorders with binge-purge episodes (1). However, hypoamylasemia was first reported in obesity by Kondo *et al.* (2). Taketa *et al.* (3) reported that the low total amylase activity in a population of obese male undergraduate students was due to a preferential decrease in the salivary type (S-type) isoamylase activity rather than in the pancreatic type (P-type) isoamylase activity.

This observation was extended in the present study to a population of obese children in order to see whether similar changes in serum isoamylase levels are present in childhood obesity, which has received a lot of attention in recent years as an "unfavorable lifestyle disease" or a "senile diseases in childhood". In addition, an attempt was made to elucidate the mechanism of low serum levels of S-type isoamylase in obesity by comparing the values before and after treatment for reduction of body weight. The results obtained in this study indicated that reduction in body weight was correlated with the increase in S-type isoamylase activity.

Patients and Methods

We evaluated a group of students in a school for obese children, which was operated by the National Sanatorium Minami-Okayama Hospital from August 1992 through August 1994. The curriculum of this school involved short-term hospitalization and education with regard to exercise and diet for the treatment of obesity. School sessions were held during the spring, summer and winter vacations and were open to obese primary and junior high school students. Children who were outpatients at the outpatient clinic of Okayama National Hospital and the National Sanatorium Minami-Okayama Hospital from April 1993 through March 1994 and had diseases without altered amylase activities served as non-obese controls.

Students of the school were measured for height and body weight on admission to the school and blood samples were collected the following morning before breakfast. Outpatients were measured and their blood samples were collected at the time of hospital visits. Standard body weights were obtained from a standard body weight table for different ages, heights and sexes (4). The percentage of increase over the standard body weights for that age, height and sex group was calculated and used as a parameter of obesity. This figure is known as the obesity index (OI).

In the phase I study, the total and isoamylase activ-

* To whom correspondence should be addressed.

ities of 153 students were measured (86 males, 67 females; mean age, 10.1 years, 6 to 15 years, mean OI, 34.1 %; range 23.8 % to 128.0 %). In the phase II study, total and isoamylase activities were determined before and after treatment on 26 students who were hospitalized or outpatients at the clinic of the National Sanatorium Minami-Okayama Hospital for long-time corpulence therapy in order to see the effect of weight reduction on the amylase activities. Our weight-reduction therapy consisted of additional expenditure by physical exercise amounting to 300 kcal/day, psychological support, and a diet of 1,360–1,660 kcal/day (consisting of 60–75 g protein, 40–45 g fat and the remainder in carbohydrates). The 26 students consisted of 11 males and 15 females with a mean age of 11.5 years old, ranging from 8 to 15 years old, and with a mean OI of 43.5 %, ranging from 28.4 % to 134.5 %.

Serum levels of total amylase (EC 3.2.1.1) were determined with *p*-nitrophenylmaltoheptaoside (Boehringer Mannheim Yamanouchi Co., Ltd., Tokyo, Japan) as a substrate. P-type isoamylase activity was determined by the same method with an added monoclonal antibody that specifically inhibits S-type isoamylase activity (Isoamylase EPS, Boehringer Mannheim Yamanouchi Co., Ltd.) (5, 6). The assays were carried out with a 736 Hitachi autoanalyzer (Hitachi Ltd., Tokyo, Japan). The S-type isoamylase activity was calculated by subtracting the P-type isoamylase activity from the total. The results were expressed as means ± standard deviations and 95 % confidence interval (CI). Significance levels of the differences among strata of obese children were analyzed by the Dunnet method of multiple comparison and the Pearson correlation coefficients were calculated for the differences in amylase activities and OI before and after treatment.

Results

Phase I study. The demographic data of the obese students we studied are shown in Table 1. We divided the students into five strata according to their OIs: normal, OI < 20 %; slight obesity, OI ≧ 20 and < 30 %; moderate obesity, OI ≧ 30 and < 50 %; marked obesity, OI ≧ 50 and < 70 %; extreme obesity, OI ≧ 70 %. There were no statistically significant differences in age and height among the strata of different OI.

