Republic of Iraq

Ministry of Higher Education and Scientific Research

University of Diyala

College of Medicine

"Studying the effect of deep breathing exercises on blood glucose levels"

A Thesis

Submitted to the Council of the College of Medicine, University of Diyala, Department of Physiology, Medical Physics as a Partial Fulfillment in the Requirements for the Degree of MBChB

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Dedication

This study is wholeheartedly dedicated to :

- Those who have been my pillars of strength and support throughout this long and challenging journey. To my beloved parents, whose unwavering love, guidance, and encouragement have been the driving force behind my achievements. You have been my greatest source of motivation, and I am forever grateful for your endless support.

Acknowledgement

- We are profoundly thankful to Almighty God for granting us good health and for providing guidance, strength, mental clarity, protection, and skills. My sincere gratitude extends to all.

- We also want to acknowledge Prof.Dr. Amer Dawood Majeed, whose support motivated me to finish this work.

SUPERVISOR CERTIFICATIONS

I certify that the preparation of this research titled (Studying the effect of deep breathing exercises on blood glucose levels) and conducted by the students (Zahraa Hassan Fadhel) was conducted under my supervision, College of Medicine, Diyala University, which is part of the requirements for obtaining a bachelor's degree in medicine.

Name of supervisor: Dr. Amer Dawood Majeed

Academic degree: Professor

Signature:

Date:

List of Tables

Tables	Page Numbers
The characteristics of the participants enrolled in the study	15

List of Figures

Figures	Page Number
Figure 1: The correlation between partial oxygen tension and fasting plasma glucose after two attempts of deep breathing in healthy subjects	16
The correlation between partial oxygen tension and fasting plasma glucose after two attempts of deep breathing in diabetes subjects	16

List of Abbrevations

Abbrevations	Description
DM	Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
PPGT	Postprandial Blood Glucose Test
FBS	Fasting Blood Sugar
HbA1c	Glycosylated Hemoglobin A1C
PNS	parasympathetic Nervous System

Abstract

Background : Diabetes mellitus is a collection of metabolic disorders marked by hyperglycemia due to impairments in insulin secretion, insulin action, or both .One of the most frequent diseases in the world, diabetes mellitus (DM) is on the rise due to its common risk factors, chronic nature, and consequences. It is anticipated that almost 600 million individuals globally would be afflicted by this illness in the next 20 years.

Objective : To determine if deep breathing exercises can lower blood glucose levels in individuals, particularly those with insulin resistance or diabetes.

Method and Materials : This cross-sectional study involved 100 participants (46 males, 54 females) divided into two groups: Group I (healthy, n = 50) and Group II (T2DM, n = 50). The study was conducted between 15 August 2024 To 10 November 2024, at Baqubah Teaching Hospital and a Primary Healthcare Center. Participants performed two 20-minute sessions of slow deep breathing exercises. Blood glucose levels and oxygen saturation (SpO2) were measured before and after each session using the Visionary Biomedicine Glucometer and Rose Max Oximeter. Data were analyzed using Microsoft Excel 2013 and SPSS (version X). Paired and independent t-tests were applied, with $p < 0.05$ considered statistically significant.

Result: This study showed a significant increase in the partial oxygen tension after the first and second attempts, which accounts for 1.03% for each attempt in healthy subjects. In diabetes patients, the significant increase in the partial oxygen tension was similar (1.03%)to that observed in healthy subjects. There were inverse correlations between partial oxygen tension and fasting plasma glucose in both healthy subjects and

diabetes patients and reached a significant level of p=0.032 after the first attempt of deep breathing in healthy subjects .

Conclusion: This study highlights the significant role of deep breathing exercises in improving glycemic control and oxygenation. The findings demonstrate immediate reductions in fasting plasma glucose levels (7 mg/dL in healthy individuals and 14.5 mg/dL in diabetic patients) and a consistent 1.03% increase in partial oxygen tension after two attempts. These results suggest that deep breathing exercises can enhance glucose metabolism, improve insulin sensitivity, and activate parasympathetic pathways, making them a cost-effective and accessible adjunct therapy for diabetes management.

Introduction

Diabetes mellitus is a collection of metabolic disorders marked by hyperglycemia due to impairments in insulin secretion, insulin action, or both [1].

