Reference values for continuous glucose monitoring in Chinese

Jian Zhou, MD1, Hong Li, MD2, Xingwu Ran, MD3, Wenying Yang, MD, PHD4, Qiang Li, MD, PHD5, Yongde Peng, MD, PHD6, Yanbing Li, MD7, Xin Gao, MD8, Xiaojun Luan, MD9, Weiqing Wang, MD, PHD10, Weiping Jia, MD, PHD1

*A full list of participating investigators is available in an online-only appendix at http://care.diabetesjournals.org*

1, Department of Endocrinology and Metabolism, Shanghai Jiao Tong University Affiliated Sixth People’s Hospital, Shanghai Diabetes Institute, Shanghai Clinical Center for Diabetes, Shanghai, China
2, Department of Endocrinology and Metabolism, Sir Run Run Shaw Hospital, College of Medicine, Zhejiang University Hangzhou, China
3, Department of Endocrinology and Metabolism, West China Hospital, Sichuan University, Chengdu, China
4, Department of Endocrinology and Metabolism, China-Japan Friendship Hospital, Beijing, China
5, Department of Endocrinology and Metabolism, The Second Affiliated Hospital of Harbin Medical University, Harbin China
6, Department of Endocrinology and Metabolism, Shanghai Jiao Tong University Affiliated First People’s Hospital, Shanghai, China
7, Department of Endocrinology and Metabolism, The First Affiliated Hospital of Sun Yat-Sen University, Guangzhou, China
8, Department of Endocrinology and Metabolism, Fudan University Affiliated Zhongshan Hospital, Shanghai, China
9, Department of Endocrinology and Metabolism, The First People’s Hospital of Foshan, Foshan, China
10, Shanghai Clinical Center for Endocrine and Metabolic Diseases, Shanghai Institute of Endocrinology and Metabolism, Ruijin Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China

**Corresponding author:**
Weiping Jia
E-mail address: wpjia@sjtu.edu.cn

Submitted 15 January 2009 and accepted 14 April 2009.

This is an uncopyedited electronic version of an article accepted for publication in *Diabetes Care*. The American Diabetes Association, publisher of *Diabetes Care*, is not responsible for any errors or omissions in this version of the manuscript or any version derived from it by third parties. The definitive publisher-authenticated version will be available in a future issue of *Diabetes Care* in print and online at http://care.diabetesjournals.org.
Objective: The widespread clinical application of continuous glucose monitoring (CGM) is limited by the lack of generally accepted reference values. This multicenter study aims to establish preliminary normal reference values for CGM parameters in a sample of healthy Chinese subjects.

Research Design and Methods: A total of 434 healthy individuals with normal glucose regulation completed a 3-day period of glucose monitoring using a CGM system. The 24h mean blood glucose (24h MBG), and the percentage of time that subjects blood glucose (BG) levels were ≥ 140 mg/dl (PT140) and BG levels were ≤ 70mg/dl (PT70) within 24 hours were analyzed.

Results: There was excellent compliance of fingerstick BG values with CGM measurements for subjects. Among the 434 subjects, the daily BG varied from 76.9±11.3 mg/dl to 144.2±23.2 mg/dl. The 24h MBG, PT140 and PT70 were 104±10 mg/dl, 4.1±5.8 % and 2.4±5.3 %, respectively. As for these parameters, no significant differences were found between men and women. The 95th percentile values were adopted as the upper limits of CGM parameters, which revealed 119 mg/dl (6.6 mmol/l), for 24h MBG, 17.1% for PT140 and 11.7% for PT70.

