

Comparative Analysis of Zero-Carbohydrate versus Balanced Breakfast on Mitigating the Dawn Phenomenon in Diabetes Patients

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SUMMARY

A common problem for several Diabetic Patients is an early-morning rise in blood sugar levels known as the “Dawn Phenomenon”. Due to the high sugar levels, Diabetic patients often minimize or eliminate all carbohydrates from their breakfast thereby eating an unbalanced meal that is generally not recommended. This research compares the impact on blood sugar levels between a zero-carbohydrate breakfast and a balanced breakfast with healthy carbohydrates. The dawn phenomenon is caused due to the release of sugars from the liver in the morning. Type 2 Diabetics have lower insulin-producing capabilities or higher insulin resistance which leads to high glucose levels in the morning even in the absence of food or carbohydrates. This study examined if additional insulin triggered by dietary intake of carbohydrates would reduce the dawn phenomenon. The hypothesis was that introducing healthy simple carbohydrates in the breakfast would trigger the release of additional insulin, reducing blood sugar levels compared to a zero-carbohydrate breakfast. A diabetic patient experiencing the dawn phenomenon recorded the average 6-hour morning blood sugar levels for two different types of breakfasts: a zero-carbohydrate baseline control and a balanced breakfast that included carbohydrates. The balanced breakfast led to a 1.5% reduction in estimated A1C, a widely used measure of diabetes. Though not a significant reduction and within the tolerance of error, the results indicate that patients do not have to sacrifice eating balanced breakfasts which is a significant benefit for Diabetic patients.

INTRODUCTION

Diabetes is a common disease caused due to high blood sugar levels. The disease is caused when the pancreas cannot produce enough insulin or the body cannot utilize the insulin effectively. Prolonged high blood sugar levels can lead to a range of long-term complications to the heart, eye, kidney, nerves, foot and other health issues.

50% of Diabetic patients experience a phenomenon called the “Dawn Phenomenon” that results in elevated blood sugar levels in the morning. This is caused due to the body's natural release of hormones during the early morning hours. These hormones stimulate the liver to release stored glucose, leading to a rise in blood sugar levels [1]. The magnitude of blood glucose elevation during the dawn phenomenon in type 1 diabetes has been quantified as a 15-25 mg/dL increase from the nocturnal nadir to pre-breakfast levels [2].

The dawn phenomenon is caused by the natural release of certain hormones such as the growth hormone, cortisol, glucagon, and epinephrine. These are counter-regulatory hormones since they oppose the action of insulin to control sugars [3, 4]. The Growth Hormone is known to increase insulin resistance [5] which further increases the Dawn Phenomenon. Cortisol, the stress hormone, also increases insulin resistance as a counter-regulatory mechanism to ensure glucose remains available in the bloodstream for immediate energy needs during stress [6]. Epinephrine is linked to a decrease in insulin secretion which also increases the Dawn Phenomenon [7].

In response to these high morning blood sugar levels, many diabetic patients resort to drastic dietary measures including reducing or eliminating carbohydrates from their breakfast. An unbalanced meal is against general nutritional guidelines and may have other adverse side effects.

This research investigates an alternative approach to managing the dawn phenomenon by comparing the impact on blood sugar levels between a zero-carbohydrate breakfast and a balanced breakfast that includes healthy carbohydrates.

The study hypothesizes that introducing healthy carbohydrates in the breakfast may trigger the release of additional insulin, resulting in similar or lower overall blood sugar levels compared to a zero-carbohydrate breakfast. The balanced breakfast led to a 1.5% reduction in estimated A1C. This means that Diabetic patients do not have to resort to extreme unbalanced dietary measures to control the Dawn Phenomenon. The 1.5% reduction in estimated A1C was achieved by a reduction of 2 mg/dL daily, which is not a statistically significant reduction. Due to this, we cannot infer that a balanced meal will help reduce sugar levels and lead to better Diabetic Control. However, by not increasing the sugar levels, the balanced meal will offer a sustainable healthy alternative to extreme diets.

RESULTS

A breakfast containing no carbohydrates served as the baseline control for this experiment. A second experiment with a breakfast containing carbohydrates was conducted to test the hypothesis that introducing carbohydrates would trigger the release of additional insulin which would reduce blood sugar levels.

Two separate experiments were conducted on a diabetic patient that was experiencing the dawn phenomenon. The patient wore a Continuous Glucose Monitor (CGM) that recorded the blood sugar levels continuously. The CGM provided average sugar levels in mg/dL over three-hour time windows over 7 days. e.g. 7-day average glucose between 6 AM - 9 AM, 9 AM to 12 noon, etc.

The patient was asked to follow a zero-carbohydrate breakfast for 7 days. The average 6-hour morning blood sugar levels between 6 AM and 12 noon were calculated from the recorded 3-hour averages. The patient was then asked to eat a balanced breakfast that included some healthy carbohydrates for 7 days. The average 6-hour morning blood sugar levels for the two different types of breakfasts - the zero-carbohydrate breakfast and the balanced breakfast - were compared over each 7-day period.

