J Nutr Sci Vitaminol, **53**, 247–252, 2007

Effect of Vietnamese Common Diet on Postprandial Blood Glucose Level in Adult Females

Pei-Ying LIN[1], Bui Thi NHUNG[1,2], Nguyen Cong KHAN[2], Nobuko SARUKURA[1], Daisuke KUNII[3], Tohru SAKAI[4], Afework KASSU[5] and Shigeru YAMAMOTO[6,*]

[1]*Department of International Public Health Nutrition, and* [5]*Department of Preventive Environment and Nutrition, Institute of Health Biosciences, The University of Tokushima, Tokushima, Japan*
[2]*National Institute of Nutrition, Hanoi, Vietnam*
[3]*National Institute of Health and Nutrition, Tokyo, Japan*
[4]*Department of Clinical Nutrition, Osaka Prefecture University, Osaka, Japan*
[6]*International Nutrition, Ochanomizu University Graduate School of Humanities and Sciences, Tokyo, Japan*

(Received February 2, 2007)

Summary To elucidate the effect of a typical Vietnamese diet including a high content of white rice on postprandial blood glucose levels, the present study was designed. Thirty healthy female subjects with a similar body mass index, 10 each in their twenties, forties and sixties, were recruited. Four meals with a similar protein energy percentage (13–15%) but different energy ratios of fat and carbohydrate (FC ratio) and vegetable contents were provided by cross-over design. Meal A was designed according to the commonly consumed diet in Vietnam. The FC ratio was 14 : 71 and 84 g of carbohydrate was from rice. Meal B contained carbohydrate in a lower ratio than meal A by fat replacement and its FC ratio was 30 : 57. Meal C was similar to meal A except lacking vegetables. The energy of meal A, B and C was about 2.1 MJ. Meal D was designed to match the amount of carbohydrate and fat within A and B, respectively. The FC ratio of meal D was 26 : 61 and the energy was about 2.4 MJ. Fasting blood glucose was measured before consumption of a test meal. Postprandial blood glucose was measured every 30 min for 2 h. Areas under the curve (AUC) were calculated to compare the glycemic response among the four test meals. There was no significant difference in AUC among the four test meals in the subjects in their twenties. In the subjects in their forties, the AUC of meal A tended to be lower than that of meal C ($p=0.07$). In the subjects in their sixties, the AUC of meal A was significantly higher than that of meal B ($p<0.001$). Glycemic responses showed a significant relationship with age ($r=0.26$, $p<0.01$); however, there was no association between glycemic responses and BMI ($p=0.20$). Dietary fat ratios were inversely associated with glycemic responses ($r=-0.28$, $p<0.01$). In conclusion, the diet with about 70% energy from carbohydrate which is commonly consumed by Vietnamese may increase glycemic response, especially in elderly people and dietary vegetables may be beneficial to prevent such an increase in glycemic response.

Key Words Vietnamese common diet, glycemic response

Evidence shows an increasing prevalence of diabetes in the Asian population and also indicates the risk of diabetes in Asians may be higher than that of other racial groups at the same body mass index (BMI) (*1*–*6*). The use of white rice as a staple food, since white rice has been demonstrated and classified as a high glycemic index (GI) food, has been considered as a risk factor for diabetes (*5*–*7*).

Willett and colleagues (*8*) proposed a "Healthy Eating Pyramid" recently which suggested refined carbohydrates, such as white rice, should be used sparingly, as are sweets. Plant oil was suggested to be near the foundation of the pyramid to meet the fact that Americans get 35% or more of their daily energy from fat. Based on evidence, plant oil contains plenty of polyunsaturated fatty acid, which is considered superior to animal fat (*8*). It has been considered that the prevalence of diabetes increased severely in recent years because Americans consumed too much carbohydrate instead of fat, following the "Food Guide Pyramid" published in 1992 (*9*). The suggestions to use white rice sparingly (*8*) may bring about a great impact on the dietary culture of Asians.