Serum levels of total amylase, the P-type isoamylase and the S-type isoamylase in the strata of OI are shown in Table 1. Activities of total amylase, P-type isoamylase and S-type isoamylase tended to decrease as the OI increased. The decreases in total and isoamylase activities were all statistically significant in the groups with OIs of more than 50 %.

A correlation matrix of total amylase activity, P-type isoamylase activity, S-type isoamylase activity and OI based on the students in Table 1 is given in Table 2. It is apparent that the total amylase activity is mostly accounted for by the S-type isoamylase activity as inferred from the high correlation coefficient of 0.956, although there was also a fairly high correlation between the total amylase activity and the P-type isoamylase activity with a correlation coefficient of 0.536. There were statistically significant negative correlations between the degree of obesity and total amylase, P-type isoamylase and S-type isoamylase activities. The correlation coefficient between OI and S-type isoamylase activity was closer to that observed between OI and total amylase activity than that

Table I Demographic data of the studied students and serum levels of total amylase, pancreatic type (P-type) isoamylase and salivary type (S-type) isoamylase in different strata of obesity index (OI)

Strata of OI[a]	Number of cases	Age (years)	Height (cm)	OI[a] (%)	Activity of amylase (IU/l)					
					Total		P-type		S-type	
< 20 %	60	10.3 ± 2.5	135.8 ± 15.3	0.56 ± 9.79	170.5 ± 47.8	**	49.8 ± 14.6	**	120.7 ± 42.3	**
≧ 20 %, < 30 %	11	10.0 ± 3.1	143.5 ± 19.1	26.48 ± 2.90	152.8 ± 23.5	**	45.4 ± 12.1	**	107.5 ± 22.7	*
≧ 30 %, < 50 %	32	9.6 ± 2.0	137.0 ± 11.9	40.70 ± 4.65	149.3 ± 37.6	**	44.9 ± 14.1	**	104.3 ± 30.7	
≧ 50 %, < 70 %	28	9.8 ± 1.7	140.7 ± 11.9	58.86 ± 5.40	125.5 ± 36.4		40.3 ± 12.8		85.3 ± 32.5	
≧ 70 %	22	10.5 ± 2.5	145.2 ± 15.8	88.50 ± 16.13	132.0 ± 53.0		37.6 ± 10.7		94.4 ± 51.1	

*$P < 0.01$; **$P < 0.005$.

a: Percentage increase over standard body weight for the same age, height and sex, see Materials and Methods.
Results are expressed as mean ± S.D.

Table 2 A correlation matrix of serum levels of total amylase, pancreatic type (P-type) and salivary type (S-type) isoamylase in a total of 153 students studied in section 1

	P-type isoamylase	S-type isoamylase	Obesity index
Total amylase	0.536**	0.956**	−0.388**
P-type isoamylase		0.265*	−0.312*
S-type isoamylase			−0.335*

*$P < 0.01$; **$P < 0.001$.

Table 3 A correlation matrix of differences in total amylase, pancreatic type (P-type) isoamylase and salivary type (S-type) isoamylase activities before and after weight reduction in 26 students studied in section 2

	Differences in		
	P-type isoamylase	S-type isoamylase	Obesity index
Differences in			
Total amylase	0.429*	0.942***	−0.496**
P-type isoamylase		0.112	−0.071
S-type isoamylase			−0.489*

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

observed between OI and P-type isoamylase activity.

Phase II study. There were no significant differences in the mean activities of total amylase, P-type isoamylase and S-type isoamylase activities before and after weight reduction, although amylase activities all tended to increase after treatment in cases with successful weight reduction. The correlations between differences in OI before and after obesity treatment and those in total amylase, P-type isoamylase and S-type isoamylase activities before and after the treatment were analyzed, and correlation coefficients obtained among them are presented in Table 3, and their scattergrams in Fig. 1. The differences in OI was negatively correlated with the differences in total amylase and S-type isoamylase activities ($P < 0.05$, $P < 0.01$). There was no significant correlation between the differences in OI and the differences in P-type isoamylase activity. As the OI became smaller the increases in total amylase and S-type isoamylase activities became greater.