For each 7-day breakfast period, the average blood glucose in mg/dL was converted to A1C using the formula [8]: $eAG = 28.7 \times A1C - 46.7$, where eAG is the estimated Average Glucose.

A1C or HbA1c is a blood test used to measure the average level of glucose (sugar) in the blood over the past two to three months. It is a crucial tool for diagnosing and managing diabetes

The balanced breakfast led to a 1.5% reduction in estimated Diabetes A1C readings compared to the zero-carbohydrate breakfast (Table 1)

Nr	Breakfast	Avg. Sugar (6 AM-9 AM) A	Avg. Sugar (9 AM-12 PM) B	Avg. Sugar (6 AM-12 PM) C	Avg. Sugar (7 days) D	A1C E	A1C Reduction
1	Control: Zero Carbs	137 mg/dL (CGM)	150 mg/dL (CGM)	143.5 mg/dL (A+B)/2	142 mg/dL (CGM)	6.6	NA (Control)
2	Balanced: With Carbs	119 mg/dL (CGM)	151 mg/dL (CGM)	135 mg/dL (A+B)/2	140 mg/dL D1- ((C1-C2)/4)	6.5	1.5% (E1-E2) /E1 %

Table 1: Estimated A1C for two types of breakfast: Zero Carbohydrates and a Balanced breakfast containing carbohydrates. Average blood sugar values over 3 hours and 7-day windows were collected from a Continuous Glucose Meter (CGM). Average 7-day blood sugar in mg/dL was used to estimate A1C using a formula [8]. Derived value calculations, if any, are shown alongside the corresponding value. Carbohydrates are abbreviated as Carbs.

DISCUSSION

The balanced breakfast led to a 1.5% reduction in estimated Diabetes A1C readings compared to the zero-carbohydrate breakfast (Table 1). The reduction in the average six-hour morning (6 AM to 12 noon) blood sugar levels was 8.5 mg/dL or 6% (Table 1). The results were counter-intuitive since increasing carbohydrates in the diet should have resulted in a higher blood sugar level during the 6 AM to 12-noon morning time window.

Potential explanation of the results

As noted above, the “Dawn Phenomenon” causes the liver to release stored glucose, leading to a rise in blood sugar levels in the morning. The initial surge in blood glucose levels should have triggered the release of insulin by the pancreas. For a healthy individual without diabetes, this insulin would have been enough to bring down the blood glucose levels within normal levels. For diabetic patients experiencing the dawn phenomenon, the glucose uptake into the cells is reduced due to either reduced insulin production or higher insulin resistance.

It is likely that the initial surge of sugars and resultant insulin levels triggered by the dawn phenomenon was triggered in the early morning hours after 3 AM [1]. A subsequent balanced breakfast at 7 AM, with the additional 39.9g of dietary carbohydrates, may have triggered the release of additional insulin which may have contributed to the reduction in the average six-hour morning (6 AM to 12 noon) blood sugar levels by 8.5 mg/dL.

Further, the rate of sugars released into the bloodstream due to the additional carbohydrates in the balanced breakfast was reduced due to the soluble fiber in the diet [9]. 6.6g of fiber including soluble fiber was present in the breakfast with an additional 8g of fiber from the supplement. The slow absorption and release of glucose meant that the 39.9g of carbohydrates in the balanced breakfast did not cause an additional surge that a diabetic with compromised insulin production or insulin resistance could not overcome. In essence, this additional slow release of sugars over the six-hour morning window served as a “booster” dose of insulin. Finally, the insoluble fiber from the nuts and seeds in the diet improved insulin sensitivity [10].

Limitations and potential future experiments

One limitation of this study was that it involved only one patient. Due to this, it is hard to generalize the results across a broader population of Diabetic patients. A potential future experiment could include additional human participants to derive more generalized repeatable results.

Another limitation was that the study did not test for the impact of varying sugar levels. Due to this, a potential future experiment could include additional breakfast meals with lower levels of carbohydrates than the one studied here with 39.9g. e.g. 10g, 20g and 30g of carbohydrates.

An additional limitation was that the study did not test for the impact of additional carbohydrates in the absence of any fiber, nuts and seeds. A future experiment could involve the effect of additional carbohydrates in the absence of any fiber, nuts and seeds.

Significance of Results

The 1.5% reduction in estimated A1C is within the tolerance of error. Due to this, we cannot infer that a balanced meal will help reduce sugar levels and lead to better Diabetic Control. However, this research strongly suggests that a balanced meal does not increase the average blood sugar levels in the 6 AM to 12 noon time window. Due to this, diabetic patients experiencing the dawn phenomenon do not have to sacrifice eating sustainable healthy breakfasts and resort to extreme diets.