Compared with America, the fat intake ratio was low in Asian countries, especially in Vietnam. According to the National Nutrition Survey in Vietnam, energy from protein, fat, and carbohydrate (PFC ratio) were 13, 12, and 75%, respectively (*10*). Some rural regions in Vietnam were reported to get more than 80% of their energy intake from carbohydrate (*10*). We hypothesized that the use of rice as a staple food is not the only risk factor for diabetes as there might be a synergistic effect with others, among which is a deficient ratio of macro-

* To whom correspondence shoud be addressed.
E-mail: yamamoto.shigeru@ocha.ac.jp

nutrients. Though rice had been classified as high-GI food, most of the time individuals do not eat rice only but combine it in mixed meals. Some researchers also suggested that a single food consumed with other dishes has a lower GI value than a single food consumed by itself (*11, 12*). Glycemic load (GL) was then introduced to represent the combination of quality and quantity of carbohydrate consumed (*13*). However, the utility of GI/GL is still controversial (*12, 13*). A review of the literature indicated the dietary GI or GL was used as a measure of glycemic response in young subjects or diabetes patients (*13–15*). There have been no adequate studies on comparison of postprandial glycemic responses among the young or elderly healthy subjects.

This study was aimed to provide data on postprandial glycemic responses based on the Vietnamese common diet with high carbohydrate intake by involving three different age groups.

MATERIALS AND METHODS

Subjects. This study was conducted in Khanh Van Commune, Ninh Binh Province, Vietnam. Healthy female subjects of three age groups with similar BMI (those in their twenties, forties and sixties) were recruited from a pool of farmers and participated after harvesting season. Ten subjects were enrolled in each group. Informed consent was received from all subjects and approval for the study was given by the Ethical Committee of the Ministry of Health, National Institute of Nutrition, Vietnam. Hypertension, hyperlipidemia, diabetes, impaired fasting glucose, alcohol drinking, and smoking were exclusion criteria. A self-monitored blood glucose device (SMBG device, Precision Xtra, Abbott Laboratories, Abbott Park, Illinois, USA) was used to measure blood glucose for screening. Fasting blood glucose more than 110 mg/dL was excluded according to American Diabetes Association's (ADA) criteria (*16*). Height and weight were measured to 0.1 cm and 0.1 kg, respectively, using a digital weight balance and height scale.

Test meals. Four test meals (A, B, C and D) were designed using white rice as a staple food and pork with or without vegetables as side dishes. Seasonings were almost the same for all the meals. The composition of test meals is shown in Table 1. Since the purpose of this study was to elucidate the effect of dietary FC ratio, the proportion of energy from protein of the four test meals was kept relatively constant (13–15%). Meal A was designed to represent the Vietnam common diet according to the National Nutrition Survey of Vietnam (*10*). Its FC ratio and energy intake were as commonly consumed in Vietnam. The total energy of meal A, B and C was about 2.1 MJ. FC ratios in test meals A and B were 14 : 71 and 30 : 57, respectively. Studies also indicated that dietary vegetables improved glycemic control by reducing or delaying the absorption of carbohydrate (*17–20*). Meal C was designed to be similar to meal A except lacking vegetables and its FC ratio was 15 : 71. To elucidate whether glycemic response was also influenced by a deficient FC ratio, and not only because of the amount of carbohydrate, meal D was designed to match the amount of carbohydrate and fat within A and B, respectively. The total energy of meal D was 2.4 MJ with an FC ratio of 26 : 61. Energy intake and food composition were determined by Nutritive Composition Table of Vietnamese Foods (*21*). All test meals were measured, prepared and divided into portions each morning.

Table 1. Dietary composition and PFC ratios of four test meals.

	Meal A*	Meal B	Meal C	Meal D
White rice (g)	110	86	110	110
Oil (g)	4	13	4	13
Lean pork (g)	40	40	40	40
Vegetable (g; cabbage)	100	100	0	100
Fish sauce (g)	5	5	5	5
Protein (g)	18.4	16.5	16.6	18.4
Fat (g)	7.9	16.7	7.9	16.9
Carbohydrate (g)	89.2	70.9	83.8	89.2
Fiber (g)	2.0	1.9	0.4	2.0
P : F : C ratio	15:14:71	13:30:57	14:15:71	13:26:61
Total energy (MJ)	2.1	2.1	2.0	2.4

*Meal A was designed to represent the Vietnam common diet. 1 kcal=4.186 kJ.