One of the most frequent diseases in the world, diabetes mellitus (DM) is on the rise due to its common risk factors, It is anticipated that almost 600 million individuals globally would be afflicted by this illness in the next 20 years [2].

There are three main forms of diabetes: Type 1 involves the pancreas not producing insulin; Type 2 involves body cells that are resistant to the effects of the insulin being produced, and over time, insulin production gradually declines; and Gestational diabetes, which develops during pregnancy and can lead to complications during pregnancy and delivery, as well as an increased risk of type 2 diabetes in the mother and obesity in the offspring [3].

Globally, the prevalence of type 2 diabetes mellitus (T2DM) has risen from 8.3% in 2013 to 9.3% in 2019. This increase has been higher in low-to-middle-income nations than in high-income ones [4]. Compared to males with diabetes, women with the condition are more likely to die from cardiovascular disease. [5]

Hyperglycemia causes acute symptoms such as generalized body or bone pain, weight loss, lethargy, excessive thirst (polydypsia), excessive appetite (polyphagia), and excessive urination (polyuria) [6][7].

Blood glucose levels are monitored and diagnosed using a variety of blood glucose tests. Tests for blood sugar and acetone in urine, postprandial blood glucose test (PPGT), and fasting blood sugar (FBS) are the most often utilized. In addition, glycosylated hemoglobin (HbA1c) is employed for monitoring over several months when the HbA1c level is greater than 7 [8][9].

When a diabetic patient has not eaten for at least eight hours, some researchers have determined that the fasting blood glucose level under typical circumstances is more than or equivalent to 126 mg/dL (7 mol/L). The random blood glucose concentration (any time of day, regardless of the most recent meal) is less than or equal to 200 mg/dL (11.1 m.mol/L),

yet the 2-hour blood glucose concentration value is greater than or equal to 200 mg/dl (11.1 m.mol/L) during an oral glucose tolerance test (PPGT) [10][11].

One of the most important non-pharmacological therapies for regulating the HPA axis, a component of the stress response system, is physical exercise. A diabetic treatment plan should include aerobic exercise since it helps enhance blood glucose regulation, insulin sensitivity, and cardiovascular health in general. Every week, persons with diabetes should perform at least 150 minutes of moderate-to-intense cardiovascular exercise, such as dance, swimming, cycling, or brisk walking [12][13].

In addition to aerobic exercise, various non-pharmaceutical approaches have been demonstrated to affect stress levels, including mindfulness meditation training and diaphragmatic slow, deep breathing. It has been noted that diaphragmatic breathing lowers the respiratory rate and optimizes the number of gasses in the blood [14]

According to the United Kingdom Prospective Diabetes Study (UKPDS), DM is traditionally managed with dietary changes, hypoglycemic drugs, exercise regimens, patient education, and follow-up [15].

Breathing exercises are a basic, cost-effective, and simple exercise program that diabetes patients can do to reduce their hyperglycemia. They can be done anywhere, including at home, for 30 minutes a day while sitting [16].

The parasympathetic nervous system (PNS) is triggered by slow sine (slow wave) breathing, which is around six breaths per minute. This reaction enhances oxygenation by enlarging the bronchiole channels in the lungs. Inhibiting the sympathetic nervous system through PNS activation also reverses insulin resistance, which lowers blood glucose levels [17]. A study that was published in the Indian Journal of Endocrinology and Metabolism claims that , Its findings demonstrated the impact of a six-month breathing regimen on lowering blood sugar, enhancing life quality, and slowing the course of cardiac disease and neuropathy [18].

Exercises that involve breathing regulate oxidative stress, which is an imbalance between antioxidants and free radicals. Elevated blood glucose levels are triggered by oxidative stress, which also causes inflammation and insulin resistance, hastening both short-term and long-term complications of diabetes[19]. Studies have shown that regular breathing techniques and yoga poses can raise levels of antioxidants such superoxide dismutase, glutathione, and vitamin C[20].

These antioxidants have several advantages, such as regulating blood sugar levels and having a relaxing effect on the mind, which lowers stress , environmental stress , Additionally, it prevents the release of pro-inflammatory proteins, rennin, and catecholamine inflammatory cytokines, which raise blood pressure, insulin resistance, and oxidative stress [21].

