Recent Research in Endocrinology and Metabolic Disorder

Received: 15 July 2019
Revision received: 23 July, 2019
Accepted: 29 July, 2019

www.rriemd.com
DOI :10.33702/rremd.2019.1.1.1: 2019 : 1(1) 1-6

Review Article

Glycemic control may be influenced by climate changes in type 2 diabetes mellitus (T2DM)

Hiroshi Bando [1,2], Yoshikane Kato[3], Setsuko Kanazawa[3], Mayumi Tanaka[3], Etsuko Sueki[3], Hiroe Kanagawa[3], Takafumi Kawata[3], Atsuko Kawahito[3], Aya Aihara[3]

[1]Tokushima University / Medical Research, Tokushima, Japan
[2]Japan Low Carbohydrate Diet Promotion Association, Kyoto, Japan
[3]Kanaiso Hospital, Tokushima, Japan

ABSTRACT

Authors have continued clinical research on type 2 diabetes mellitus (T2DM). The trigger of this research was to make notice of elevated HbA1c of younger male diabetics for hot climate in the summer 2018. Enrolled subjects were 89 male patients with T2DM. Methods include the classification of 6 groups by the age, which are 21-40, 41-50, 51-60, 61-70, 71-80 and 81-90. HbA1c values in median were calculated for five seasons of 15 months. Basal HbA1c in 6 groups was 7.0%, 7.1%, 7.2%, 7.2%, 6.9% and 7.0%, respectively. Seasonal changes in HbA1c values are as follows: i) groups 21-50 showed highest in the summer, ii) groups 51-70 showed gradually decrease from winter to summer, iii) groups 71-90 showed gradually decrease from winter to autumn, and increase for winter. For seasonal HbA1c changes, influence of hot climate during from spring to summer may be involved for 21-50 years. More activity in spring to summer may be related for 51-70 years. Less exercise and more eating may be observed for 71-90 years. There are not enough analyze for related factors, then further study concerning various biomarkers would be expected.

Key words: hot climate, type 2 diabetes mellitus (T2DM), body mass index (BMI), anthropometry, waist circumference

Abbreviations: type 2 diabetes mellitus (T2DM), low carbohydrate diet (LCD), body mass index (BMI), Japan LCD promoting Association (JLCDPA)., cardiovascular risk factors (CVRF), Meal Tolerance Test (MTT).

Citation: Hiroshi Bando. (2019). Glycaemic control may be influenced by climate changes in type 2 diabetes mellitus (T2DM), Recent Research in Endocrinology and Metabolic Disorder, 1(1)1-6 . http://dx.doi.org/10.33702/rremd.2019.1.1.1

Author for correspondence: *Hiroshi Bando, Tokushima University / Medical Research, Tokushima, Japan Low Carbohydrate Diet Promotion Association, Kyoto, Japan*
Email: pianomed@bronze.ocn.ne.jp

INTRODUCTION

In recent years, there have been some standards concerning the recommended control of type 2 diabetes mellitus (T2DM). Several guidelines related to the target of HbA1c, blood glucose [1], blood pressure [2] and lipids [3] were found. For the values of HbA1c and blood glucose, a guidance statement was proposed by American College of Physicians (ACP) [4] with evidence-based medicine data. The recommended target of HbA1c in T2DM would be 7-8 % rather than strict controlled level before.

The therapy of diabetes has been based on proper diet and exercise. Calorie Restriction (CR) was formerly the standard method for nutritional treatment. After that, Atkins and Bernstein and others in European countries have introduced Low Carbohydrate Diet (LCD), and LCD has been spreading until now [5,6] For several evidence-based investigation, the superiority of LCD has been reported such as the Diabetes Remission Clinical Trial (DiRECT) study [7,8].

On the other hand, the author and co-investigator once started LCD in Japan [9]. Since then, we have continued treating many diabetic patients, and developed clinical studies on comparison of CR and LCD [10]. We proposed three types of LCD meal, which are super-LCD, standard-LCD, petite-LCD, which are useful for lots of people [11]. We have developed LCD movement socially through Japan LCD promoting Association (JLCDPA). Furthermore, we have reported various research related to CR and LCD, such as research on ketone bodies, and Meal Tolerance Test (MTT) with 70g of carbohydrate in CR meal [12,13].

