ORIGINAL ARTICLE

# Breathing Techniques for Vagal Nerve Stimulation: An Approach to Lowering Blood Glucose and Increasing Muscle Strength in Diabetes Mellitus

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## ABSTRACT

**Introduction:** Blood glucose control is vital in diabetes management, regulated by autonomic function and muscular strength. Controlled breathing enhanced vagal tone, promoting relaxation, blood glucose homeostasis and muscle strength. Specific Breathing Technique (SBT) is a non-invasive intervention to regulate blood glucose via autonomic modulation. Hand grip strength is an indicator of overall muscle strength and is correlated with blood glucose level, the lower hand grip, the higher blood glucose in diabetic patients. **Objective:** To assess SBT's effectiveness in blood glucose levels and muscle strength in diabetic patients. **Materials and Methods:** A randomized controlled trial was conducted. Both groups received standard protocol, the intervention group practiced daily SBT (6 weeks). Blood glucose and hand grip strength were measured at baseline and post intervention. **Results:** The intervention group showed a significantly reduced fasting blood glucose level (p=0.000) and better hand grip strength than the control group (p =0.000). **Discussion:** SBT enhances vagal stimulation, promoting parasympathetic function, muscle relaxation, and insulin sensitivity, it may improve muscle strength through autonomic regulation. **Conclusion:** SBT is considered a non-invasive approach for blood glucose control and muscle strength improvement in diabetes care.

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**Keywords:** Blood glucose, Diabetes mellitus, Muscle strength, Breathing technique, Vagal nerve stimulation

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## INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a complex chronic disease, characterized by persistent hyperglycemia due to dysfunctional pancreatic **β**-cell and insulin resistance, cannot be cured and causes related complications (1). According to International Diabetes Federation (IDF), T2DM affects over 536.6 million (9.8 %) people worldwide, with numbers projecting over 700 million by 2045 (2,3). T2DM significantly impacts the healthcare system; direct costs in 2021 become US$ 966 billion according to IDF and in US with annual cost of over $327 billion. In Indonesia total direct medical cost in 2016 US$ 576 million and 74% of cost was for hospitalization and treatment of related diabetes complications in Indonesia. (2-5).

Pharmacological therapy remains the primary approach for glycemic control, while lifestyle modifications, though beneficial, are frequently underutilized(4). Although exercises are already recommended to improve hyperglycemia, many patients struggle with limitations

due to physical comorbidities such as cardiovascular issues, balance disorder, joint problems or reduced muscle strength. Muscle strength, often measured using handgrip strength, is a key indicator of overall skeletal muscle strength and the storage site of plasma glucose. Lower hand grip strength is linked to poor glycemic control in T2DM patients, with onset occurring after the age of 40 years. (6,7)

This has led to an exploration of alternatives, a non-invasive intervention such as breathing exercises and vagal nerve stimulation (VNS)(8). Breathing exercises, particularly diaphragmatic breathing and slow breathing, are known to stimulate the parasympathetic nervous system, which helps regulate various bodily functions. These exercises activate the vagal nerve, the X cranial nerve, which plays a crucial role in controlling the autonomic nervous system, affecting heart rate, digestion, and metabolic regulations. When properly stimulated, the vagal nerve enhances insulin sensitivity, reduces inflammation, and promotes relaxation (9,10,11).

Vagal Nerve Stimulation (VNS) treats epilepsy and depression, through implanted devices which are impractical (8,12,13). However, recent studies have explored breathing exercises as a potential method for improving glucose metabolism. Breathing exercises trigger a parasympathetic response, activate the vagal nerve, and are linked to improving glucose metabolism and muscle strength (8,13,14). This study explores the impact of specific breathing techniques (SBT) for VNS as non-invasive and adjuvant therapy for lowering blood glucose and increasing muscle strength in T2DM patients. We therefore aimed to optimize VNS via specific breathing exercises to reduce blood glucose and enhance muscle strength in humans with T2DM.

