# Seasonal Changes of HbA1c Levels in Type 2 Diabetes Mellitus Patients

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## Abstract

**Objective:** There are changes in plasma glucose and HbA1c of type 2 diabetes mellitus (T2DM) patients in different seasons. HbA1c levels may increase during winter season in most T2DM patients without weight gain. In this study, we described the seasonal changes of HbA1c levels in T2DM patients.

**Materials and Methods:** This analytical cross-sectional study conducted from 2013 to 2017 on 402 patients with T2DM, aged 20–80 years old who referred to Yazd diabetic research center. Body weight, height, waist circumferences (WC), blood pressure (BP), body mass index (BMI), fasting plasma glucose (FPG), 2 hours post-prandial (2hpp), and HbA1c measured and compared during four seasons.

**Results:** Four hundred and two T2DM patients invited and fulfilled this study. Most of them (56%) were women. The mean age of patients was 58.96 (± 11.10) years old. The mean HbA1c, 2hpp, systolic and diastolic blood pressure were significantly different in four seasons (*P*-value respectively: 0.022, 0.007, 0.001 and 0.005). The mean difference of HbA1c was significant in the warm and cold seasons (*P*-value: 0.047). The percentage of people who were below 7% had a significant difference between the warm and cold seasons (*P*-value: 0.015).

**Conclusion:** The results of this study showed that, in Yazd with desert climate, postprandial hyperglycemia is more prominent in summer. The seasonal changes of glycemic status are an important factor in management of T2DM patients.

**Keywords**: Type 2 diabetes mellitus, Glycated hemoglobin A, Seasons

## Introduction

In the past, communicable diseases were regarded as the biggest health problem of the world but now, the increasing trend of non-communicable diseases death rate, especially in developing countries, is a serious threat to the health system (1). The overall prevalence of type 2 diabetes (T2DM) in Iran is 4-4.5% and in population older than 30 years old is about 14% (2).

Previous studies showed some modifiable factors in control of blood sugar changes such as stress, nutritional status and physical inactivity. Also there are some non-modifiable factors such as gender, age, familial history of diabetes and seasonal changes which influence the glycemic control (3,4). Previous studies have shown that the incidence of diabetes is higher in female, age over 50 years old and people with positive family history (5).

The studies in other countries that examined the effects of seasonal changes, a strong correlation was found between fasting plasma glucose (FPG) level with season and ambient temperature (4,6), so that the incidence of severe hypoglycemia and changes in HbA1c levels are significantly increased in autumn and winter (7). A study in Japan showed that FPG increase in winter in comparison with autumn. In addition, it shows that there is a strong correlation between FPG and season, in winter FPG increase about 0.31 mmol/ lit (5.58 mg/ dlit) compared to autumn (8). However, unfortunately, there is no comprehensive study in Iran, especially the Yazd province. The aim of this study was to evaluate glycemic changes in different seasons in T2DM patients.

## Materials and Methods

This analytical cross-sectional study conducted from 2013 to 2017 on 402 patients with T2DM, referred to Yazd diabetic research center. They selected by convenient method. They were between 20-80 years old.

The ethics committee of Shahid Sadoughi University of Medical Sciences approved this study, IR.SSU.REC.1395.113.

The measured variables included; age, sex, height, weight, body mass index (BMI), blood pressure, duration of the disease, type of treatment (oral medicine or insulin), FPG, 2 hours post-prandial (2hpp), HbA1c.

Blood chemistry tests such as FPG and 2hpp were analyzed using an auto analyzer BA-400 (Bio systems, European), and commercially available kits were used according to the manufacturer’s instructions. HbA1c measured by high-performance liquid chromatography on a diamant analyzer (Bio-Rad, München, Germany).

Weight measured without shoes with light clothing by an electronic weighing scale (Glamor, BF-1041-A) and recorded to the nearest 100 g. Height measured once at baseline without shoes with the subject stretching to the maximum height and the head positioned in the plane using a portable stadiometer and to the nearest 0.1 cm. BMI calculated using weight and height values. Waist and hip circumferences measured to the nearest 0.1 cm using a non-stretchable tape with an insertion buckle at one end.

### Statistical analyses

The sample size was calculated by two mean comparisons, considering type one error 0.05, study power of 80% and deference of 2. The SPSS version 20 software was used for statistical analysis. Results were expressed as mean ± standard deviation (SD). Analysis of variance (ANOVA) for quantitative variables and chi square tests for qualitative variable were used. *P*-value of less than 0.05 was considered statistically significant.

## Results

In this study, 402 T2DM patients were evaluated. The mean age of participants was 58.96 (±11.10) years, 177 (44%) were males and 225 (56%) were females. Clinical characteristic of participants are summarized in Table 1.

Among all studied patients, 237 (63.3%) patients had family history of DM. We observed that 71.4% of patients were on oral antidiabetic medication (OAD), 13.7% on OAD plus insulin, 8.4% on insulin and 6.3%

**Table 1. The studied variables in T2DM patients**

| Variable | Mean (±SD) | Frequency (%) |
|---|---|---|
| **Sex (female)** | | 225 (56%) |
| **Positive family history** | | 237 (63.3%) |
| **Oral medication** | | 287 (71.4%) |
| **Age** | 58.96 (±11.10) | |
| **Duration of known diabetes (years)** | 7.98 (±6.81) | |
| **Duration of treatment (years)** | 5.84 (±5.77) | |
| **BMI (Kg/m²)** | 28.84 (±4.79) | |

on life-style modification. The mean of FBS, DBP, SBP, 2HPP, HbA1c in four seasons is presented in Table 2.