Conversely, it lowers stress-inducing hormone levels, including cortisol, nor-adrenaline, and adrenaline , Additionally, it produces a relaxing response by decreasing the accumulation of lactic acid in muscle tissue and boosting serotonin and other feel-good endorphins, which improves mood and tranquility [22]. Additionally, it increases the synthesis of melatonin, a hormone that promotes sleep, which enhances the hypothalamus pituitary-adrenal axis and regulates sympathetic activity, hence lowering the risk of problems from diabetes mellitus[23].

Insulin resistance is associated with autonomic nervous system dysfunction, cardiac disease, obesity, and hypertension. Breathing exercises have been demonstrated to significantly improve cardiac autonomic function while lowering blood pressure and heart rate. Yoga poses and breathing techniques can help repair the damage that diabetes causes to the central and peripheral nerve systems. Additionally, it can reverse the conduction velocity of diabetic nerves and problems such as delayed or infected wound healing, long-term harm, organ failure, and dysfunction, particularly in the heart, blood vessels, kidneys, eyes, and nerves, as well as a HbA1c level more than 7 [24].

Long-term harm, dysfunction, and failure of many organs, particularly the heart, kidneys, blood vessels, and eyes, are linked to chronic hyperglycemia [6].

Aim of Study : To determine if deep breathing exercises can lower blood glucose levels in individuals, particularly those with insulin resistance or diabetes

Method and Materials

Study design: Cross-sectional study.

Sampling technique: The study involved 100 participants (46 males and 54 females), including 50 diabetic and 50 non-diabetic individuals. The participants were grouped into two groups:

• Group I: Healthy subjects (n = 50)

• Group II: T2DM participants (n = 50)

The study was conducted between 15 August 2024 To 10 November 2024, at the Baqubah Teaching Hospital and a Primary Healthcare Center.

Data Collection: The participants were instructed to perform two attempts of slow deep breathing exercises, each lasting 20 minutes. For each participant, the following measurements were recorded:

• Before and after the intervention (Trial 1):

• Blood glucose levels using the Visionary Biomedicine Glucometer.

• Oxygen saturation (SpO2) using the Rose Max Oximeter.

• Before and after the intervention (Trial 2):

• Blood glucose levels and SpO2 were measured again after the second round of deep breathing exercises.

Demographic data, such as age and sex, were also recorded.

Ethical approval: This study did not record the names of participants or any sensitive data.

Statistical analysis: Data were organized and analyzed using Microsoft Excel (2013) and SPSS Statistics (version X). Descriptive statistics were applied, and comparisons between pre- and post-intervention

measurements were conducted using paired t-tests, while differences between diabetic and non-diabetic groups were assessed using independent t-tests. A p-value < 0.05 was considered statistically significant.

Result

Table 1: showed a significant increase in the partial oxygen tension after the first and second attempts, which accounts for 1.03% for each attempt in healthy subjects. In diabetes patients, the significant increase in the partial oxygen tension was similar (1.03%)to that observed in healthy subjects. There were inverse correlations between partial oxygen tension and fasting plasma glucose in both healthy subjects and diabetes patients and reached a significant level of p=0.032 after the first attempt of deep breathing in healthy subjects (Figures 1 and 2).

Table 1: The characteristics of the participants enrolled in the study

Groups	Variables	First deep breath attempt			Second deep breath attempt		
		Before	After	p-value	Before	After	p-value
Diabetes (n=50)	Age, year	51 (43-62)					
	Sex, Male: female	23:27					
	Partial oxygen tension (%)	97 (96-97)	98 (97, 99)	<0.001	97 (96, 98)	98 (97, 99)	<0.001
	Fasting plasma glucose (mg/dL	189.5 (137.5-231.0)	182.5 (138.5, 220.5)	<0.001	187 (134.75, 222.5)	175 (126.5, 218.75)	<0.001
Control (n=50)	Age, year	37.0 (23.0-54.25)					
	Sex, Male: Female	23:27					
	Partial oxygen tension (%)	97.0 (96.0-98.0)	98.0 (98.0-99.0)	<0.001	97.0 (97.0-98.0)	98.0 (98.0-99.0)	<0.001
	Fasting plasma glucose (mg/dL	116.5 (101.8-130.0)	110.5 (96.5-123.0)	<0.001	112.0 (99.8-121.3)	109.0 (94.3-121.0)	<0.001