## MATERIAL AND METHODS

The Health Research Ethics Committee Subject Institut Ilmu Kesehatan Strada Indonesia approved this study (Reference No. 000584/EC/KEPK/I/11/2023). Sixty T2DM patients in Kediri, East Java, aged over 40 and on dual oral antidiabetic therapy for at least one year, had the moderate level of activity, were randomly assigned to intervention or control groups. Exclusion criteria were those with insulin therapy, unstable medical conditions, cognitive disorder, severe cardiovascular or pulmonary disease, immune or renal disorder, or malignancies.

Participants were randomized using computer-generated allocation. Both groups continued standard diabetes management, while the intervention group additionally performed daily Specific Breathing Techniques (SBT) for less than three minutes, over six weeks, under certified coach supervision. SBT involved neck movements, side gazes, and diaphragmatic breathing, which participants monitored to ensure accuracy and to avoid overdose exercises.

### Outcome Measures

Primary outcomes, including fasting glucose level, were measured at baseline and post-intervention using a glucometer. Secondary outcomes, hand grip strength with dynamometer at baseline and post-intervention.

### Statistical analysis

Continuous data were presented as mean + standard deviation (SE). Kolmogorov-Smirnov was used to evaluate the normality of data distribution and continued. Paired T-Test for compared two groups, with significance set at $p< 0.05$.

## RESULT

The participants' demographic profiles were similar. Out of 113 individuals were initially screened, 60 participants were enrolled and randomized. Of these, 53% were female and aged 61-70 years, with 47% having completed undergraduate education and 80% are retired.

**Table I: Demography Data**

| Variable | Category | Total Participant (n,%) | Control Group (n,%) | Intervention Group (n,%) |
|---|---|---|---|---|
| Gender | Male | 28 (47%) | 15 (50%) | 13 (43%) |
| | Female | 32 (53%) | 15 (50%) | 17 (57%) |
| Age (years) | 50-60 | 14 (23%) | 6 (20%) | 8 (27%) |
| | 61-70 | 32 (53%) | 17 (57%) | 15 (50%) |
| | 71-80 | 14 (24%) | 7 (23%) | 7 (23%) |
| Education Level | High School | 32 (53%) | 15 (50%) | 17 (57%) |
| | Undergraduate | 28 (47%) | 15 (50%) | 13 (43%) |
| Employment | Retired | 48 (80%) | 25 (83%) | 23 (77%) |
| | Employed | 12 (20%) | 5 (17%) | 7 (23%) |

p-value between control group and intervention group > 0.05 ( 1.0)

### Blood Glucose Level

The reduction in fasting blood glucose showed significant difference between two groups (197.86 ± 54.14 mg/dL to 174.03 ± 44.32 mg/dL, p= 0.000) for SBT group, while the control group had no significant change (214.53 ± 25.53 mg/dL to 212.50 ± 24.99 mg/dL, p=0.312).

### Muscle Strength

Hand grip strength in the intervention group improved significantly (16.13 ± 5.94 to 18.59 ± 6.42 kg, p=0.000) but the control group had no significant difference (20.64 ± 7.40 kg to 20.63 ± 7.36 kg, p =0.884).

**Table II: Blood Glucose Level & Hand Grip Strength**

| Group | Measure | Baseline (Mean +SD) | Post Intervention 6 weeks (Mean +SD) | p value |
|---|---|---|---|---|
| Control group | Blood Glucose (mg/dL) | 214.53 ± 25.53 | 212.50 ± 24.9 | 0.31 |
| | Handgrip (Kg) | 20.64 ± 7.4 | 20.63 ± 7.36 | 0.884 |
| Intervention Group | Blood Glucose (mg/dL) | 197.86 ± 54.1 | 174.03 ± 44.32 | 0 |
| | Handgrip (Kg) | 16.13 ± 5.9 | 18.59 ±6.42 | 0 |

Footnote :
Control group : participant who only received standard diabetes management ; Intervention groups : participants who add on daily Specific Breathing technique ( SBT) for six weeks

