Research Article

Slow Deep Breathing Exercises Are of Value in Improving Blood Glucose Levels in Type 2 Diabetes: A Controlled Clinical Trial

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Objectives: This cohort-controlled clinical study aimed to investigate the effect of slow deep breathing on random blood glucose (RBG) levels and to correlate it with saturated peripheral oxygen (SpO_2)

Methods: A total number of 100 participants were grouped into two groups; Group I: healthy subjects (n=50) and Group II: T2DM participants (n=50). The participants were breathed deeply for two cycles, each for 20 minutes. RBG and SpO_2 (%) were determined before and after each cycle.

Results: RBG levels were significantly decreased and SpO2 (%) values were significantly elevated after slow deep breathing exercises in both groups. There is an insignificant inverse correlation between SpO_2 (%) and RBG in Group II

Conclusion: Physical therapy could act as an adjuvant intervention in controlling blood glucose in T2DM.

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Introduction

Breathing has a direct central effect on the autonomic nervous system, which inhibits the vagal tone during inhalation and restores the activity of the vagal tone during exhalation.[1] Breathing exercise denotes an equal ratio of inhalation to exhalation to balance sympathetic and parasympathetic activities for a certain period.[2][3] Heart rate variability is a determinant factor related to breathing exercises, and it is usually used to determine autonomic nervous system dysfunction, e.g., diabetes mellitus.[4] In one

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clinical trial that included 58 women with type 2 diabetes mellitus (T2DM), aerobic exercise supplemented with slow, deep breathing significantly reduced fasting plasma glucose and cortisol hormone compared with anaerobic exercise alone.[5] The authors suggested that slow, deep breathing reduces plasma glucose due to alleviating stress.[6][7] Saturated peripheral oxygen (SpO_2) is significantly improved following deep breathing exercises consisting of a cycle of normal breathing, diaphragmatic breathing, deep breathing, and huffing and coughing, which is associated with a significant increase in heart rate.[8] In T1DM, a low SpO_2 is associated with neuropathy but not cardiovascular complications.[9] Therefore, we thought that deep breathing could overcome autonomic neuropathy; improve SpO_2; and alleviate stress leading to lowering blood glucose in T2DM patients. This controlled clinical study aimed to show the effects of deep breathing on blood glucose and SpO_2, and the relationship between these two determinants.

Materials and Methods

This study was conducted in the Department of Physiology, Medical Physics in the College of Medicine at the University of Diyala from January 1 to June 31 2024. The Scientific and Ethical Committees approved this study as a graduate student project (2024 ADM 839, dated 27-03-2024). This cohort cross-sectional study is designed to study the effect of activating the vagal tone by using slow deep breathing exercises on the random blood glucose level in patients with T2DM. In this randomized controlled trial, the adult participants including healthy subjects (Group I) and T2DM patients (Group II) instructed to do slow, deep breathing exercises.

The study's eligibility criteria are adults of both sexes aged (18-70) and voluntarily healthy subjects. The inclusion criteria are T2DM without apparent complications. Patients with respiratory diseases, using analeptic drugs or expectorants, pregnancies, and nursing mothers were excluded from the study.

Each patient and healthy subject is instructed to do the following procedure of deep breathing exercise: The participant in a comfortable sitting position was instructed to do slow, deep breathing exercises through the nose (both inspiration and expiration) for 20 minutes for each attempt with a range of 8-10 breaths per minute. Two cycles of slow, deep breathing were achieved with an interval of 30 minutes between the first and second cycles.

The primary outcome of this study is the determination of random blood glucose (RBG) using a portable glucometer at the time of pre-exercise and post-exercise periods for each cycle. The secondary outcome of this study is a simultaneous determination of SpO_2 (%) by using a pulse oximeter.

Sample size and power

The sample size estimation for a cross-sectional and difference between two independent means (two groups) was done using Gpower 3.1 software (Heinrich-Heine-Universität Düsseldorf, Germany, adjusting the α error probability at 0.05 and a power ($1-\beta$) error probability at 0.8. The sample size was 45 participants for each group. A total of 50 health subjects (Group I) and 50 T2DM patients (Group II) were enrolled in the study.

Statistical analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, version 26, IBM-compatible cooperation, USA). The results are presented as median (interquartile range; Q1 and Q3). The difference between Groups I and II, and the effect of deep breathing exercises were analysed using independent two-sample Mann-Whitney U test, and Wilcoxon's matched-pair signed rank test, respectively. The correlation between SpO_2 and RBG was estimated using Pearson's (rho) correlation test. The level of significance is ≤ 0.05.

Results

Table 1 showed a significant increase in the SpO_2 after the first and second cycles, which accounts for 1.03% for each cycle in healthy subjects. Diabetic patients and healthy subjects showed a significant increase in SpO_2 of 1.03%. There were inverse significant (p=0.032) correlations between SpO_2 and RBG in healthy subjects after the first cycle of deep breathing (Figures 1). Figure 2 shows insignificant changes in the RBG levels between Groups I and II after the first cycle of breathing exercises, while patients in Group II responded significantly (p=0.006) to breathing exercises after the second cycle, as they showed a significant reduction in blood glucose level compared with healthy subjects.