According to several reports, there has been some variability in diet and exercise performance in patients with diabetes. In other words, some seasonal changes have been found concerning the control state of glucose variability [14]. The climate in the winter is cold, then patients apt to lead a daily life with eating more and less exercise [15]. Therefore, diabetes control may be worsening in winter [16]. However, this tendency may be different in a wide range of diabetic patients, such as age, severity and social differences. We have been treating many diabetic patients continuously for many years. From this clinical experience, we have noticed that diabetes control of younger male diabetic patients showed worsening in summer 2018. At that time, it was so hot in Japan for several months. Therefore, we have tried to investigate seasonal HbA1c changes in patients from young to older diabetic male patients.

SUBJECTS AND METHODS

In this study, subjects enrolled were 106 male diabetic patients. They were diagnosed as T2DM with the age of 23-88 years old (Table 1). Regarding the diagnosis, other diabetic types such as type 1 diabetes mellitus and other special types of diabetes were excluded in the criteria of current study.

Methods were investigating our accumulating data of diabetic patients for years. HbA1c values of consecutive five seasons were calculated as an average data from December 2017 to February 2019. The seasons were defined as follows: i) winter is from December to February, ii) spring is March to May, 2018, iii) summer is June to August and iv) autumn is September to November.

The biomarkers are obtained as follows. In addition to HbA1c, weight, height, Body Mass Index (BMI), waist circumference and thigh circumference were measured in spring, 2018. The reason is that April would become the start of the fiscal year in Japan. The waist circumference was measured at the level of the navel in standing upright position. Thigh circumference was measured at 10 cm above the upper line of the patella when standing with relaxed condition. Using the values of stature, waist circumference and thigh circumference, three ratios of anthropometry were calculated.

Statistical analysis

In current study, the data were calculated statistically [17]. The obtained results were shown as the median value plus the quartiles of 25% and 75%, which was described as median [25%-75%] [18]. This statistical method means that 50% of the data in the group are situated around the median value [19].
The calculation method includes BMI, the ratios of waist/stature, thigh/stature, and thigh/waist. Data were described as the median value and 25% and 75% of the quartiles. The changes in HbA1c value of five seasons were shown in Figure 1. The median value of HbA1c in winter 2018 was the standard level as 0 point. The changes in HbA1c after that were described in six groups.

Ethical considerations

Current investigation was basically performed by the adequate ethical principles that was the Declaration of Helsinki. Further, some commentary for the Ethical Guidelines for Research in the medical field for Human beings and also in the conduction of the Good Clinical Practice (GCP) were included. There were some ongoing consideration, concerning the protection of human rights. “Ethical Guidelines for Epidemiology Research” was also applied according to the related guideline. Those principles were described from Japan by the Ministry of Education, Culture, Sports, Science and Technology and by the Ministry of Health, Labor and Welfare.

Regarding to this study, authors have established a necessary ethical committee of the hospital. It includes the president, the vice-president, director of the Pharmaceutical section, the head-nurse, director of the administration and expert in the legal specialty professionals. We have discussed enough and made confirmation that current study has no problems and agreed with all members.

RESULTS

1) Basal data

The subjects were 89 male patients with T2DM. Their anthropometry data and HbA1c values in six groups were shown in Table 1. The value of HbA1c were calculated as the average levels from December 2017 to February 2018, which was the first winter. The groups with 21-40 and 41-50 years old showed higher tendency values of BMI than that of other groups. Further, the ratios of waist/stature, thigh/stature and thigh/waist is a litter higher in the group of 21-40. Other 5 groups showed similar data. The basal HbA1c on the first winter in 6 group was 7.0%, 7.1%, 7.2%, 7.2%, 6.9% and 7.0%, respectively. These data of HbA1c were similar from 6.9% to 7.2% in 6 groups.

Table 1 Data of Anthropometry and HbA1c in the groups

age (yr)	n	Body Mass Index	waist/stature	thigh/stature	thigh/waist	HbA1c (%)
21 – 40	10	29.9 [25.3 – 31.8]	0.59 [0.49 – 0.64]	0.31 [0.23 – 0.32]	0.50 [0.47 – 0.52]	7.0
41 – 50	12	27.4 [22.8 – 29.9]	0.53 [0.48 – 0.58]	0.26 [0.25 – 0.28]	0.47 [0.44 – 0.51]	7.1
51 – 60	17	24.6 [22.4 – 27.2]	0.52 [0.48 – 0.55]	0.25 [0.23 – 0.26]	0.48 [0.46 – 0.51]	7.2
61 – 70	19	24.5 [21.6 – 27.2]	0.52 [0.48 – 0.56]	0.25 [0.23 – 0.27]	0.48 [0.44 – 0.50]	7.2
71 – 80	17	24.6 [21.8 – 25.9]	0.54 [0.50 – 0.58]	0.24 [0.23 – 0.26]	0.45 [0.43 – 0.47]	6.9
80 – 90	14	24.9 [22.7 – 27.1]	0.55 [0.50 – 0.58]	0.25 [0.25 – 0.27]	0.46 [0.44 – 0.49]	7.0

Values represent median level and [25% and 75%] of the quartile levels.
HbA1c values were calculated as the average data from December 2017 to February 2018.

