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Effects of breakfast with different calorigenic amounts on blood glucose, insulin and glucagon levels

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Abstract: This study was aimed to investigate the relationship between breakfast and serum glucose, insulin and glucagon concentrations in order to establish a model breakfast appropriate for Chinese. Twenty-four volunteers were randomly assigned to four study groups: high carbohydrate breakfast, high fat and protein breakfast, the typical breakfast and fasting. Each subject had serum and urine samples collected while fasting and at 1, 2 and 3.5 hours following the meal. The concentration of serum glucose, insulin and glucagon was measured. The levels of serum glucose in group A, B and C differed significantly at 1 and 2 hour after meal compared to those at fasting ($P < 0.05$). The serum glucose in group A increased insignificantly after meal. The serum insulin levels were in group A, B and C significant different compared with control group($P < 0.05$). Those peaked at 1 hour after meal, with group C rising the furthest. Compared with the fasting group, the serum glucagons rose and maintained the increase after breakfast in group A, B and C ($P < 0.05$). The data suggested that various diets with different calorigenic amounts increased hormone concentration to various extents. We found that a breakfast rich in carbohydrates could maintain proper blood glucose level.

Key words: Calorigenic amounts, Blood glucose, Insulin, Glucagon, Breakfast
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SUBJECTS AND METHODS

Subjects

Twenty-four 21 to 24 years old healthy medical students enrolled in Zhejiang University College of Medicine volunteered for the study. They consisted of 11 males and 13 females weights all within the normal range for their height according to Chinese norms.

Methods

The subjects were randomly assigned to four study groups: Group A (high glucose diet), Group B (high fat and protein diet), group C (common diet) and control group (without breakfast). Serum and urine samples were taken from the 3 groups respectively at 1, 2 and 3.5 hour after meal and from the control group also. The concentration of serum glucose was measured with Glucoxidase-Peroxidase Terminal Chromophoto-Test. Serum insulin and glucagon levels were measured with by radio-immunological analysis. Urine glucose was measured with Urine-testing paper. All subjects consumed no food on the morning of the study, but were allowed to drink water. Subjects ate food prepared in a standardized manner.

Experimental diet

The experimental diets were as follows:
Group A: one bowl of porridge (50 g rice), sugar rice block (150 g rice)
Group B: 2 meat dumplings(100 g flour, 30 g fine meat)
Group C: one bowl of porridge(50 g rice), one egg(55 g), one meat dumpling(50 g flour, 15 g fine meat), 200 ml acidophilus milk
Group D: No food.

The various caloric contents and proportions of carbohydrate, fat and protein are shown in Table 1.

Statistical analysis

Study data was analyzed by Single Factor Variance Analysis and F-test using SPSS for Windows (Version 8.0) statistic software, in which the averages and the standard deviations

were calculated using Excel 97 software.

RESULTS

1. Using the actual breakfast diet of college students as basis, the compositional rates of caroligenic substances were worked out in the testing breakfasts and shown in Table 1.

2. Urine glucoses from all urine samples taken respectively at 1.0, 2.0 and 3.5 hour after meal and at limoseric state were measured with Urine-testing paper. Test result show nogative.

3. The changes of serum glucose concentration of testing meal are shown in Table 2. The serum glucose averages in limoseric state from all four groups were below the clinical normal range. Those in limoseric state significantly differed from those at 1 or 2 hours after meal ($P < 0.05$), but did not differ from those at 3.5 hours after breakfast. Furthermore, with time, the serum glucose levels rose gradually to the normal level in the control group. The serum glucose average in group A rose markedly over the normal standard at 1 hour after the meal, and then gradually down to the normal level at 3.5 hours after the meal, near to that of the control group. Also, those in group B and group C rose step by step within 1 hour after meal, and then kept at the normal level. But the serum glucose average in group B was persistently lower than those in group A and group C ($P < 0.05$).

4. The changes of serum insulin are shown in Table 3. The serum insulin levels were significantly different between the four groups after breakfast and descended gradually to those in the control group at different time-points.

5. The mean serum glucagons levels are shown in Table 4. The serum glucagon levels were significantly different between group A, B and C. Compared with group D, glucagon levels rose and maintained the increase for 3.5 hours following breakfast in group A, B and C.