In this study, DBP, SBP, 2hpp, HbA1c and FPG in four seasons were evaluated. There was a correlated difference in DBP between summer and autumn (*P*-value: 0.014), spring and autumn (*P*-value: 0.038). SBP was also correlated between winter and summer (*P*-value: 0.011).

The mean of HbA1c among participants in warm and cold seasons was 7.72 (± 1.31) and 7.51 (± 1.25) respectively, and this difference was statistically significant (*P*-value: 0.047).

As shown in table 3, the percentage of people who were below 7% had a significant difference between the warm and cold seasons (*P*-value: 0.015).

## Discussion

Our findings showed that there is no any significant difference in FPG and HbA1c between different seasons, however mean of 2hpp in summer was significantly higher than other seasons among T2DM patients who referred to Yazd diabetes research center.

Yazd in center of Iran has a desert climate with very low rainfall that has the average temperature of 25°C. During winter, the mean of temperature in January and February reaches to -0.3°C. In summer, the mean of temperature in July and August reach to 39ºC.

Previous studies (8-10), have shown that Iranian people consumed different food and fruits in different seasons and seasonal food variation leads to exposure with different levels of vitamins and carbohydrate in

**Table 2. The mean of FPG, DBP, SBP, 2hpp and HbA1c in four seasons**

| Variable | | Mean (±SD) | *P*-value |
|---|---|---|---|
| **HbA1c** | Spring | 1.58 (7.697) | 0.022 |
| | Sumer | 1.51 (7.750) | |
| | Autumn | 1.61 (7.762) | |
| | Winter | 1.33 (7.453) | |
| **FPG** | Spring | 53.64 (150.370) | 0.095 |
| | Summer | 52.79 (152.166) | |
| | Autumn | 53.39 (147.514) | |
| | Winter | 49.44 (143.142) | |
| **2hpp** | Spring | 76.17 (221.008) | 0.007 |
| | Summer | 84.25 (226.630) | |
| | Autumn | 85.74 (217.371) | |
| | Winter | 74.42 (206.598) | |
| **SBP*** | Spring | 19.24 (135.038) | 0.001 |
| | Summer | 19.13 (133.410) | |
| | Autumn | 19.67 (136.859) | |
| | Winter | 19.36 (138.815) | |
| **DBP**** | Spring | 11.00 (75.237) | 0.005 |
| | Summer | 10.39 (74.933) | |
| | Autumn | 10.44 (77.541) | |
| | Winter | 9.75 (75.630) | |

*SBP (Systolic Blood Pressure)
**DBP (Diastolic Blood Pressure)

**Table 3. Comparison of the frequency of patients with the level HbA1C below and above 7% in cold and warm seasons**

| Variable | | Season | | Total |
|---|---|---|---|---|
| | | Warm | Cold | |
| **HbA1c** | **< 7%** | 90 | 110 | 200 |
| | | 45% | 55% | 100% |
| | | 30.4% | 39.4% | 34.8% |
| | **≥ 7%** | 206 | 169 | 375 |
| | | 54.9% | 45.1% | 100% |
| | | 69.6% | 60.6% | 65.2% |
| **Total** | | 296 | 279 | 575 |
| | | 51.5% | 48.5% | 100% |
| | | 100% | 100% | 100% |

*P*-value: 0.015

different seasons. For example, Toorang et al showed that consumption of fruit especially melons in summer is higher than winter.

Moreover, previous studies reported seasonal variation in physical activity in some regions with significant difference in mean temperature of summer and winter (11). It is well-known that regular physical activity has important influence on glycemic status and T2DM patients who spend enough time for exercise have lower HbA1c (12).

In our region, during colder months in autumn and winter in comparison with warmer months of spring and summer outdoor physical activity increased. People during summer that temperatures exceed 35º C, prefer to stay at home. Considering to reports from different parts of the world, pattern of physical activity is dependent on climate. For example, in regions with cold weather, physical activity increased in August and September and improve glycemic status and body composition in comparison with colder months of winter that limit outdoor physical activity for a great part of people (13-15). Besides the seasonality nature of physical activity and carbohydrate consumption that affect glycemic status of diabetic patients in different seasons, other parameters such as sun-exposure, vitamin D deficiency and melatonin levels can influence the insulin sensitivity. Some evidences showed that serum 25-hydroxy vitamin D levels had inverse relationship with T2DM (16) and vitamin D has protective effects on beta cells (17). Melatonin that secreted from pineal body, and increased during darkness can lead to insulin resistance (18). Regarding to these studies, winter with lower sun-exposure and more darkness that decrease vitamin D levels and increase melatonin secretion can create more insulin resistance.

Diabetologists and nutritionists who care diabetic patients should consider seasonal changes of glycemic status among T2DM. Physicians can change dose of antidiabetic drugs to overcome seasonal changes and nutritionist should give appropriate consultation to patients. The other importance of seasonality in glycemic status is analysis of research results.

## Conclusions

Seasonal changes in glycemic status are an important factor in management of T2DM patients in regions with high difference in mean of temperature between cold and warm months. In Yazd with desert climate, postprandial hyperglycemia is more prominent in summer.

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## Conflict of Interest

The Authors have no conflict of interest.

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