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Moving in the right direction: Exploring the benefits of aerobic exercise in patients with recently elevated HbA1c levels

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ABSTRACT

Regular exercise is recognized as having health advantages for all individuals, including enhancements in glycemic control, insulin efficacy, cardiovascular fitness, systemic inflammation, diabetes-related health concerns, and mental well-being. This study aimed to explore aerobic exercise benefits on patients with recently elevated HbA1c levels. A parallel, randomized controlled trial was conducted. A total of 60 participants were assigned to one of the two groups: The aerobic exercise (AE) Group and the Control group. Assessment included HbA1c (glycosylated hemoglobin), post-prandial blood sugar (PPBS) as well as fasting blood sugar (FBS) at baseline (at 0 weeks before the training) and after the 12 weeks (post-training). The results showed that in 12 weeks, there was a statistically substantial difference in the two groups' mean values of HbA1c, PPBS, as well as FBS ($p<0.001$). Current research findings indicate that a 12-week protocol of aerobic exercise may serve as an essential therapeutic approach for achieving glycemic control in patients with recently elevated HbA1c levels.

KEYWORDS

Aerobic Exercise; Type 2 Diabetics; Glycemic Control; Glycosylated Haemoglobin; Fasting Blood Glucose

1. INTRODUCTION

Diabetes is a significant chronic illness impacting 422 million individuals worldwide and is responsible for 1.5 million deaths annually (Hossain et al., 2024). Diabetes is linked to premature mortality, primarily due to atherosclerotic vascular disease along with microvascular problems impacting small blood arteries in the eyes, kidneys, as well as nerves, resulting in significant morbidity (Jönsson, 2002; Almomani et al., 2023).

The Egyptian physician “Hesy-Ra” is noted for being the first to describe diabetes around 3000 BC. However, it was the Upper Egyptian Ebers Papyrus, dating back to 1550 BC, that provided a more detailed account, referring to the condition as “plentiful urine” (see issue cover). In today's world, diabetes remains a pressing public health issue that imposes a considerable strain on the Egyptian economy. Individuals diagnosed with type 2 diabetes (T2D) account for around 90%-95% of the global diabetes population and signify an escalating epidemic (Hegazi et al., 2015).

In Egypt, approximately 15.56% of adults aged 20 to 79 are affected by diabetes, resulting in an annual mortality of 86,478 linked to the condition. In 2013, the International Diabetes Federation (IDF) estimated that 7.5 million individuals in Egypt have diabetes, with approximately 2.2 million having pre-diabetes. Additionally, reports suggest that 43% of patients with diabetes and the majority of individuals with pre-diabetes in Egypt may remain undiagnosed (Whiting et al., 2011; International Diabetes Federation, 2013). Cost researchers projected that the economic impact of T2D in Egypt amounted to $1.29 billion in 2010. This figure omits expenses linked to pre-diabetes and costs associated with diminished productivity. This inflation-adjusted value will be doubled by 2030. Given the rapidly increasing population, the health authorities in Egypt must promptly handle this issue to prevent substantial healthcare expenditures in the forthcoming years (Hegazi et al., 2015).

The uncontrollable risk factors for diabetes include familial history, race or ethnicity, as well as gestational diabetes. Obesity, physical inactivity, cholesterol levels, hypertension, alcohol consumption, smoking, dietary habits, in addition stress are all modifiable factors (American Heart Association, 2023; Al-Tamimi et al., 2024).

WHO defines physical activity as any movement produced by skeletal muscles that requires the consumption of energy, such as during leisure time, travel to and from locations, or work-related activities (WHO, 2022).

Exercise is a fundamental aspect of diabetes management; it continues to be significantly underutilized. The health benefits are well-documented and encompass enhancements in glycemic control, insulin sensitivity, cardiovascular fitness, systemic inflammation, complications related to diabetes, as well as mental well-being for nearly all individuals. Due to its beneficial effects on health, it is essential for practitioners to advocate for nearly all diabetic and prediabetic patients to engage in and maintain a routine of regular physical activity. Guidelines for physical activity are essential for the proper management of patients with diabetes (Colberg, 2008).