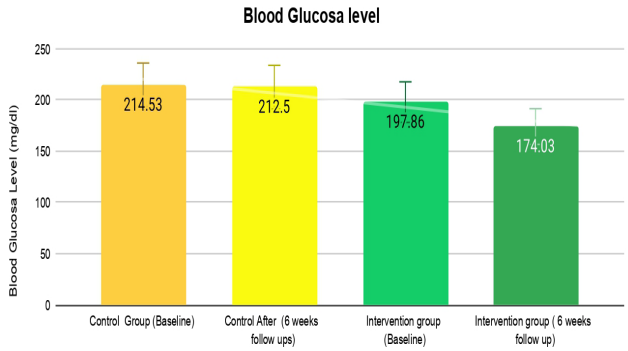


**Figure 1: Blood Glucose Level Diagram. No significant change in the control group but the intervention group had a significant decrease.**

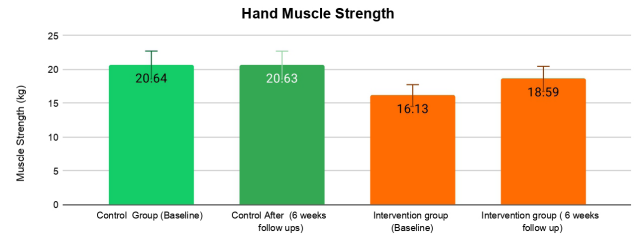


**Figure 2: Muscle strength ( handgrip) Diagram. No significant increase in the control group but while the intervention group had a significant increase.**

## DISCUSSION

This study provides evidence that Specific Breathing Techniques (SBT) for Vagal Nerve Stimulation (VNS) offers' a potential, non-invasive intervention to improve both glycaemic control and muscle strength in T2DM.

This study showed that SBT effectively stimulates the parasympathetic nervous system, enhancing insulin sensitivity and glucose metabolism. This study aligns with the previous study, which found that poor glycaemic control is linked to impaired sympathetic nerve activity, highlighting the importance of sympathovagal imbalance. SBT activates the peripheral branches of the vagus nerve (subdiaphragmatic), promoting insulin release and reducing hepatic glucose production through efferent signalling to pancreas or liver through specific neurons such as Npy2r and P2ry1, were found to innervate the majority of the airways, lungs and also detected in the stomach (13,15,17).
In addition, previous study found improvement in muscle strength, particularly hand grip strength. This result is aligned with studied who found that respiratory muscle training had a beneficial effect on the morphological characteristic and contractile of the diaphragm breathing, showed hypertrophy of IIa & IIb fiber types and diaphragmatic mass increased. (11) SBT in this study found that slow deep diaphragmatic breathing could reduce diaphragmatic metaboreflex hyperactivity, counteract the sympathetic vasoconstrictor activity and resulting increased perfusion in muscle skeletal and diminished the influence of respiratory fatigue (11). This enhanced oxygen delivery to muscles, particularly for diabetic patients who often experience muscle weakness due to chronic hyperglycemia, which may explain the observed improvement in muscle functions and strength (11,13,15).

This study result could improve patient outcomes. This study contributes the new insight of breathing exercises specifically focusing on non-invasive methods as a simple exercise and can be done by everyone even with limitations.

### Research Limitation

There are some limitations in this study, first the small sample sizes, the duration was limited to six weeks, which may not reflect the long-term effects on SBT of glycemic control and muscle strength. Additionally, confounding factors such as lifestyle habits such as occupations, exercises habits, daily meals, and stressor were not controlled, which may have influenced the outcomes. Furthermore, the study did not measure HbA1c, a more reliable marker for long-term blood glucose management, due to the short study period.

### Recommendation For Future research

Larger sample diversity should be included to increase the generalisability of these findings. Longer duration of the intervention period and including HbA1C as an outcome measure would provide further insight into long term effects of SBT. Additionally, exploring the effects in combination with different types of physical activity or dietary intervention could provide further insight to its efficacy.

## CONCLUSION

This study demonstrated SBT as non-invasive methods to maintain blood glucose and enhance muscle strength in patients type 2 DM. SBT could be used as an adjuvant therapy for those with limitations in physical activity. Further research is warranted to explore the long-term benefit of SBT in T2DM patients.

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**CONFLICT OF INTEREST STATEMENT**

The authors declare no conflict of interest.

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