Groups	Variables	First deep breath attempt			Second deep breath attempt		
		Before	After	p-value	Before	After	p-value
Group II (n=50)	Age, year	51 (43-62)					
	Sex, Male: female	23:27					
	Peripheral oxygen saturation (%)	97 (96-97)	98 (97, 99)	<0.001	97 (96, 98)	98 (97, 99)	<0.001
	Random blood 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
Group I (n=50)	Age, year	37.0 (23.0-54.3)					
	Sex, Male: Female	23:27					
	Peripheral oxygen saturation (%)	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
	Random blood 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

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

The results are expressed as median (Inter-quartile range). p-value was calculated using Wilcoxon's matched-pair signed rank test.

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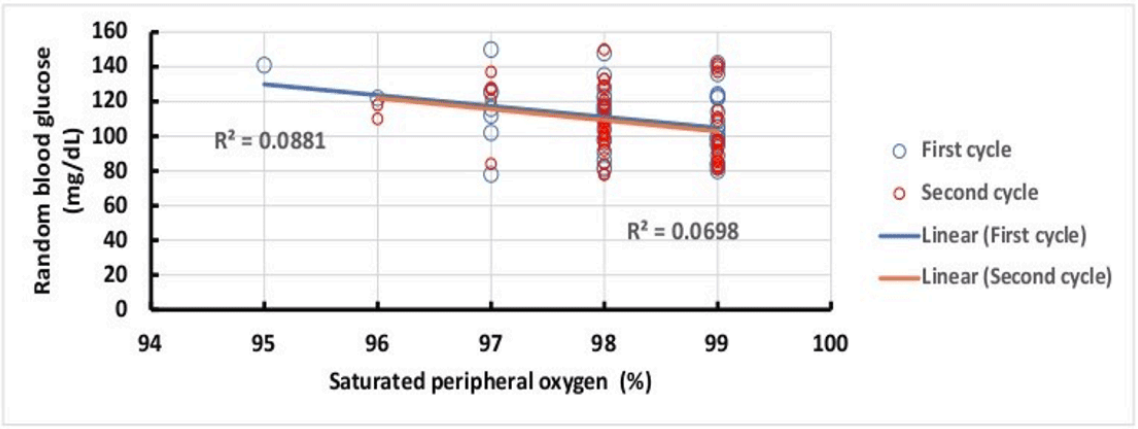

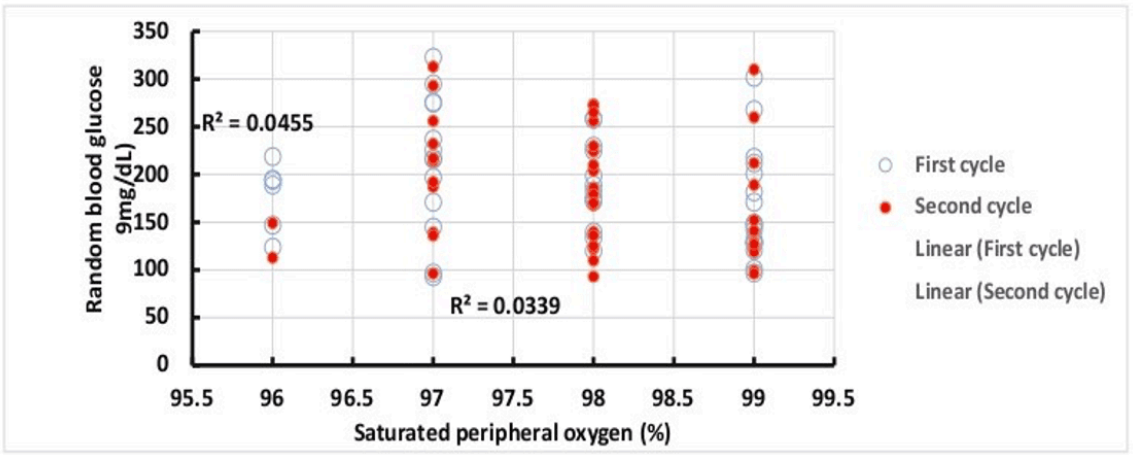

Figure 1. The correlation between saturated peripheral oxygen and blood glucose after two attempts of deep breathing in healthy subjects (above) and type 2 diabetes mellitus (below)