Because of their well-documented benefits on insulin sensitivity and glucose tolerance, aerobic activities have long been recommended for people with type 2 diabetes. It is estimated that only approximately 28% of people with type 2 diabetes adhere to these recommendations (Eves & Plotnikoff, 2006). Type 2 diabetics have a lower capillary density, a lower proportion of type I fibers, and an increased amount of type IIb fibers in their muscles. Aerobic capacity tolerance is also affected by this abnormality in muscle fiber composition (Colberg et al., 2010).

Physical activity has been shown to have beneficial advantages in lowering HbA1c levels, however, just a few research have identified the best exercise recommendations. This study aims to assess the impact of aerobic activities on enhancing glycemic control among patients with recently raised HbA1c levels.

2. METHODS

2.1. Participants

This study was a parallel, randomized, controlled trial. Sixty individuals were recruited from the National Heart Institute in Cairo, Egypt. All individuals submitted their written informed consent to participate in the study. The study obtained approval from the Ethics Committee of Cairo University, reference number P.T.REC/012/005097, and was conducted from March to October

2024. The inclusion criteria were: a diagnosis of type 2 diabetes for under 6 months, a sedentary lifestyle, no engagement in strength training in the preceding year, absence of current insulin use, and an age range of 25 to 45 years. Subjects with advanced retinopathy or neuropathy, uncontrolled hypertension, severe orthopedic, cardiovascular, or respiratory conditions that limit physical activity, pregnant individuals, and those with subjective or objective evidence of coronary artery disease were excluded from the study. All other individuals were found to be eligible after medical screening.

2.2. Randomization

Every patient completed an informed consent form after receiving information about the study's nature, goal, and benefits. They were also informed about their right to decline or withdraw at any time and about the confidentiality of the collected information. All information was encrypted to safeguard people's privacy.

Using sealed randomization block envelopes (blocks of six stratified by gender), a physical therapist, who is not informed of the study's hypothesis, divides patients into two groups after a physician's clinical evaluation and diagnosis: the Aerobic Exercise (AE) Group and the Control Group. Each group consists of 20 subjects. Therapy sessions for patients were also scheduled by him. An impartial research assistant built the randomization blocks.

2.3. Exercise Training Protocols

2.3.1. Aerobic exercise training (AET) group

Thirty patients engaged in supervised aerobic exercise training in conjunction with their medications for a duration of 12 weeks, utilizing cycle ergometers (Daum® fitness 3, Furth, Germany) 3 days in a week that are not consecutive.

Each session commenced with a 5-minute warm-up, succeeded by 60 minutes of cycling and finished with a 5-minute cool-down. Exercise intensity as well as training heart rate reserve (HRR) were derived from the Karvonen-Formula in which target HR = [(maximum HR−resting) % intensity] +resting HR, where maximum HR = 220−age (Burgomaster et al., 2007). The training program was developed in alignment with the American College of Sports Medicine (ACSM) guidelines that was implemented from July 2014 to November 2014. The participants were instructed to sustain their perceived effort level between 13 and 14 on Borg's scale. All 60 individuals demonstrated improved adherence and consented to finish the training programs. No significant negative impact was detected.

2.3.2. Control group

Thirty patients were not provided with any training; however, they continued to take their medications.

2.4. Parameters

HbA1c (glycosylated hemoglobin), post-prandial blood sugar (PPBS), as well as FBS evaluated upon commencing (at 0 weeks before the training) and after the 12 weeks (post-training). The HbA1c level was assessed utilizing the Nyco Card HbA1c test (NycoCard reader II, Axis Shield PoC, manufactured in Norway). FBG was measured using a glucometer (Elegance C.T.X-12).

2.5. Sample Size Calculation

A preliminary power analysis was carried out using G*Power 3.1.9.2 software to mitigate the risk of a type II error, employing the following parameters: power (1−α error P) = 0.95, α = 0.05, and effect size = 1.187. The analysis involved a sample size of 50 participants, divided into two groups of 25 each. In this calculation, we utilized HbA1as the principal outcome measure in a pilot study involving 14 subjects.

2.6. Statistical Analysis

Findings are presented as group mean ± standard deviation. The preliminary baseline measures were evaluated using an unpaired t-test to identify differences among the groups prior to intervention. The post-training changes were analyzed among groups using a paired t-test. Statistical analyses were conducted utilizing SPSS Software (SPSS 25). The change in outcomes from pre-study to post-study is statistically significant at the $p<0.05$ level.