Study design and blood glucose measurement. Each subject took the 4 test meals on separate mornings by cross-over design. Subjects were asked to fast before testing for at least 10 h. Nothing was allowed to be eaten or drunk except water. On the test morning, the subjects arrived at the local health center by the least strenuous means of transportation. After resting in a comfortable position for at least 10 min, body weight was measured. Fasting blood glucose was measured before consumption of the test meal. Test meals were consumed within 15 min. Postprandial blood glucose was measured every 30 min for 2 h from the consumption of the test meals. The incremental area under the curve (AUC) changes in blood glucose was computed by the trapezoidal method (*22*). The AUC for each test meal was expressed as glycemic response for 2 h. AUCs of the four test meals among the three age groups were compared. The blood glucose was measured using a SMBG device. This biosensor glucose test strip is based on an electron-transferred glucose oxidase reaction (*23*). A fill trigger electrode was designed to minimize the possibility of inaccurate results due to low sample volume. The accuracy of the glucose test strip was demonstrated by comparing 393 capillary blood glucose obtained by YSI Glucose analyzer (YSI Inc., Yellow Springs, OH). Agreement between the two methods of measurements was observed with a correlation coefficient (r)>0.98, mean absolute bias of 4.9% and a 3.5% reproducibility of normal glucose concentration. Capillary blood samples were measured with three test strips in three SMBG devices and the average of the three readings was used.

Statistical analysis. Incremental AUCs for each test meal were calculated and the data were expressed as

Table 2. Characteristics of the study subjects.

Group	Age (y)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Fasting Blood Glucose (mg/dL)
Twenties (n=10)	23.4±0.5	155.1±1.2	44.0±2.3	18.2±0.8	85.0±2.8
Forties (n=9)	42.3±0.6	153.5±1.6	46.1±2.2	19.5±0.6	88.3±2.3
Sixties (n=10)	61.4±0.4	153.2±1.1	47.6±1.7	20.3±0.8	92.6±1.3

Data are presented as means±SE.