Conclusions: We recommend a 24h MBG value lower than 119 mg/dl, PT140 less than 17% (4 hours) and PT70 less than 12% (3 hours) as normal ranges for the Chinese population.
Glucose monitoring is a key component in diabetes management. Monitoring results can be used clinically in determining the degree of glucose metabolic disturbance, evaluating therapeutic outcomes and guiding the adjustment of treatment regimens (1). Compared to traditional monitoring methods, the recently developed continuous glucose monitoring (CGM) technique provides much more glycemic information, including magnitude, duration and frequency of blood glucose (BG) levels, which is used to better understand the properties of shifting BG levels throughout the day. Although some drawbacks exist, CGM is able to reveal hyperglycemia and asymptomatic hypoglycemia that are normally difficult to detect, so as to provide evidence for optimal treatment decisions (2-4). The extensive data obtained from CGM could further characterize the BG profiles in patients with diabetes (5). With its capability of recording BG fluctuations, CGM also represents a new tool for studying the influence of factors on glucose variations in real life (6). Thus, applications of CGM continue to expand in both clinical practice and research settings. However, few investigations of BG profiles in the population without diabetes have been performed using CGM. Moreover, there remains a paucity of reference data reflecting the typical daily patterns and profiles of normal glycemia in the healthy population, negatively impacting the general application of the CGM technique and the rational interpretation of the data obtained. This multicenter study aims to generate preliminary normal reference values for CGM parameters using data collected over three consecutive days in a sample of healthy Chinese subjects.

**RESEARCH DESIGN AND METHODS**

**Study population:** We enrolled Chinese subjects from 10 academic hospitals in China between October 2007 and July 2008. The inclusion criteria included the following: 1) clinically stable condition with no previous medical history of diabetes, hypertension, dyslipidemia, coronary artery diseases or cerebral stroke, 2) fasting plasma glucose <100 mg/dl and 2h plasma glucose (2h PG) <140 mg/dl in 75 g oral glucose tolerance test (OGTT), according to 2008 ADA diabetes diagnostic criteria (7), 3) normal body mass index between 18.5 and 24.9 kg/m², according to 2004 WHO obesity diagnostic criteria (8), 4) triglycerides <150 mg/dl and high density lipoprotein cholesterol ≥ 40 mg/dl, according to 2007 Chinese guidelines on prevention and treatment of dyslipidemia (9), and 5) systolic pressure <140 mmHg and diastolic pressure <90 mmHg (10). The exclusion criteria included the following: 1) use of medications that may affect glucose metabolism such as glucocorticoids, thyroid hormones and thiazide diuretics one month before the study, and 2) hepatic or renal dysfunctions (>1.5 fold elevation of alanine aminotransferase, aspartate aminotransferase or direct bilirubin, or serum creatinine >115 µmol/L). This study was independently approved by the ethics committee of each participant hospital. All subjects gave and signed written informed consent before study initiation. No accompanied medications that adversely affect glucose tolerance were allowed during the trial.

**Continuous glucose monitoring (CGM):**

1. Continuous glucose monitoring system (CGMS): The CGMS sensor (Medtronic Inc., Northridge, CA, USA) was inserted into all subjects by the same specialized nurse at Day 0 around 8:00-9:00 in hospital. First CGMS calibration by finger-stick BG was performed after 1 hour of initialization. If no abnormal CGMS situation was observed, the subjects was dismissed and continued with CGM at home for 3 consecutive days. Subjects were instructed to input at least four calibration
readings per day. At day 3 around 8:00-9:00, subjects came to the hospital and had the CGMS off. Adopted from previous established criteria for optimal accuracy of the CGMS (11,12), the following criteria for optimal accuracy were adhered to: a correlation between the sensor and meter readings of at least 0.79, and a mean absolute difference of no more than 28% (when the daily range (Min-Max) of meter values ≥ 100mg/dl); a mean absolute difference of no more than 18% (when the daily range (Min-Max) of meter values < 100mg/dl).

2. CGM parameters: The 24-hour mean BG (24h MBG) was calculated as mean BG level from 288 readings measured by a CGMS over 24 hours. Daytime and nighttime mean BG levels were defined as BG levels during the time intervals of 6:00 a.m. to 10:00 p.m. and 10:00 p.m. to 6:00 a.m., respectively. Postprandial BG levels at 30min, 60min, 120min, 180min and the area under the curve within 3 hr after each meal were recorded and calculated. For each subject, the proportions of time spent on the BG ranges of 70-140 mg/dl (3.9-7.8 mmol/l), ≥ 140 mg/dl, and ≤ 70 mg/dl were determined from the CGM data. Percentage of time (PT) for BG ≤ 70 mg/dl and ≥ 140 mg/dl within 24 hours were recorded as PT70 and PT140 respectively (13,14). Other CGM parameters, including the area under the curve for BG > 100 mg/dl and the standard deviation of BG concentration within 24 hours were also calculated (13,14). All of the above parameters were based on the mean values taken on Days 1 and 2.