2) HbA1c changes in 5 seasons

The changes in HbA1c values of 5 seasons in 6 groups were shown in Figure 1. In the group 21-40, HbA1c value showed increasing from winter, the highest in the summer and decrease after that. In the group 41-50, HbA1c value showed a litter higher in the summer and decrease after that.

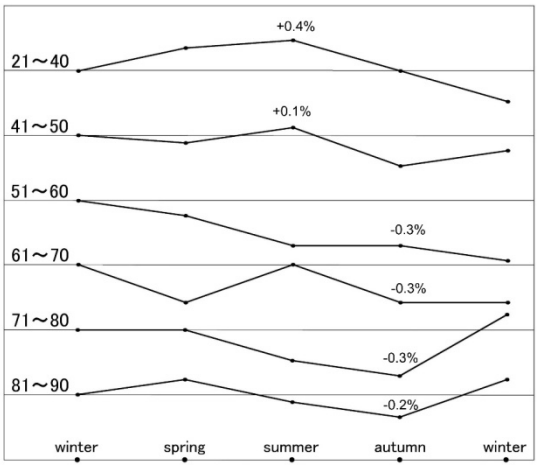

Figure 1: Seasonal HbA1c changes in 6 groups aged 21-90

Furthermore, group 51-60 and 61-70 revealed that HbA1c has no elevation in the summer, decrease in autumn and stable in winter. In contrast, group 71-80 and 81-90 showed that HbA1c has gradual decrease from spring to autumn and elevation in the winter. It is in only group 71-90 that there is rather acute elevation of HbA1c from autumn to winter

DISCUSSION

Across the world, diabetes mellitus has become crucial problem, and the control of glucose variability has been important to decrease macro-angiopathy and micro-angiopathy [20]. The goal for the therapy of the diabetes would be to reduce the incidence of cardiovascular events [21]. As a matter of fact, the important factors include the values of HbA1c, profile of blood glucose, blood pressure and lipids. These management for multi-factors can lower the cardiovascular events and improve the prognosis of the diabetic patients [22].

According to some previous reports, there have been discrepancies between cardiovascular events and mortality level in diabetics with same target values [16]. These factors differ time and frequency in various clinical trial research. Among them, seasonal difference can be included for the evaluation of diabetic condition [14]. Diabetic control has been said to be worse in the winter season, which would be due to less more eating and less exercise [14,15].

For years, authors and colleagues have continued clinical practice and research on diabetes, such as glucose variability, comparison of calorie restriction (CR) and low carbohydrate diet (LCD), MTT and others [23,24]. Among the continuous diabetic practice, there was an impressive episode from spring to summer, 2018. During the period we had found several diabetic younger cases who showed exacerbation of the diabetic control. We had come to know and noticed that persisting extremely hot climate can be involved in the worse tendency of glucose control. We have continued managing many diabetic patients for long years. Then, we have begun to investigate the detail changes of seasonal changes of HbA1c values in different age groups.

The value of BMI was rather higher in groups 21-40 than that of other groups. Further, subjects' anthropometry characteristics including waist/stature, thigh/stature and thigh/waist were also similar situation. Authors have formerly reported the research concerning waist circumference (WC), waist-to-height ratio (WHtR) and thigh-to-waist ratio (TWaR) in type 2 diabetes mellitus (T2DM) [25]. From above, diabetic male patients in group 51-90 may show the similar composition of body muscle and fat with aging.

HbA1c values in groups 21-50 increased from spring to summer as seasonal changes. These causes may be involved in their hot circumstances for working with various stressors and accumulating malaise. Previous report about diabetes and temperature [26] revealed that as the temperature decreases 1 degree Centigrade, the risk of HbA1c more than 7% increases in the diabetic practice. Consequently, diabetic patients show higher HbA1c in the winter than those in the summer [26].