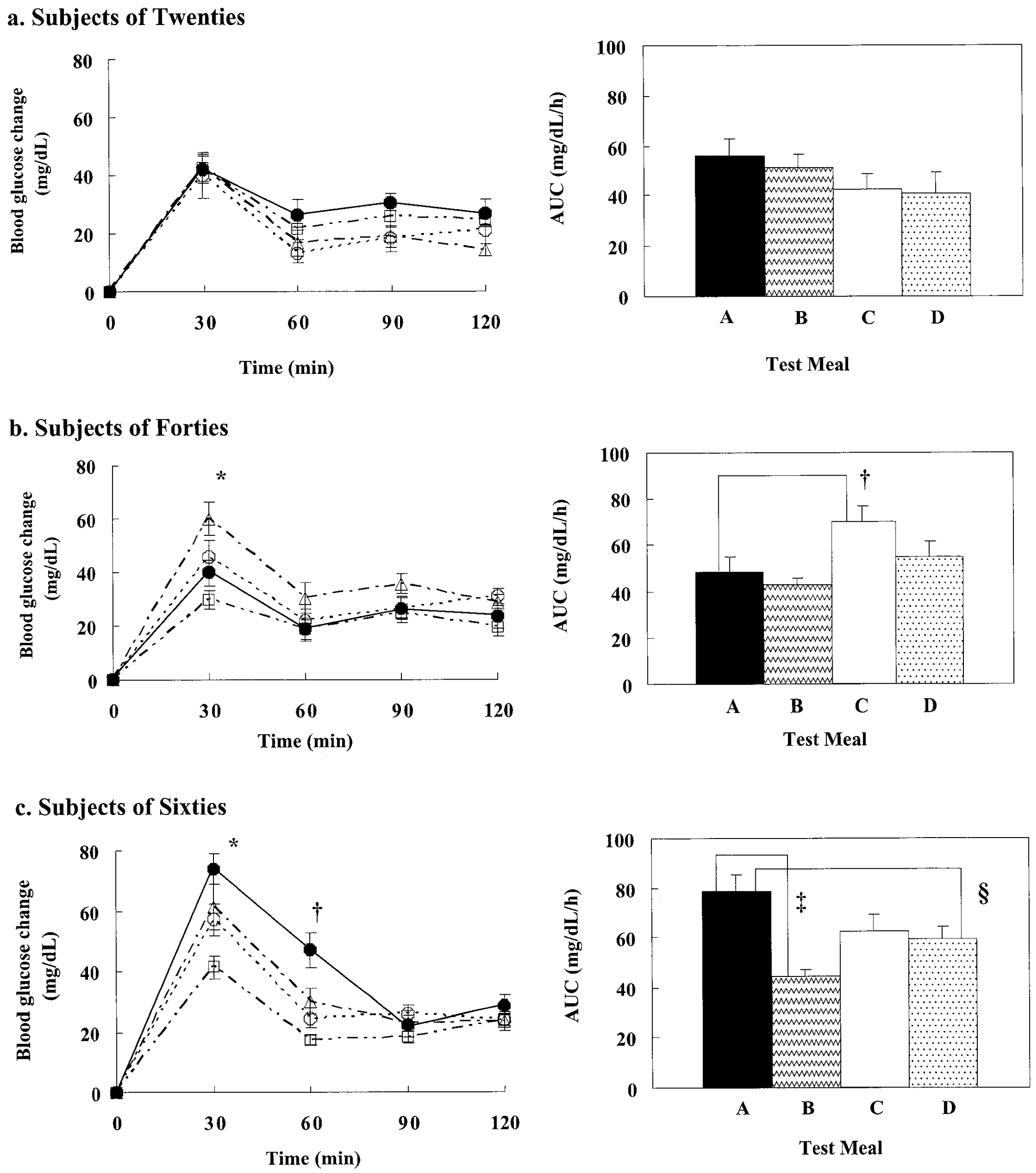

Fig. 1. Postprandial blood glucose level and the AUC after subjects consumed four test meals (●, A; □, B; △, C; ○, D) for 120 min. Meal A was compared with the other three test meals. Two-way ANOVA showed a main effect of age and a significant age-by-test meal interaction (both $p<0.01$). (a) Data for subjects in their twenties. (b) Data for subjects in their forties. *$p<0.05$, and †$p=0.07$ for A vs. C. (c) Data for subjects in their sixties. *$p<0.01$ A vs. B. †$p<0.001$ A vs. B, $p<0.05$ A vs. C, and $p<0.01$ A vs. D. ‡$p<0.001$, §$p=0.07$.

mean±SE. Two-way ANOVA was used to test the main effect and the interaction between age and test meal. Mean contrasts according to modified Bonferroni inequalities were used to analyze significance. Mean values of the four test meals in each age group were compared by analysis of variance (ANOVA). Tukey's multiple comparison test of means was used to compare treatments pairwise. Simple correlations were determined by Pearson's correlation coefficient (r). Partial correlations were measured between postprandial gly-

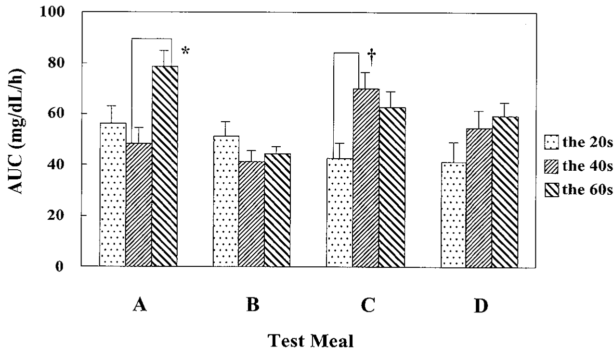

Fig. 2. Postprandial glycemic responses (AUCs) to the same test meals when compared among the three age groups. *$p<0.01$, †$p<0.05$.

Table 3. Correlation analyses between postprandial glycemic response (AUC) and age, BMI and dietary fat ratio.

	Postprandial glycemic response (AUC)			
	*r**	*p*-value	beta*	*p*-value
Age	0.26	<0.01†	0.26	<0.01†
BMI	−0.12	0.20	−0.12	0.20
Dietary fat ratio	−0.28	<0.01†	−0.27	<0.01†

* *r* for Pearson's correlation coefficient, and beta for partial correlation coefficient.
† $p<0.01$ significant difference.

cemic response (AUC) and age, and BMI and dietary fat ratios by controlling for the impact of energy intake. Analysis of the data was carried out with SPSS version 11.5 J statistical software. *p* values less than 0.05 were considered statistically significant.