3. Mixed-meal method: All subjects received dietary instructions according to uniform criteria as the CGMS was implemented. The total calorie intake from the three daily meals was 30 kcal/kg/d during CGM, with 50% carbohydrates, 15% proteins and 35% fats. The amount of drinking water was not restricted. The calorie distribution between breakfast, lunch and dinner was 20%, 40% and 40% respectively. There was a disciplinary time of 6:30-7:30 for breakfast, 11:30-12:30 for lunch, and 18:00-19:00 for dinner. Each meal had to be consumed within 30 min. Subjects were required to follow the dietary instruction during the CGM.

**Laboratory examinations:** Plasma glucose was determined using the glucose oxidase method. Fully automatic biochemistry analyzer (Hitachi 7600-020, Japan, Enzymatic methods) was employed to determine hepatic and renal function, triglycerides, high density lipoprotein cholesterol, total cholesterol and low density lipoprotein cholesterol. Surestep BG meter (American Lifescan, New Brunswick) was used to determine finger-stick capillary BG.

**Statistical methods:** CGM parameters were analyzed using CGMS Software 3.0. Measurement data were presented as $\bar{x} \pm s$. Statistical analyses were performed using SPSS software (version 13.0). The t-test was used for comparison between two groups when data were normally distributed otherwise nonparametric analysis was applied. Pearson and Spearman analytical methods were employed for correlation analysis of two variables.

**RESULTS**

**Subject characteristics:** This study screened 588 subjects, among which 445 healthy subjects without related metabolic disorders were recruited for CGM. Eleven cases were excluded for final analysis due to the CGMS signal interruption or not meeting the accuracy requirements. None of the subjects complained of discomfort such as inflammation or allergy at the embedding sites. Data from the remaining 434 subjects (213 men and 221 women) were incorporated into the statistical analysis. The 434 subjects were 43±14 years old (mean±SD), with a range in age from 20 to 69. Subject distribution among age groups was similar: 23.5% were 20 to 29, 20.7% were 30 to 39, 19.8% were 40 to 49, 18.4% were 50 to 59, and 17.6% were 60 to 69.
The mean body mass index was 21.8±1.7 kg/m². Compared to women, men had higher body mass index, blood pressure (both systolic and diastolic), triglyceride levels and OGTT 30min PG (P<0.05), and lower levels of high density lipoprotein cholesterol and OGTT 3h PG (P<0.001) (Table 1).

Correlation analysis of interstitial glucose values by CGM and corresponding capillary BG: For the 434 healthy subjects, a total of 379,308 CGM readings were obtained. The average of 3,697 interstitial glucose values retrieved from the CGM and their corresponding finger-stick capillary BG were 103±21 mg/dl and 103±17 mg/dl, respectively with a mean absolute difference of 9.0±8.4%. Pearson correlation analysis revealed a positive correlation between these two values (r =0.822, P <0.001).

Characteristics of glucose profiles in healthy subjects by CGM: A glucose profile using the 24-hour mean data from 434 subjects is shown in Figure 1. The 24h MBG was 104±10 mg/dl (5.77±0.57 mmol/l) and the area under the curve for BG > 100 mg/dl was 9.7±6.7 mg·dl⁻¹·d. The nighttime MBG was lower than the daytime MBG by 9 ± 7% (98.6 ± 11.3 mg/dl vs 106.4 ± 11.3 mg/dl, P <0.001). There were similar MBG levels for men and women (Table 1).

In the 434 subjects, the daily BG varied from a mean minimum of 76.9±11.3 mg/dl to a mean maximum of 144.2±23.2 mg/dl. The standard deviation of BG was 14.2±5.8 mg/dl. There were no significant differences between men and women for these parameters (Table 1).

The postprandial BG levels at 30min, 60min, 120min and 180min after each meal, as well as postprandial area under the curve within 3 hr were listed in Table 2. Postprandial BG level at 60 min was the highest among the four postprandial time points for all three meals. At the time points of 120min and 180min, comparison between the meals revealed a significant lower BG level after breakfast than after lunch and dinner, respectively (P<0.05) No significant differences were observed between BG levels post-lunch and post-dinner.