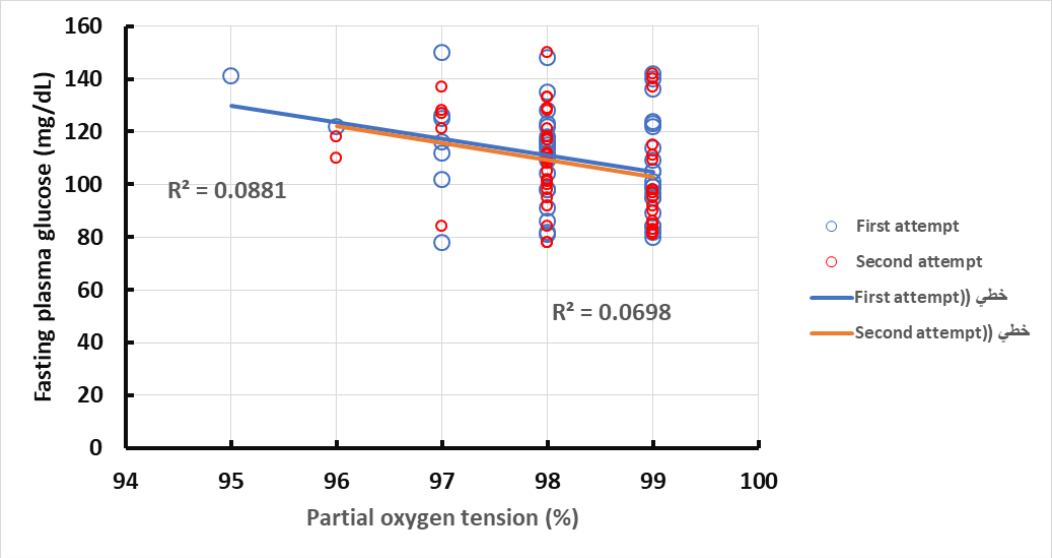


Figure 1: The correlation between partial oxygen tension and fasting plasma glucose after two attempts of deep breathing in healthy subjects

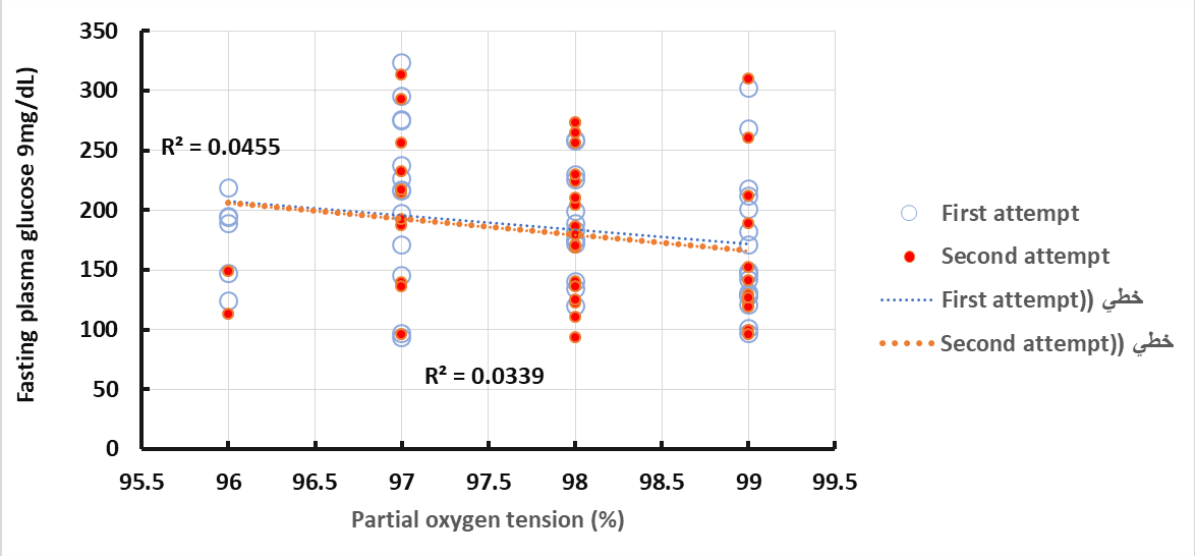


Figure 2: The correlation between partial oxygen tension and fasting plasma glucose after two attempts of deep breathing in diabetes subjects