RESULTS

Originally there were 10 subjects in each age group; however, one subject in her forties was dropped from the study due to a physical problem. Characteristics of the study subjects are shown in Table 2. The heights, weights, BMIs and fasting blood glucose showed no significant difference among the three age groups ($p>0.05$). A main effect of age and age-by-test meal interactions was significant (both $p<0.01$; Fig. 1). In the subjects in their twenties, glycemic response to meal A was higher than that to the others after 60 min, although the difference was not significant (Fig. 1a). The AUCs of meal A, B, C and D were 56±7, 51±6, 43±6 and 40±7 mg/dL/h, respectively, with no significant difference among them.

In the subjects in their forties, meal A, which contained vegetables, had significantly lowered glycemic response at postprandial 30 min when compared with meal C ($p<0.05$, Fig. 1b). The AUCs of meal A, B, C and D were 48±6, 41±4, 70±7 and 55±7 mg/dL/h, respectively. Meals A and C tended to show different glycemic response for the 2 h ($p=0.07$).

In the subjects in their sixties, the greater amount of carbohydrate contained in meal A showed a considerable effect on glycemic response, which was significantly higher than for meal B at postprandial 30 min ($p<0.01$) and 60 min ($p<0.001$) (Fig. 1c). At postprandial 60 min, meal A had a significant converse effect on glycemic response compared with meal C ($p<0.05$). Glycemic response to meal D was significantly lower than that to meal A at postprandial 60 min ($p<0.01$). The AUCs of meals A, B, C and D were 79±6, 45±3, 63±6 and 59±5 mg/dL/h, respectively. The glycemic response for 2 h was significantly different between meals A and B ($p<0.001$), and it tended to show significance between meals A and D ($p=0.07$).

When comparing the glycemic responses to the same test meal among three age groups (Fig. 2), significant differences in meal A was observed for those in their forties versus their sixties ($p<0.01$) and in meal C for the subjects in their twenties compared to their forties ($p<0.05$). Pearson's correlation analyses indicated age was significantly correlated with postprandial glycemic response (AUC) ($r=0.26$, $p<0.01$) (Table 3). A significant negative correlation was observed between AUC and dietary fat ratio ($r=-0.28$, $p<0.01$). There was no association between BMI and AUC ($r=-0.12$, $p=0.20$). After partial correlation analysis, the correlations between AUC vs. age and AUC vs. dietary fat ratio remained significant (beta=0.26, $p<0.01$ and beta=−0.27, $p<0.01$, respectively).

DISCUSSION

The diet with about 70% energy from carbohydrate, which is commonly consumed by Vietnamese, increased glycemic response, especially in the elderly subjects. The increased glycemic response was considered to be mainly due to a low dietary fat ratio and excess carbohydrate since protein intake levels were similar, being 13–15% of total energy intake. The additional amount of fat in meal D reduced glycemic response when compared with meal A, despite the identical amount of carbohydrate. Furthermore, the glycemic response to meal A displayed marked postprandial hyperglycemia compared with meal B. Our results were consistent with other studies which pointed out that fat contained in a mixed meal would delay the absorption of carbohydrate and attenuate the glycemic response (*11, 12*). Though fat was thought as non-GI (*8*) to attenuate the glycemic response, its high energy density could not be ignored.

Glycemic response to meal A displayed marked postprandial hyperglycemia in the subjects in their sixties compared with meal B, while the same effects couldn't be observed in the subjects in their twenties and forties. It may be speculated that the small difference in the AUC observed in the subjects in their twenties and forties might be due to the leveling off in glycemia as indicated by Brand-Miller et al. (*24*). In their study involving lean healthy volunteers, Brand-Miller et al. (*24*) pointed out that increasing the glycemic load produced a stepwise increase in glucose AUC only observed at the low doses. In that study, five doses (one, two, three, four and six slices) of bread were tested. The dose-response relationships observed at lower doses and a leveling off in glycemia after a load of four slices of bread suggests healthy individuals are able to control glycemia within narrow physiological boundaries by increasing the amount of insulin secreted (*24*). On the other hand, test meals in the present study were designed to be close to the daily intake in Vietnam. After converting the amount of rice into carbohydrate, 84 g and 66 g of carbohydrate were contained in meal A and B, respectively. These amounts were over 52 g carbohydrate, which was equivalent to the mentioned four slices of bread. The glycemic effect caused by different amount of carbohydrate seemed to be attenuated by other factors such as fat and protein contained in side dishes (*11*). However, the considerable difference observed in the subjects in their sixties might be caused by age or potentially by adipose tissue (*25, 26*). It has been indicated that abdominal fat and body fat percentage are increasing in Vietnamese, especially in females (*5*). It is also worth mentioning that decreasing insulin sensitivity due to body fat increased with age has been observed (*26*). However, it was the limitation of this study that the blood glucose used as an indicator and BMI used as the anthropometric criterion were inadequate to provide a further explanation.