MATERIALS AND METHODS

Procedure & Experiment Design

A Diabetic patient experiencing the Dawn Phenomenon was sought out for two experiments spanning a total of 14 days. Through collaboration, the patient was asked to follow two breakfast meal plans a) Zero-carbohydrate breakfast b) Balanced breakfast with healthy simple carbohydrates. The patient was Instructed to follow each breakfast plan for 7 days and provide the requested data described below. For both breakfast plans, apart from the breakfast, the patient was instructed to avoid having anything after midnight until their breakfast. After breakfast, they did not have any other meal before noon. The only exception was coffee or tea with no added sugar. The patient could add milk, creamer or a zero-calorie sweetener as long as it was followed consistently for both breakfast plans. Exercise routines and timing, as well as, medication dosage and timing was kept constant for the 14 days period. The Diabetic Patient who participated in the study was a 52-year old male living in the US. The patient had Type 2 Diabetes. For Diabetes control, the patient was on a nightly dose of 1000 mg of extended-release Metformin taken after dinner. The patient took other non-diabetic medications, multi-

vitamins and 8g of a Psyllium fiber supplement in the morning. The patient exercised 3-5 times a week in the evening which typically included a brisk 30-minute walk. The patient typically had his breakfast in the morning around 7 AM.

Zero Carbohydrate Breakfast Ingredients (Control)

The ingredients of the Zero Carbohydrate Breakfast are listed below (Table 2)

Nr	Ingredient	Total Calories	Total Carbs (weight)	Total Fiber (weight)	Total Protein (weight)	Total Fat (weight)
1	2 Boiled Eggs	138	0g	0g	12g	8g
	TOTAL	138	0g	0g	12g	8g

Table 2: Zero Carbohydrate Breakfast Ingredients (Control). The Calories and Carbohydrate information was calculated based on the serving size and nutritional label on the product. Carbohydrates are abbreviated as Carbs.

Balanced Breakfast (with Carbohydrates) Ingredients

The Balanced breakfast ingredients are listed below (Table 3)

Nr	Ingredient	Total Calories	Total Carbs (weight)	Total Carbs (Calories)	Total Fiber (weight)	Total Protein (weight)	Total Fat (weight)
1	Chia Seeds (1 tablespoon)	53	3.3g	13.2	3.1g	2g	3.1g
2	Cashewnuts (2 pieces)	21	1g	4	0g	0.7g	2g
3	Almonds (2 pieces)	22	0.8g	3.2	0.35g	0.7g	2g
4	Dates (1/2 piece)	27	7.5g	30	0.75g	0g	0g
5	Figs (1/2 piece)	27	7g	28	1g	0g	0g
6	Dried Mango (8.5g)	30	7.3g	29.3	0.4g	0g	0g
7	Dried Blueberries (2 pieces)	20	5g	20	0g	0g	0g
8	Oat Milk (1/2 Cup)	60	8g	32	1g	1.5g	2.5g
	TOTAL	260	39.9g	159.7	6.6g	4.9g	9.6g

Table 3: Balanced Breakfast (with Carbohydrates) Ingredients. The Calories and Carbohydrate information was calculated based on the serving size and nutritional label on the product. The Calorie value for Carbohydrates was calculated using the formula 1g Carbohydrate = 4 Calories. Carbohydrates abbreviated as Carbs.

Data Collection

The Diabetic patient used FreeStyle Libre 3, manufactured by Abbott, which is a Continuous Glucose Monitor (CGM). The CGM recorded the blood sugar levels continuously and provided average sugar levels in mg/dL over three-hour time windows over 7 days. e.g. 7-day average glucose between 6 AM - 9 AM, 9 AM to 12 noon, etc. At the end of the 7 days for a given

breakfast type, the patient provided the 7-day average glucose in mg/dL between 6 AM - 9 AM, 9 AM to 12 noon and the entire 7-day period.

Average blood sugar for the 6-hour morning period

For each breakfast, the average blood sugar in mg/dL for the 6-hour morning period from 6 AM to 12 noon was calculated from the patient provided CGM data as follows.

$$\text{Avg Sugar (6 AM - 12 PM)} = (\text{Avg. Sugar (6 AM - 9 AM)} + \text{Avg Sugar (9 AM - 12 PM)}) / 2$$

7-day Average blood sugar

For the control, the breakfast with no carbohydrates, the 7-day average blood sugar in mg/dL was collected from the patient. From the mg/dL value, the corresponding A1C was calculated using a formula [8].

For the balanced breakfast with carbohydrates, the 7-day average blood sugar in mg/dL was calculated as follows.

Avg. Sugar (7 days) of balanced breakfast =

$$\text{Avg. Sugar (7 days) of control} - ((\text{Avg. 6 hour Control} - \text{Avg. 6 hour Balanced breakfast}) / 4)$$

The results were reported as a net improvement (or decrease) of the balanced breakfast plan over the zero-carbohydrate plan. It was reported in both mg/dL and A1C.

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