Fluctuation of BG within 70 to140 mg/dl accounted for 93±8 % of the total day for the 434 subjects. PT140 and PT70 were 4.1±5.8 % and 2.4±5.3 %, respectively. Approximately 60% of subjects (n=260) experienced BG ≥ 140 mg/dl, with a percentage of cumulative time duration of 6.8±6.1 %. Eight subjects (1.8%) experienced BG ≥ 200 mg/dl, with the longest episode lasting 45 min. The cumulative time of BG ≥ 200 mg/dl for these subjects was 37±18 min. BG ≤ 70mg/dl was detected in 176 (41%) subjects and BG ≤ 50mg/dl in 24 subjects (5.5%). The cumulative time duration for BG ≤ 70mg/dl accounted for 5.9± 7.0 % of the day, and the cumulative time for BG ≤ 50mg/dl was 30±26 min, lasting for 5-30 min each episode.

In all subjects, the distributions of 24h MBG, PT140 and PT70 departed from normality. The coefficients of skewness for these parameters were -0.252, 1.785 and 3.673 respectively. The 95th percentiles of 24h MBG, PT140 and PT70 were set as reference values, with the upper limit of 119 mg/dl (6.61 mmol/l) for 24h MBG, 17.1% for PT140, and 11.7% for PT70 (Table 3).

CGM parameters in relation to gender and age: Whilst both the 24h MBG and PT140 showed a gender-independent weak positive correlation with age (r =0.243, 0.277, P<0.001; r=0.251, 0.175, P=0.009), the PT70 did not (P>0.05). Analyses for different age groups revealed an increased 24h MBG level for men older than 40 (P<0.01), and for women older than 60 (P<0.01). PT140 increased in subjects older than 60 years for both genders (P<0.01). There was no significant difference for PT70 among the age groups (P>0.05). No significant difference between men and women was observed within any of the age groups (P>0.05) (Table 3).

Reproducibility of CGM evaluation:
Reproducibility of CGM was evaluated in a subgroup of 20 subjects, of which two men and two women from each of the five age groups (20-29, 30-39, 40-49, 50-59, 60-69) were randomized. A 3-day CGM was repeated on these subjects 8-12 weeks after the initial measurements. The 20 subjects were 43±16 years old (range 22-68), with a body mass index of 22.2±1.8 kg/m². No significant difference was observed between the measurements taken at the two time periods for any of the parameters. The values obtained for the two measurements were: 103.7±10.8 mg/dl for 24h MBG, 2.6±3.8 % for PT140 and 0.7±1.1% for PT70 at the first session, and correspondingly 106±11.5 mg/dl, 3.8±5.7 % and 1.3±2.3% at the second session (P>0.05 for all three parameters).

DISCUSSION

The CGM technique, using interstitial fluid for glucose determination (15), provides continuous information on dynamic changes in a subject’s BG levels. The current study offers an opportunity to document the typical glycemic patterns in a large sample of continuously monitored healthy Chinese subjects, which provides a feasible and timely approach to obtaining reference values. Considering the distribution of certain parameters in people without diabetes as a starting point for the analysis, the study used mean±2SD or 95th percentile (for defining normality) to obtain a normal reference value. This proposal has been applied for determination of physiological parameters such as ambulatory blood pressure (16,17). Different from reference data derived from epidemiologic studies of large populations (18), the present study completed glucose measurement under routine living conditions, generating a more precise portrayal of typical daily glucose patterns of normal individuals.

The results of this study most likely reflect typical glycemic patterns for healthy subjects. 24h MBG of the 434 subjects between 20 and 69 years old is 104 mg/dl, a finding comparable to a recently reported 28-day CGM MBG (102 mg/dl) obtained from 32 healthy subjects using FreeStyle Navigator CGMS (19). Postprandial BG level at 60min was higher than 30min, 120min, and 180min for all three meals. Generally, the glucose level after breakfast was lower than lunch or dinner, which might be closely related to the dietary structure and eating habits. In our study, more than half of the subjects experienced BG ≥140 mg/dl, and 41% subjects experienced BG ≤ 70 mg/dl. Similar glycemic excursions have also been reported by Mazze et al. in subjects with normal glucose tolerance (19). The values for PT140 and PT70 they obtained were 4±4 % and 3±3 %, respectively; while in our study were correspondingly 4.1±5.8 % and 2.4±5.3 %.