Studies indicate that dietary fiber contained in vegetables delayed the absorption of carbohydrates and ameliorated the postprandial glycemic response (*17–20*). In this study we observed an interesting phenomenon. The favorable effect occurred only in the subjects in their forties and not in the subjects in their twenties and sixties. The results of the subjects in their twenties and sixties were also different. In the subjects in their twenties, the AUCs of meals A and C were similar and low but in the subjects in their sixties, the AUCs of both test meals were similarly high. The results may suggest that the young group had the ability to control blood glucose level regardless of the dietary vegetables. In the elderly group, the AUC was high even though they took the meal with vegetables (meal A); nevertheless, an increase in the AUC was not observed by taking the meal without vegetables (meal C). This observation needs further studies to elucidate the favorable effects of dietary vegetables in the elderly.

The GI might be of some help to patients with impaired glucose tolerance (*11, 12*). Nevertheless, the GI concept, especially considering its interpretation by health professionals or the general population, should not be the only, nor the most important, criterion to judge a food (*12*). A low dietary fat ratio and excess carbohydrate could also account for increased glycemic response, not only using rice as a staple food. Our observation was in line with the recommendation by the ADA which states that the amount of available carbohydrate is more important than the source (*27*), since most of the time individuals consume a mixed meal rather than a single food. A dietary guideline must be based on ordinary dietary habits, or it will be futile. The dietary pattern of consuming rice as a staple food with other side dishes might represent a good dietary habit of Asians, with total energy intake being taken into account. However, such test meals are probably not exactly representative of those in everyday life. Further studies involving a large number of young and elderly healthy subjects are needed to elucidate the effect of the dietary FC ratio in mixed meals.

In conclusion, the present study showed that postprandial glycemic responses were different among three age groups, despite the consumption of the same test meal. The diet with about 70% energy from carbohydrate, which is commonly consumed by Vietnamese, increased glycemic response, especially in the elderly subjects. Dietary vegetables may also be beneficial to prevent such an increase in glycemic response.

Acknowledgments

The subjects participating in this study are gratefully acknowledged. We would also like to express our gratitude for the assistance of the Ministry of Health, National Institute of Nutrition, Vietnam and Local Health Center in Khanh Van Commune and to the staff who helped to conduct the study. This work was partially supported by funds from the US-Japan Cooperative Medical Science Program.

REFERENCES

1) Ota T, Takamura T, Hirai N, Kobayashi K. 2002. Preobesity in World Health Organization classification involves the metabolic syndrome in Japanese. *Diabetes Care* **25**: 1252–1253.

2) Le Nguyen TD, Tran TM, Kusama K, Ichikawa Y, Nguyen TK, Yamamoto S. 2003. Vietnamese type 2 diabetic subjects with normal BMI but high body fat. *Diabetes Care* **26**: 1946–1947.

3) WHO Expert Consultation. 2004. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* **363**: 157–163.

4) Dickinson S, Colagiuri S, Faramus E, Petocz P, Brand-Miller JC. 2002. Postprandial hyperglycemia and insulin sensitivity differ among lean young adults of different ethnicities. *J Nutr* **32**: 2574–2579.

5) Le DS, Kusama K, Yamamoto S. 2006. A community-based picture of type 2 diabetes mellitus in Vietnam. *J Atheroscler Thromb* **13**: 16–20.

6) Shiwaku K, Hashimoto M, Nogi A, Kitajima K, Yamasaki M. 2004. Traditional Japanese dietary basics: a solution for modern health issues? *Lancet* **363**: 1737–1738.

7) Miller JB, Pang E, Bramall L. 1992. Rice: a high or low glycemic index food? *Am J Clin Nutr* **56**: 1034–1036.