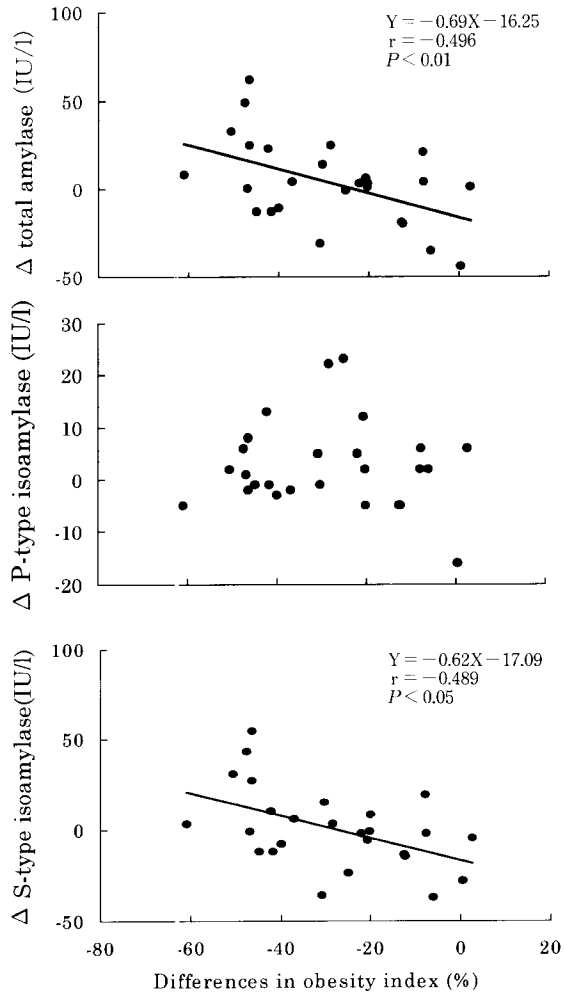

Fig. 1 Differences in total amylase activity in serum, differences in pancreatic type (P-type) isoamylase activity in serum and differences in salivary type (S-type) isoamylase activity in serum *vs* differences in obesity index calculated by subtracting the body weight after weight-reduction therapy from the initial body weight.
Δ: Differences in amylase activity.

Discussion

Kondo *et al.* (2) reported a decrease in total amylase activity in the serum of obese subjects. Taketa *et al.* (3), who studied a male population with a mean age of 18.2 years, ascribed this decrease to a preferential decrease in S-type isoamylase activity. The preferential decrease in S-type isoamylase in obesity was confirmed in the present study in a population of children (86 boys and 67 girls; mean age, 10.1 years; range, 6 to 15 years).

Although it is clear that the low serum activities of S-type isoamylase is entirely unrelated to binge-purge type eating disorders, it was not known whether individuals with lower serum levels of S-type isoamylase tended to become obese or the low serum levels of S-type isoamylase resulted from increased body weight. In this study, it was demonstrated that the reduction of body weight in obese children resulted in increased activities of serum S-type isoamylase. Therefore, increased weight appears to reduce the activity of serum S-type isoamylase. This was revealed by analysis of the correlation between the individual difference in OI and that in S-type isoamylase activity, although the mean serum levels of S-type isoamylase before and after weight reduction were not significantly different. This is hard to account for, but is probably due to the differences in total weight loss in responses to weight-reduction therapy and the wide individual variation in S-type isoamylase levels, which have also been reported in the general, healthy population (7, 8). Proof in the opposite direction, namely, reduction in S-type isoamylase activity in subjects who gain body weight is difficult or impossible to obtain in experimental conditions in humans.