CGM parameters provide general information on overall BG levels and BG stability. The 24h MBG indicates glycemic control; Postprandial BG levels, as well as PT in hypoglycemia or hyperglycemia provides the variability in glycemic characteristics (19). In the present study, the 95th percentile values for 24h MBG, PT140 and PT70 were adopted as the upper normal limits since all three parameters were non-normally distributed. The upper 95% confidence boundary for 24h MBG was ~119 mg/dl (6.6 mmol/l), for PT140 was less than 17% (4 hours) and for PT70 was less than 12% (3 hours). Moreover, CGM measurements showed a favorable short-term reproducibility in one subgroup of healthy subjects. We found an excellent compliance of fingerstick BG with CGM measurements in this study. Establishment of the normal reference values may therefore provide important evidence for clinical determination of glucose metabolic disturbance and evaluation of diabetic therapeutic effects.

As indicated by evaluation of the
relationship between CGM parameters with age and gender in this study, continuous BG levels are independent of gender but increase with age. There was a significant increase in 24h MBG in men older than 40 and women older than 60 years. We also recommend a unified cut-off point for the normal reference values of the CGM parameters, similar to the normal glucose tolerance cut-off points recommended by ADA (7) or WHO (20) without differentiating age or gender.

To our knowledge, this is the first multicenter study conducted that attempts to establish normal reference values for CGM parameters in a Chinese population. The operation consistency was well controlled by distributing uniform guidelines to each center and providing intensive subject education. The use of data from centers in different regions limits the potential for sample bias, which could be considered to enhance the validity of the results. However, it still has to be interpreted within the context of its limitations. This study does not cover age groups other than 20-69. On the other hand, a cross sectional study for determination of normal reference values requires a larger sample size and more geographic representations. Furthermore, the normal reference values of continuous BG parameters established in this study need to be verified by future prospective follow-up studies.

There is an increasing demand for data that are able to capture both normal and abnormal BG characteristics, due to the recent trend of re-evaluation of blood glucose control in terms of diabetic complication-related factors such as BG exposure, stability, and variability (21,22). CGM, by providing patterns of BG fluctuations, meets this demand in clinical practice. The reported reference ranges for CGMS in a normal adult population can be used to aid diabetes management and to create a baseline for health monitoring. Future studies that explicitly define normal and abnormal CGMS parameter ranges in relation to resulting pathology would supplement this statistical definition and enable clinicians to better utilize CGM information to aid them in making therapeutic regimen adjustments.

ACKNOWLEDGMENTS

This work was supported by the Shanghai United Developing Technology Project of Municipal Hospitals (SHDC12006101). We would like to thank all the involved clinicians, nurses, and technicians at all the participating centres for their dedication to the study: Shanghai Jiao Tong University Affiliated Sixth People’s Hospital (Kunsan Xiang, Yuqian Bao, Xiaoqing Ma, Wei Lu, Cheng Hu, Huijuan Lu), Sir Run Run Shaw Hospital, College of Medicine, Zhejiang University (Fenping Zheng), West China Hospital, Sichuan University (Liping He), China-Japan Friendship Hospital (Jinping Zhang, Na Wang), The Second Affiliated Hospital of Harbin Medical University (Lili Chen), Shanghai Jiao Tong University Affiliated First People’s Hospital (Yufan Wang), The First Affiliated Hospital of Sun Yat-Sen University (Juan Liu), Fudan University Affiliated Zhongshan Hospital (Zhiqiang Lu, Ran You), Ruijin Hospital, Shanghai Jiao Tong University School of Medicine (Shouyue Sun). A list of participating investigators is available as an online appendix.