8) Willett WC. 2001. Eat, drink and be healthy. The Harvard Medical School Guide to Healthy Eating. Simon & Schuster Source, New York, Free Press.

9) United States Department of Agriculture. 1992. Food Guide Pyramid Booklet, Center for Nutrition Policy and Promotion, United States Department of Agriculture, Washington, DC.

10) Khoi HH, Khan NC, Mai LB, Tuyen LD. 2003. General Nutrition Survey 2000. Medical Publishing House, Hanoi.

11) Flint A, Moller BK, Raben A, Pedersen D, Tetens I, Holst

JJ, Astrup A. 2004. The use of glycemic index tables to predict glycaemic index of composite breakfast meals. *Br J Nutr* **91**: 979–989.

12) Pi-Sunyer FX. 2002. Glycemic index and disease. *Am J Clin Nutr* **76**: 290S–298S.

13) Willett W, Manson J, Liu S. 2002. Glycemic index, glycemic load, and risk of type 2 diabetes. *Am J Clin Nutr* **76**: 274S–280S.

14) Indar-Brown K, Noreberg C, Madar Z. 1992. Glycemic and insulinemic responses after ingestion of ethnic foods by NIDDM and healthy subjects. *Am J Clin Nutr* **55**: 89–95.

15) Coulston AM, Hollenbeck CB, Swislocki AL, Reaven GM. 1987. Effect of source of dietary carbohydrate on plasma glucose and insulin responses to mixed meals in subjects with NIDDM. *Diabetes Care* **10**: 395–400.

16) Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. 2003. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* **26**(Suppl 1): S5–20.

17) Dror Y. 2003. Dietary fiber intake for the elderly. *Nutrition* **19**: 388–389.

18) Buyken AE, Toeller M, Heitkamp G, Vitelli F, Stehle P, Scherbaum WA, Fuller JH. 1998. Relation of fibre intake to HbA1c and the prevalence of severe ketoacidosis and severe hypoglycemia. EURODIAB IDDM Complications Study Group. *Diabetologia* **41**: 882–890.

19) Chandalia M, Garg A, Lutjohann D, von Bergmann K, Grundy SM, Brinkley LJ. 2000. Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. *N Engl J Med* **342**: 1392–1398.

20) Fukagawa NK, Anderson JW, Hageman G, Young VR, Minaker KL. 1990. High-carbohydrate, high-fiber diets increase peripheral insulin sensitivity in healthy young and old adults. *Am J Clin Nutr* **52**: 524–528.

21) National Institute of Nutrition. 2000. Nutritive Composition Table of Vietnamese Foods. Medical Publishing House, Hanoi.

22) Wolever TM, Jenkins DJ, Jenkins AL, Josse RG. 1991. The glycemic index: methodology and clinical implications. *Am J Clin Nutr* **54**: 846–854.

23) Abbott Laboratories. Clinical Performance of the True-Measure™ Technology Test Strip on Capillary, Arterial, Venous and Neonatal Blood Samples, P/N 487107 Rev. 0 11/02.

24) Brand-Miller JC, Thomas M, Swan V, Ahmad ZI, Petocz P, Colagiuri S. 2003. Physiological validation of the concept of glycemic load in lean young adults. *J Nutr* **133**: 2728–2732.

25) DeFronzo RA, Bonadonna RC, Ferrannini E. 1992. Pathogenesis of NIDDM. A balanced overview. *Diabetes Care* **15**: 318–368.

26) Basu R, Breda E, Oberg AL, Powell CC, Dalla Man C, Basu A, Vittone JL, Klee GG, Arora P, Jensen MD, Toffolo G, Cobelli C, Rizza RA. 2003. Mechanisms of the age-associated deterioration in glucose tolerance: contribution of alterations in insulin secretion, action, and clearance. *Diabetes* **52**: 1738–1748.

27) Franz MJ, Bantle JP, Beebe CA, Brunzell JD, Chiasson JL, Garg A, Holzmeister LA, Hoogwerf B, Mayer-Davis E, Mooradian AD, Purnell JQ, Wheeler M; American Diabetes Association. 2002. Evidence-based nutrition principles and recommendations for the treatment and prevention of diabetes and related complications. *Diabetes Care* **25**: 148–198.