In groups 51-70, some patients are working and others are free at home in Japan. Although the climate is severely hot outside, they can probably control their lives without overuse the body. Groups 71-90 belong to the elderly. Most of them seem to lead daily life without obligatory working. Furthermore, some elderly are attending to daycare center a few times a week. From above, their daily lives are probably stable throughout the year.

There have been several reports of seasonal changes related to HbA1c.
Firstly, the biomarker HbA1c has been influenced by several factors. There was a report that HbA1c values in diabetic patients were followed up for 13 years in high-income country [27]. Several factors influencing HbA1c were sex difference, age difference, socio-economic condition and national governmental project for diabetes [27].

Secondly, the seasonality of cardiovascular risk factors (CVRF) was investigated in a large set of population-based studies [14]. CVRF included BMI, BP, waist circumference, HDL, LDL, TG, glucose levels. CVRFs show a seasonal pattern characterized by higher levels in winter, and lower levels in summer. This pattern could contribute to the seasonality of CV mortality [14].

Thirdly, there are seasonal changes in glucose, blood pressure and cholesterol. By multicenter study, seasonal changes of values in HbA_{1c}, BP, and LDL-C were measured. As a result, achievement of the target level of these biomarkers were lowest in winter, indicating the necessary consideration for diabetic practices [28].

There are limitations of current research. We examined HbA1c changes of four seasons in different age groups. Some difference tendencies were found, but we did not evaluate several factors which can influence glucose variability. For example, BMI, blood pressure, cholesterol, daily life, amount of food, carbohydrate intake, amount of work, exercise status, lifestyle habits, temperature, humidity and others may be involved in these factors. Then, it would be necessary to review in detail for future research.

In summary, we studied seasonal Hb1c changes in 6 age groups. HbA1c were a little higher in summer with 21-50 years old, lower in autumn with 51-90 years old. Various factors may be affecting this

tendency. These results suggest that it would be necessary to consider the adequate management together with related factors such as seasons, environmental factors and lifestyles.