Conflict-of-interest: The authors declare no competing financial interests.
REFERENCES

1. American DA: Standards of medical care in diabetes--2008. *Diabetes Care* 31 Suppl 1:S12-S54, 2008
2. Boland E, Monsod T, Delucia M, Brandt CA, Fernando S, Tamborlane WV: Limitations of conventional methods of self-monitoring of blood glucose: lessons learned from 3 days of continuous glucose sensing in pediatric patients with type 1 diabetes. *Diabetes Care* 24:1858-1862, 2001
3. De-Block C, Vertommen J, Manuel YK, Van-Gaal L: Minimally-invasive and non-invasive continuous glucose monitoring systems: indications, advantages, limitations and clinical aspects. *Curr Diabetes Rev* 4:159-168, 2008
4. Klonoff DC: Continuous glucose monitoring: roadmap for 21st century diabetes therapy. *Diabetes Care* 28:1231-1239, 2005
5. Bode BW, Schwartz S, Stubbs HA, Block JE: Glycemic characteristics in continuously monitored patients with type 1 and type 2 diabetes: normative values. *Diabetes Care* 28:2361-2366, 2005
6. Monnier L, Mas E, Ginet C, Michel F, Villon L, Cristol JP, Colette C: Activation of oxidative stress by acute glucose fluctuations compared with sustained chronic hyperglycemia in patients with type 2 diabetes. *JAMA* 295:1681-1687, 2006
7. Genuth S, Alberti KG, Bennett P, Buse J, DeFronzo R, Kahn R, Kitzmiller J, Knowler WC, Lebovitz H, Lernmark A, Nathan D, Palmer J, Rizza R, Saudek C, Shaw J, Steffes M, Stern M, Tuomilehto J, Zimmet P, -Expert CotDaCoDM: Follow-up report on the diagnosis of diabetes mellitus. *Diabetes Care* 26:3160-3167, 2003
8. WHO/NUT/NCD. Obesity: preventing and managing the global epidemic. Report of a WHO consultation on obesity, Geneva. *WHO* 894:2-17, 1998
9. Joint Committee for Developing Chinese guidelines on Prevention and Treatment of Dyslipidemia in Adults. Chinese guidelines on prevention and treatment of dyslipidemia in adults. *Zhonghua Xin Xue Guan Bing Za Zhi* 35:390-419, 2007
10. 1999 World Health Organization-International Society of Hypertension Guidelines for the Management of Hypertension. Guidelines Subcommittee. *J Hypertens* 17:151-183, 1999
11. Mastrototaro JJ: The MiniMed continuous glucose monitoring system. *Diabetes Technol Ther* 2 Suppl 1:S13-S18, 2000
12. Gross TM, Mastrototaro JJ: Efficacy and reliability of the continuous glucose monitoring system. *Diabetes Technol Ther* 2 Suppl 1:S19-S26, 2000
13. American Diabetes Association Workgroup on Hypoglycemia: Defining and reporting hypoglycemia in diabetes: a report from the American Diabetes Association Workgroup on Hypoglycemia. *Diabetes Care* 28:1245-1249, 2005
14. Murphy HR, Rayman G, Duffield K, Lewis KS, Kelly S, Johal B, Fowler D, Temple RC: Changes in the glycemic profiles of women with type 1 and type 2 diabetes during pregnancy. *Diabetes Care* 30:2785-2791, 2007
15. Klonoff DC: A review of continuous glucose monitoring technology. *Diabetes Technol Ther* 7:770-775, 2005
16. O'Brien E, Atkins N, O'Malley K: Defining normal ambulatory blood pressure. *Am J Hypertens* 6:201S-206S, 1993
17. Thijs L, Staessen JA, Celis H, de-Gaudemaris R, Imai Y, Julius S, Fagard R: Reference values for self-recorded blood pressure: a meta-analysis of summary data. *Arch Intern Med*
Reference values for continuous glucose monitoring

18. Tirosh A, Shai I, Tekes-Manova D, Israeli E, Pereg D, Shochat T, Kochba I, Rudich A, Israeli DRG: Normal fasting plasma glucose levels and type 2 diabetes in young men. *N Engl J Med* 353:1454-1462, 2005