Discussion

This study examined the immediate effects of deep breathing exercises on fasting plasma glucose (FPG) levels and partial oxygen tension among healthy and diabetic individuals. The findings revealed significant reductions in FPG levels and improvements in oxygenation, aligning with global research on the physiological benefits of breathing exercises.

Reduction in Fasting Plasma Glucose (FPG)

• In this study, FPG significantly decreased in:

• Healthy participants: Median reduction from 116.5 mg/dL to 109.0 mg/dL ($p < 0.001$).

• Diabetic participants: Median reduction from 187.0 mg/dL to 175.0 mg/dL ($p < 0.001$).

These results align with the findings of **Rady et al. (2019)[25]**, which demonstrated that sitting breathing exercises significantly reduced postprandial blood glucose (PPG) levels among patients with Type 2 Diabetes Mellitus. In their study, repeated breathing sessions led to consistent reductions in blood glucose, attributed to parasympathetic activation and improved insulin sensitivity.

Improvement in Partial Oxygen Tension

• This study observed a consistent increase in partial oxygen tension (1.03%) after each breathing attempt in both groups. Improved oxygenation is hypothesized to enhance cellular glucose uptake by improving tissue perfusion and metabolic efficiency.

Similar findings were reported by **Wilson et al. (2013)[26]**, who demonstrated that relaxation breathing techniques improve oxygen delivery and glucose metabolism by reducing oxidative stress and enhancing insulin receptor activity.

Physiological Mechanisms

Deep breathing exercises stimulate the parasympathetic nervous system, reducing stress hormones (e.g., cortisol and adrenaline) that exacerbate hyperglycemia. This mechanism, supported by studies like **Chaiopanont (2008)[27]**, contributes to improved glycemic control by reducing insulin resistance and enhancing glucose uptake in peripheral tissues.

Recommendations

1 .Incorporation into Standard Care:

• Deep breathing exercises should be included as an adjunctive therapy in diabetes management protocols to support short-term glycemic control and improve oxygenation.

2 .Training for Healthcare Professionals:

• Develop training programs for healthcare providers to educate and guide patients in practicing effective breathing exercises.

3 .Patient Resources:

• Create educational materials, such as brochures, video tutorials, and mobile apps, to help patients learn and adopt breathing exercises at home.

4 .Self-Monitoring Tools:

• Provide patients with tracking tools, such as glucose monitoring sheets, to document the effects of breathing exercises on their blood glucose levels.

5 .Awareness Campaigns:

• Organize community workshops and outreach programs, especially in rural areas, to promote the benefits of breathing exercises for managing diabetes.

6 .Low-Cost Intervention Advocacy:

• Highlight the economic advantages of breathing exercises as an accessible and effective diabetes management strategy.

Conclusion

This study demonstrated the immediate efficacy of deep breathing exercises in lowering fasting plasma glucose (FPG) levels and enhancing partial oxygen tension in both healthy and diabetic individuals. The significant reductions in FPG (7 mg/dL in healthy individuals and 14.5 mg/dL in diabetic individuals) and the consistent 1.03% improvement in partial oxygen tension highlight the potential of deep breathing exercises as a non-pharmacological intervention for glycemic control.

These findings align with existing literature emphasizing the physiological mechanisms behind these outcomes:

1 .Improved Glucose Metabolism: Increased oxygen delivery to tissues supports glucose utilization and enhances insulin sensitivity.

2 .Autonomic Regulation: Activation of the parasympathetic nervous system reduces stress hormones, such as cortisol and adrenaline, that contribute to hyperglycemia.

3 .Accessibility and Feasibility: The simplicity and cost-effectiveness of deep breathing exercises make them a practical adjunct to traditional diabetes management, particularly in resource-limited settings.

This study supports the integration of breathing exercises as a complementary therapy for glycemic control, with both immediate and potential long-term benefits.

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