Increased S-type isoamylase activity has been assumed to be present in herbivorous animals without documentation. Since a higher energy intake from fat rather than carbohydrates or starches is characterizing the metabolic alterations in the process of gaining in weight (9), the low S-type isoamylase level in obesity would be explained by assuming relatively lower carbohydrate consumption. Another explanation is that the energy intake or carbohydrate consumption per body weight of obese subjects is lower than normal as suggested by Kondo *et al.* (2). This additionally explains the low serum level of S-type isoamylase in obese children in that the intake of starch per kg body weight would also be reduced.

Since the weight reduction in this study was achieved by reducing the total energy intake on a balanced diet, the effect of other nutrients should also be considered. Reduced amylase activity upon prolonged fasting has been reported by Folsch *et al.* (10), although this probably reflects the change in P-type isoamylase activity. Similar results in an animal experiment are suggested to be related to insulin resistance (11, 12).

Although it is purely speculation, feed-back inhibition of S-type isoamylase production may also be possible by assuming that the obese gene product, leptin (13), regulates the S-type isoamylase level by suppressing its synthesis and secretion from the salivary glands. Nishimura *et al.* (7) has reported that the activity of amylase in mixed saliva correlates with that in serum. This would be an interesting area for research and remains to be elucidated in future studies.

References

1. Gwirtsman HE, Kaya WH, George DT, Carosella NW, Greene RC and Jimerson DC: Hyperamylasemia and its relationship to binge-purge episodes: Development of a clinically relevant laboratory test. J Clin Psychiatry (1989) **50**, 196-204.
2. Kondo T, Hayakawa T, Shibata T, Sato Y and Toda Y: Serum levels of pancreatic enzymes in lean and obese subjects. Int J Pancreatol (1988) **3**, 241-248.
3. Taketa K, Ueda M and Kosaka K: Preferential salivary-type hypoamylasemia in obesity. Clin Chim Acta (1995) **235**, 117-119.
4. Murata M, Yamazaki K, Itani A and Inaba M: Standard body weight for height for ages between 5 years and 17 years. J Child Health (1997) **39**, 93-96.
5. Gerber M, Naujoks K, Lenz H, Gerhardt W and Wulff K: Specific immunoassay of α-amylase isoenzymes in human serum. Clin Chem (1985) **31**, 1331-1334.
6. Gerber M, Naujoks K, Lenz H and Wulff K: A monoclonal antibody that specifically inhibits human salivary α-amylase. Clin Chem (1987) **33**, 1158-1162.
7. Nishimura M, Ikeda S and Taketa K: Studies of individual variation of S-type serum amylase. Jpn J Health Hum Ecol (1995) **61**, 78-79 (in Japanese with English abstract).
8. Ueda M, Araki T, Shiota T and Taketa K: Age and sex-dependent alterations of serum amylase and isoamylase levels in normal human adults. J Gastroenterol (1994) **29**, 189-191.
9. Horton TJ, Drougas H, Brachey A, Reed GW, Peters JC and Hill JO: Fat and carbohydrate overfeeding in humans: Different effects on energy storage. Am J Clin Nutr (1995) **62**, 19-29.
10. Folsch UR, Dreessen UW, Talaulicar M, Willms B and Creutzfeldt W: Effect of long-term fasting of obese patients on pancreatic exocrine function, gastrointestinal hormones and bicarbonate concentration in plasma. Z Gastroenterol (1984) **22**, 357-364.
11. Schneeman BO, Inman MD and Stern JS: Pancreatic enzyme activity in obese and lean Zucker rats: A developmental study. J Nutr (1983) **113**, 921-925.
12. Trimble ER, Rausch U and Kern HF: Changes in individual rates of pancreatic enzyme and isoenzyme biosynthesis in the obese Zucker rat. Biochem J (1987) **248**, 771-777.
13. Considine RV: Weight regulation, leptin and growth hormone. Horm Res (1997) **48**, 116-121.

Received March 19, 1998; accepted February 1, 1999.