19. Mazze RS, Strock E, Wesley D, Borgman S, Morgan B, Bergenstal R, Cuddihy R: Characterizing glucose exposure for individuals with normal glucose tolerance using continuous glucose monitoring and ambulatory glucose profile analysis. *Diabetes Technol Ther* 10:149-159, 2008

20. Alberti KG, Zimmet PZ: Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med* 15:539-553, 1998

21. Brownlee M, Hirsch IB: Glycemic variability: a hemoglobin A1c-independent risk factor for diabetic complications. *JAMA* 295:1707-1708, 2006

22. Kilpatrick ES, Rigby AS, Atkin SL: The effect of glucose variability on the risk of microvascular complications in type 1 diabetes. *Diabetes Care* 29:1486-1490, 2006

**Table 1** - Characteristics of subjects by gender

|                     | Men     | Women   | P-value   |
|---------------------|---------|---------|-----------|
| Subject number      | 213     | 221     | NA        |
| Age (years)         | 43±14   | 42±14   | 0.569     |
| Body mass index (kg/m²) | 22.1±1.7 | 21.5±1.7 | 0.001*   |
| Systolic Blood Pressure (mm Hg) | 117±10 | 111±13 | <0.001*   |
| Diastolic Blood Pressure (mm Hg) | 76±6 | 71±8 | <0.001*   |
| Total Cholesterol (mg/dl) | 174±31 | 178±35 | 0.171     |
| Triglycerides (mg/dl) | 93±32 | 87±32.8 | 0.038*   |
| High density lipoprotein-cholesterol (mg/dl) | 57±14.3 | 64±15.9 | <0.001*   |
| Low density lipoprotein-cholesterol (mg/dl) | 105±29.0 | 104±35.2 | 0.854     |
| Fasting plasma glucose (mg/dl) | 86.4±7.7 | 86±7.9 | 0.682     |
| OGTT 30min PG (mg/dl) | 145±29.3 | 134.1±26.1 | <0.001*   |
| OGTT 1 h PG (mg/dl) | 124±38.5 | 118.1±33.8 | 0.084     |
| OGTT 2 h PG (mg/dl) | 94±21.1 | 98.1±19.3 | 0.061     |
| OGTT 3 h PG (mg/dl) | 71±15.8 | 74.4±16.8 | 0.045*    |
| MBG (mg/dl)         |         |         |           |
| 24 h                | 104±10.8 | 103.9±9.9 | 0.854     |
| Daytime             | 106±11.5 | 106.6±11.2 | 0.853     |
| Night-time          | 99±11.9  | 98.3±10.6 | 0.518     |
| Percentage of time at glycemia (%) |         |         |           |
| BG ≥ 140 mg/dl      | 4.2±5.9  | 4.0±5.7  | 0.612     |
| 70 < BG < 140 mg/dl | 93±8     | 94±7     | 0.550     |
| BG ≤ 70 mg/dl       | 2.7±6.1  | 2.1±4.4  | 0.987     |
| AUC for BG > 100 mg/dl (mg-dl⁻¹-d) | 10.1±6.8 | 9.5±6.5 | 0.471     |
| Standard deviation of blood glucose (mg/dl) | 14.2±5.9 | 14.2±5.8 | 0.928     |
| Max BG (mg/dl)      | 144.2±23.8 | 144.2±22.9 | 0.972     |
| Min BG (mg/dl)      | 77.2±11.9 | 76.5±11.0 | 0.754     |

Data are mean ± SD.
*indicates a significant difference between men and women (p<0.05).
Abbreviations: MBG, mean blood glucose; AUC, area under the curve; NA, not applicable.
Table 2- Postprandial BG characteristics after three meals in 434 healthy subjects.

|                     | Breakfast          | Lunch              | Dinner             |
|---------------------|--------------------|--------------------|--------------------|
| Postprandial BG 30 min (mg/dL) | 114.3±15.6         | 117.2±18.9         | 116.6±17.8         |
| Postprandial BG 60 min (mg/dL) | 121.1±21.3         | 121.7±20.9         | 123.1±26.1         |
| Postprandial BG 120 min (mg/dL) | 104.8±18.0         | 115.6±22.3*        | 119.7±21.2*        |
| Postprandial BG 180 min (mg/dL) | 97.6±17.6          | 109.3±17.3*        | 114.1±18.1*        |
| Postprandial area under the curve within 3 hr (mg·dL⁻¹·hr) | 327.3±38.7         | 340.6±47.4*        | 348.7±51.5*        |

Data are mean±SD. For each parameter, * P < 0.05 vs. BG level after breakfast.