3. RESULTS

Participants in the study included sixty individuals having type 2 diabetes. Following randomization, the study group comprised 30 people, while the control group also consisted of 30 participants. The control group with a mean age of 35±9.1 yr, while the study group with a mean age of 34±9.7 yr. The mean duration of T2DM (in months) for the control group was 5.2±0.77, while for the study group it was 4.8±0.6. The HbA1c level in the control group was 7.30±1.2, while in the study group, it was 7.19±3. Nonetheless, there was no substantial difference among the control group and the study group concerning all characteristics that could influence the findings of our study, including age, height, body weight, BMI, average duration of diabetes, as well as HbA1c levels (Table 1).

Table 1. Patients' demographic data in the control and study groups

Physical characteristic	Control group Mean±SD (n=30)	Study group Mean±SD (n=30)	t -value	p-value
Age (year)	35±9.1	34±9.7	0.411	0.68
Height (cm)	164±5.9	165±7.5	0.53	0.64
Body weight (Kg)	60±5.7	59±6.4	0.93	0.37
BMI(Kg/m^2)	23±2.9	24±3.4	1.73	0.085
Average duration of diabetes (month)	5.4±0.80	5.8±0.84	1.92	0.08
HbA1c	7.30±1.2	7.19±.1.3	0.48	0.63

The analysis of the mean values for HbA1c, PPBS, as well as FBS at baseline indicated no substantial difference among the study as well as control groups as presented in Table 2.

Table 2. Baseline values of the study and control groups

Variables	Control group Mean±SD (n=30)	Study group Mean±SD (n=30)	t -value	p-value
HbA1c	7.30±1.2	7.19±.1.3	0.48	0.63
FBS	138 ±41	142±48	0.34	0.72
PPBS	219±40	216±42	0.21	0.83

Table 3 presents the comparison of mean values for HbA1c, PPBS, as well as FBS between the study as well as control groups at the eighth week. The comparison of the two groups revealed a statistically substantial difference in the mean HbA1c value at the eighth week ($p<0.001$). The mean HbA1c exhibited a reduction of 0.76 percent in the study group, while there was no substantial difference in PPBS as well as FBS among the two groups.

Table 3. Values for the study and control groups after 12 weeks

Variables	Control group Mean±SD (n=30)	Study group Mean±SD (n=30)	t -value	p-value
HbA1c	6.03±1.46	5.1±1.6	3.62	0.0005
FBS	126±20	116±23	3.47	0.009
PPBS	202±33	180±29	3.92	0.002

4. DISCUSSION

Diabetes constitutes a major health concern impacting a substantial population worldwide, with its incidence anticipated to rise over the next decade (Sun et al., 2022). Understanding the link along with the mechanisms among physically aerobic activities as well as levels of HbA1c will enable us to investigate the possibility of exercising as a method for lowering HbA1c levels in addition managing diabetes non-pharmacologically. The impact of aerobic exercise on HbA1c levels was analyzed in relation to resistance training.

A prior meta-analysis of 12 trials involving individuals with T2DM assessed the changes in HbA1c levels resulting from aerobic training contrasted with strength training, revealing some variability in the outcomes (Yang et al., 2014). In a clinical setting, T2DM typically manifests with inadequate glycemic control, elevating both mortality and morbidity risk within the population. Elevated HbA1c levels are linked to a heightened risk of developing diabetic peripheral neuropathy which may also increase the likelihood of progressing to diabetic nephropathy as well as retinopathy over time (Stratton et al., 2000).

The current study demonstrated that aerobic exercise, in conjunction with standard care, produced an anti-glycation effect, leading to a significant decline in HBA1c levels within the study group. HbA1c levels that are elevated are associated with a higher probability of lower extremity amputation among individuals having type 2 diabetes (Adler et al., 2010). Every percentage point increase in HbA1c corresponds too much greater risks of lower extremity amputation (Adler et al., 1999). A 10-year prospective study identified peripheral neuropathy as an independent predictor of lower extremity amputation among individuals having type 2 diabetes (Adler et al., 1999).