REFERENCES

[1] American Diabetes Association. Glycemic Targets: Standards of Medical Care in Diabetes-2018. Diabetes care;41:S55-s64, 2018.
[2] American Diabetes Association. Cardiovascular Disease and Risk Management: Standards of Medical Care in Diabetes-2018. Diabetes care 41:S86-s104,2018.
[3] Jellinger PS, Handelsman Y, Rosenblit PD, Bloomgarden ZT, Fonseca VA, Garber AJ, et al. American Association of clinical eindocrinologists and American college of endocrinology guidelines for management of dyslipidemia and prevention of cardiovascular disease. Endocrine practice: official journal of the American College of Endocrinology and the American Association of Clinical Endocrinologists. 23:1-87. 2017.
[4] Qaseem A, Wilt TJ, Kansagara D, Horwitch C, Barry MJ, Forciea MA. Hemoglobin A1c Targets for Glycemic Control With Pharmacologic Therapy for Nonpregnant Adults With Type 2 Diabetes Mellitus: A Guidance Statement Update From the American College of Physicians. Annals of internal medicine 168:569-576. 2018
[5] Atkins RC. Dr. Atkins' diet revolution. Bantam Books, New York. 1981
[6] Bernstein RK. Dr. Bernstein's Diabetes Solution. Little, Brown and company, New York.1997
[7] Shai I, Schwarzfuchs D, Henkin Y, et al. (2008) Dietary Intervention Randomized Controlled Trial (DIRECT) Group. Weight Loss with a Low-Carbohydrate, Mediterranean, or Low-Fat Diet. N Engl J Med. 359: 229-241. 2008
[8] Churuangsuk C, Lean M, Combet E. Low-carbohydrate diet score is associated with higher glycated haemoglobin: a secondary analysis of the UK national diet and nutrition surveys year 1–6. Clinical Nutrition, 37, S304. doi:10.1016/j.clnu.2018.06.2064. 2018
[9] Ebe K, Ebe Y, Yokota S, Matsumoto T, Hashimoto M, Sakai Y, et al. Low Carbohydrate diet (LCD) treated for three cases as diabetic diet therapy. Kyoto Medical Association Journal 51: 125-129. 2004
[10] Bando H, Ebe K, Muneta T, Bando M, Yonei Y. Effect of low carbohydrate diet on type 2 diabetic patients and usefulness of M-value. Diabetes Res Open J. 2017; 3(1): 9-16. doi: 10.17140/DROJ-3-130. 2017
[11] Ebe K, Bando H, Yamamoto K, Bando M, Yonei Y. Daily carbohydrate intake correlates with HbA1c in low carbohydrate diet (LCD). J Diabetol 1(1): 4-9. 2018
[12] Muneta T, Kagaguchi E, Nagai Y, Matsumoto M, Ebe K, Watanabe H, Bando H. Ketone body elevation in placenta, umbilical cord, newborn and mother in normal delivery. Glycative Stress Research 3 (3): 133-140. 2016
[13] Bando H, Ebe K, Muneta T, Bando M, Yonei Y. Study of pancreas function for carbohydrate loading in diabetes with insulin resistance. Med Clin res Rep 1(2): 1-9. DOI: 10.26524/mcrr1821. 2019
[14] Marti-Soler H, Gubelmann C, Aeschbacher S, Alves L, Bobak M, Bongard V, et al. Seasonality of cardiovascular risk factors: an analysis including over 230 000 participants in 15 countries. Heart (British Cardiac Society) 100:1517-1523. 2014
[15] Bardini G, Dicembrini I, Rotella CM, Giannini S. Lipids seasonal variability in type 2 diabetes. Metabolism 61:1674-1677. 2012
[16] Liang WW. Seasonal changes in preprandial glucose, A1C, and blood pressure in diabetic patients. Diabetes care 30:2501-2502. 2007
[17] Yanai H. Four step excel statistics, 4th Edition, Seiun-sha Publishing Co.Ltd, Tokyo. 2015
[18] Mamolejo-Ramos F, tian TS. The shifting boxplot. A boxplot based on essential summary statistics around the mean. Int J Psychol res 3(1): 37-45. 2010
[19] Luo D, Wan X, Liu J, Tong T. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. Statistical Methods in Medical Research, 27(6), 1785–1805. doi:10.1177/0962280216669183 . 2016
[20] American Diabetes Association. Lifestyle management: standards of medical care in diabetes-2019. Diabetes Care. 42 (Suppl 1):S46–S60. 2019
[21] Nakanishi S, Hirukawa H, Shimoda M, Tatsumi, F, Kohara K, Obata A, et al. Verification of Kumamoto Declaration 2013 and Glycemic Targets for Elderly Patients with Diabetes in Japan for prevention of diabetic complications: A retrospective longitudinal study using outpatient clinical data. Journal of Diabetes Investigation. doi:10.1111/jdi.12909. 2018
[22] Wright JT, Jr., Williamson JD, Whelton PK, Snyder JK, Sink KM, Rocco MV, et al. A Randomized Trial of Intensive versus Standard Blood-Pressure Control. New Engl J Med 373:2103-2116. 2015

[23] Bando H, Ebe K, Muneta T, Bando M, Yonei Y. Study on responses of C-peptide and blood glucose for Carbohydrate 70g in diabetes. Endocrinol Metab 2(2):110-115. 2018
[24] Ebe K, Bando H, Muneta T, Bando M, Yonei Y. Homeostasis model assessment (HOMA) and M value in daily profile of glucose. POJ Clin Case Rep 1(1): 1-7. 2018
[25] Bando H, Kato Y, Sakamoto K, Ogawa T, Bando M, Yonei Y. Integrative Obesity and Diabetes. Investigation for waist circumference (WC), waist-to-height ratio (WHtR) and thigh-to-waist ratio (TWaR) in type 2 diabetes mellitus (T2DM). Integrative Obesity and Diabetes 3(4): 1-4. 2017
[26] Tien KJ, Yang CY, Weng SF, Liu SY, Hsieh MC, Chou CW. The impact of ambient temperature on HbA1c in Taiwanese type 2 diabetic patients: The most vulnerable subgroup. Journal of the Formosan Medical Association, 115(5), 343–349. doi:10.1016/j.jfma.2015.03.010. 2016
[27] Mair C, Wulaningsih W, Jeyam A, McGurnaghan S, Blackbourn L, et al. Glycaemic control trends in people with type 1 diabetes in Scotland 2004–2016. Diabetologia. doi:10.1007/s00125-019-4900-7. 2019
[28] Sakamoto M, Matsutani D, Minato S, Tsujimoto Y, Kayama Y, Takeda N, et al. Seasonal Variations in the Achievement of Guideline Targets for HbA1c, Blood Pressure, and Cholesterol Among Type 2 Diabetic Patients: A Nationwide Population-Based Study (ABC study) (JDDM49). Diabetes Care 42(5): 816-823. https://doi.org/10.2337/dc18-1953. 2019