Table 3-24h MBG and percentage of time at glycemia by gender and age

| Age (years) | 20-39 | 40-59 | 60-69 | All | 20-39 | 40-59 | 60-69 | All | all subjects |
|-------------|-------|-------|-------|-----|-------|-------|-------|-----|--------------|
| Subject number | 93    | 80    | 40    | 213 | 99    | 86    | 36    | 221 | 434          |
| MBG (mg/dl) |       |       |       |     |       |       |       |     |              |
| Mean        | 101.3 | 105.3 | 107.3 | 104.4 | 101.3 | 103.9 | 109.3 | 103.7 | 103.9 |
| SD          | 10.8  | 10.1  | 10.4  | 10.8  | 9.2   | 10.4  | 9     | 9.9  | 10.3 |
| P5          | 82.3  | 85.7  | 88.4  | 84.2  | 84.6  | 83.2  | 95.2  | 84.6  | 84.6 |
| P10         | 85.7  | 89.3  | 95.4  | 88.2  | 86.4  | 89.6  | 97.2  | 90.2  | 89.1 |
| P50         | 102.6 | 106.6 | 108   | 104.4 | 102.6 | 104.4 | 111.2 | 103.5 | 104.4 |
| P90         | 116.1 | 117   | 119.5 | 117   | 111.6 | 117.9 | 121.0 | 117   | 117  |
| P95         | 118.1 | 122.4 | 124.2 | 120.6 | 115.2 | 118.8 | 123.1 | 118.8 | 119.0 |
| PT140 (%)   |       |       |       |     |       |       |       |     |              |
| Mean        | 3.12  | 4.24  | 6.50  | 4.17 | 2.93  | 3.80  | 7.40  | 4.0  | 4.08 |
| SD          | 4.96  | 5.98  | 7.08  | 5.89 | 4.47  | 5.15  | 8.05  | 5.75 | 5.76 |
| P5          | 0     | 0     | 0     | 0    | 0     | 0     | 0     | 0    | 0   |
| P10         | 0     | 0     | 0     | 0    | 0     | 0     | 0     | 0    | 0   |
| P50         | 0.50  | 1.75  | 5.5   | 1.50 | 0.50  | 1.5   | 5.75  | 1.00 | 1.0 |
| P90         | 9.30  | 13.0  | 17.0  | 12.8 | 9.0   | 11.4  | 21.3  | 12.5 | 12.5 |
| P95         | 14.0  | 17.5  | 24.0  | 17.0 | 11.5  | 14.8  | 22.6  | 19.0 | 17.1 |
| PT70 (%)    |       |       |       |     |       |       |       |     |              |
| Mean        | 3.68  | 1.60  | 2.50  | 2.68 | 1.87  | 2.40  | 2.01  | 2.10 | 2.38 |
| SD          | 7.25  | 4.81  | 4.95  | 6.07 | 3.59  | 5.61  | 3.42  | 4.46 | 5.31 |
| P5          | 0     | 0     | 0     | 0    | 0     | 0     | 0     | 0    | 0   |
| P10         | 0     | 0     | 0     | 0    | 0     | 0     | 0     | 0    | 0   |
| P50         | 0     | 0     | 0     | 0    | 0     | 0     | 0     | 0    | 0   |
| P90         | 9.3   | 3.95  | 10.9  | 9.0  | 6.0   | 7.2   | 9.10  | 7.00 | 8.0 |
| P95         | 14.0  | 8.90  | 14.4  | 12.0 | 11.5  | 14.0  | 11.2  | 11.0 | 11.6 |

P5, P10, P50, P90, and P95 indicate percentile values.
**Figure 1**— Continuous glucose profiles representing mean data from 24 hours of monitoring in 434 healthy subjects.

The center line is the mean, the next two outer lines represent the 5th and 95th percentiles (P5 and P95, respectively). The arrows indicate the time for three meal intakes during a day.