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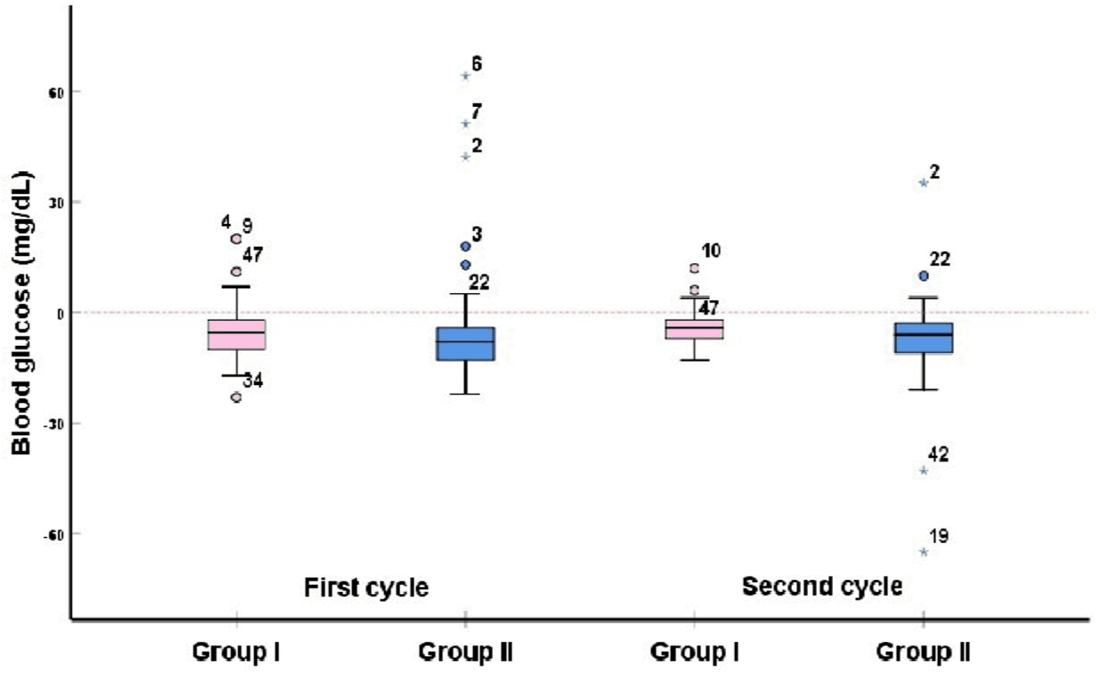

Figure 2. Comparison between Groups I and II in the difference in the blood glucose levels resulting from the first and second attempts of deep breathing exercise. A non-significant difference between Groups I and II (p=0.091) at the first attempt, and a significant difference at the second attempt (p=0.006) using an independent two-sample Mann-Whitney U test.

Discussion

The results of this study showed a significant in SpO2% in Groups I and II, and significantly correlated with blood glucose level in an inverse fashion in Group I. Two cycles of deep breathing exercises significantly decreased the RBG in Group II compared with the corresponding Group I. These results indicate that more than occasionally deep breathing exercises are of benefit in reducing the blood glucose level in diabetes compared with healthy subjects. The results of a significantly high SpO_2 after deep breathing are agreed with previous studies that reported a significantly higher SpO_2 in healthy subjects aged >65 years.[10] Moreover, slow deep breathing resulted in an increase in the SpO2 in diabetes patients, which is associated with an improvement in the baroreflex sensitivity due to restoring the autonomic nervous system activity by improving the parasympathetic tone.[11] The second finding in this study is a significant inverse correlation between SpO_2 and blood glucose levels in Group I. Our finding of an inverse relationship between glucose levels and SpO_2 agreed with other studies conducted in patients with

peripheral artery diseases subjected to exercise.[12] In Group II, the non-significant inverse correlation between blood glucose and SpO_2 could be attributed to tissue hypoxia due to high blood glucose that is not corrected with breathing exercises, and the resting ambulatory SpO_2 percentage was within normal values.[13] Previous studies did not pay attention to the effect of deep breathing on blood glucose but to other parameters e.g., heart rate variability, biomarkers of oxidative stress, blood pressure, etc.[14][15] Our results in Figure 2 agreed with the results reported by Elsayed Rady's study[16], which found that sitting breathing exercises on three attempts significantly reduced the plasma glucose levels in T2DM patients. The strength of this study is healthy subjects and T2DM patients were included, i.e., a controlled study. One of the important limitations of the study is that cardiac autonomic nervous system tests were not carried out to link these findings with cardiac autonomic neuropathy.

Conclusions

Deep breathing exercises are of benefit in type 2 diabetes mellitus as they improve the saturated peripheral oxygen percentage and significantly reduce blood glucose. Therefore, deep breathing exercises could be recommended as adjuvant intervention in controlling blood glucose in type 2 diabetes mellitus.

Statements and Declarations

Ethics

This study was reviewed and approved by the Scientific and Ethical Committees of the University of Diyala, College of Medicine, Iraq, in accordance with the institutional guidelines for Ethical Scientific Research (Approval Code: 2024ADM839; Approval Date: 27 March 2024).

Informed consent

Written informed consent was obtained from all participants after the purpose and methodology of the study were explained to them, and they were assured that their ongoing medical treatment would not be affected by participation.

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Declarations

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