Table 1 Proportion of calorigenic substances in different breakfasts

Group	Energy (kJ)	Carbohydrate		Protein		Fat	
		Weight (g)	Ratio(%)	Weight (g)	Ratio(%)	Weight (g)	Ratio(%)
Control	0	0	0	0	0	0	0
A	3383.52	161.83	80.04	15.54	7.69	11.03	12.27
B	3772.67	74.99	33.27	34.03	15.10	51.73	51.63
C	2827.21	66.92	39.61	25.19	14.91	34.14	45.47

A: high carbohydrate breakfast; B: high fat and protein breakfast; C: common breakfast

Table 2 Changes of blood glucose level after different breakfasts (mmol/L, $\bar{\chi} \pm s$, $n = 6$)

Group	Limoseric state	1.0 h after breakfast	2.0 h after breakfast	3.5 h after breakfast
Control	3.23 ± 0.71	4.10 ± 0.55	4.17 ± 0.36	4.30 ± 0.46
A	3.17 ± 0.32	6.23 ± 1.67[a]	5.55 ± 0.92[a]	4.39 ± 0.35
B	3.25 ± 0.47	4.64 ± 0.88[ab]	3.89 ± 0.78[ab]	3.94 ± 0.69
C	3.73 ± 0.38	4.60 ± 1.39[ab]	4.15 ± 0.68[ab]	4.42 ± 0.65

[a]: $P < 0.05$ compared with limoseric state, [b]: $P < 0.05$ compared with group A

Table 3 Changes of insulin level after different breakfasts (kU/L, $\bar{\chi} \pm s$, $n = 6$)

Group	Limoseric state	1.0 h after breakfast	2.0 h after breakfast	3.5 h after breakfast
Control	7.061 ± 1.967	6.318 ± 3.386	6.300 ± 2.872	4.366 ± 1.945
A	7.050 ± 4.460	77.142 ± 40.085[a]	71.803 ± 24.826[a]	23.992 ± 12.784[a]
B	19.846 ± 4.598[b]	88.900 ± 34.211[a]	90.935 ± 43.255[a]	38.202 ± 31.436[a]
C	12.147 ± 5.373[b]	106.453 ± 78.134[a]	68.112 ± 58.081[a]	17.666 ± 14.403[a]

[a]: $P < 0.05$ compared with control group, [b]: $P < 0.01$ compared with control group

Table 4 Changes of glucagon level after different breakfasts(ng/L, $\bar{\chi} \pm s$, $n = 6$)

Group	Limoseric state	1.0 h after breakfast	2.0 h after breakfast	3.5 h after breakfast
Control	184.703 ± 46.124	165.352 ± 49.910	171.704 ± 37.989	167.634 ± 34.179
A	158.491 ± 29.216	203.161 ± 30.238[a]	226.926 ± 38.684[a]	220.748 ± 43.532[a]
B	158.517 ± 22.484	183.514 ± 8.971[a]	183.114 ± 19.495[a]	198.400 ± 15.078[a]
C	178.786 ± 33.438	227.820 ± 37.435[a]	235.255 ± 25.158[a]	221.293 ± 32.059[a]

[a]: $P < 0.05$ compared with limoseric state

DISCUSSION

When all groups were in limoseric state, and 3.5 hours after meal in groups A, B, C, the serum glucose means of the four groups had no difference from each other. Some differences observed were probably attributable to experimental error.

The four groups' average serum glucose level differed during limoseric state. There were significant differences in mean serum glucose concentrations at 3.5 hours after breakfast between the groups A, B and C, suggesting that diet consumed at breakfast affected glucose concentration. Insulin secretion groups that consumed breakfast was significantly higher than that in the control (fasting) group(Fischer *et al.*, 2001).

The glucagon levels of the four groups in limoseric state had no significant difference; while the three testing groups at 3.5 hours after meal had higher glucagon levels than those in the control group. The data here suggested that various diets with different calorigenic substances change the hormone concentration to various extents. Breakfast rich in fat and protein led to higher hormone level, and better hunger endurance, which was lowered in the case of long time abstinence from breakfast.

This investigation indicated that the serum glucose concentrations and the levels of insulin and glucagons were all different among the four groups 1 or 2 hours after meal, with the serum glucose contents of group A > B > C. The data showed that high carbohydrate breakfast diet (group A) played a major role in keeping the serum glucose concentration high and constant (Ke and Yang, 1997; Yu *et al.*, 1995). But, this was not so in the case of the high fat-containing and protein-containing diet group whose complicated utilization of their meal nutrients did not lead to extremely high serum glucose concentrations slowly (Silberba *et al.*, 1996; Gannon *et al.*, 1993). Breakfast diet like that of group C is the prevalent choice of college students. Although this sort of diet has fat and protein to some extent, its relatively low energy and carbohydrate values are insufficient for maintaining a high and stable serum glucose level.

Imaginably, this breakfast will meet the demand for general energy and in the ingestion rate of the three nutrients if some carbohydrate is added to it.

Sufficient carbohydrate intake can maintain an ideal dynamic level of serum glucose level suitable for Chinese. The diet of group C cannot maintain a high and stable serum glucose level for a long time, but will do if sufficient carbohydrate is added to supply 60% of the general energy. In this case, the human body will have enough energy for various activities in the morning.

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