There is a risk of hypoglycemia-related anxiety with the increased usage of intensive therapy (many injections of insulin), which hinders the efficacy of existing diabetic drugs in attaining and maintaining optimal glycemic control (Adler et al., 2010; Ismail-Beigi et al., 2010). On the other side, exercise, when used wisely in conjunction with conventional treatment, may reduce the likelihood of hypoglycemia, which may help patients achieve enhanced glucose control for extended periods and, in turn, reduce the risk of complications in T2DM.

Through mechanisms unrelated to insulin, aerobic exercise multiplies the rate of glucose absorption in muscle tissue by a factor of five. When you work out for a long time, your muscles replenish their glycogen stores, which means that insulin-dependent mechanisms can keep glucose absorption going for up to 48 hours after exercise, while insulin-independent processes can keep it going for about 2 hours. Short bursts of activity (approximately 20 minutes) at an intensity level occasionally raised to near-maximal effort may increase insulin effectiveness for up to 24 hours (Sheri et al., 2021).

The Look Action for Health in Diabetes (AHEAD) trial was the most extensive randomized study assessing a lifestyle intervention in older persons having type 2 diabetes, in contrast to a diabetes support and education control group. The rigorous lifestyle intervention group aimed for a weight reduction of at least 7% by implementing a moderate dietary energy deficit and a minimum of 175 minutes per week of unsupervised exercise (Wing et al., 2013).

Our findings align with those of Shah et al. A 2021 analysis indicated that aerobic exercise is crucial for optimizing blood glucose levels and facilitating anthropometric modifications. Various forms of aerobic training are beneficial for persons having type 2 diabetes mellitus. Moderate Intensity Continuous exercise markedly enhances HbA1c, BMI, as well as body composition while facilitating weight reduction. Supervised organized aerobic exercise program significantly decreases BMI, FBG, as well as HbA1c levels (Shah et al., 2021).

Aerobic exercise should be a weekly routine for people who have diabetes. Aerobic exercise sessions should ideally endure a minimum of 10 minutes, aiming for approximately 30 minutes per day or more, on most days of the week for persons with type 2 diabetes. Regular exercise, or ensuring no more than two days pass between sessions, is advised to reduce insulin resistance, irrespective of diabetes type (Tonoli et al., 2012; Jelleyman et al., 2015).

The majority of the literature regarding the impact of exercise on glycemic parameters in type 2 diabetes has focused on interventions that include aerobic exercise. Aerobic exercise involves sustained, rhythmic activity engaging large muscle groups, exemplified by walking, jogging, and cycling. The latest guidelines from the American Diabetes Association (ADA) recommend that individual sessions of aerobic activity should ideally last a minimum of 30 minutes per day as well be conducted 3 to 7 days a week. Engaging in moderate to vigorous aerobic exercise training (65%–90% of MHR) enhances VO2 max cardiac output, leading to a substantial reduction in cardiovascular as well as overall mortality risk for those diagnosed with type 2 diabetes (Kirwan et al., 2017).

Improved cardiac output, pulmonary function, insulin sensitivity, oxidative enzyme activity, vascular responsiveness and compliance, and mitochondrial density are all outcomes of aerobic exercise (Garber et al., 2011). Moderate to high levels of aerobic exercise are linked to significantly reduced cardiovascular as well as overall mortality risks in individuals with type 1 in addition type 2 diabetes (Sluik et al., 2012).

Among individuals suffering from type 2 diabetes, regular exercise leads to reductions in A1C levels, triglycerides, blood pressure, as well as insulin resistance (Snowling & Hopkins, 2006).

Recent research indicates that a 12-week program of aerobic exercise may be essential for attaining glycemic control in patients with recently high HbA1c levels. This demonstrates the possible benefit of integrating these training methods into diabetes management without the necessity of medication.

5. CONCLUSIONS

In conclusion, this study highlights the significant impact of a 12-week aerobic exercise program on glycemic control in patients with recently elevated HbA1c levels. The findings demonstrate that regular aerobic exercise effectively reduces HbA1c, post-prandial blood sugar, and fasting blood glucose, reinforcing its role as a non-pharmacological therapeutic approach for diabetes management. Given the increasing prevalence of type 2 diabetes, incorporating structured exercise programs into routine care can offer substantial health benefits. Future research should explore long-term adherence and the potential integration of aerobic training with other lifestyle modifications.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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