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The effect of exercise training at different intensities on blood glucose regulation and cardiorespiratory fitness in patients with Type 2 Diabetes: a randomized controlled trial

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Abstract

Diabetes mellitus is a major global health concern affecting nearly 382 million people worldwide. Physical activity has long been regarded as the "gold standard" in treating type 2 diabetes. Nonetheless, the diabetes population has a low prevalence of physical activity. **Aim:** the present study aims to investigate the effects of low and high-intensity interval training on blood glucose levels and cardiorespiratory fitness in patients with type 2 diabetes. **Methodology**: a prospective randomized controlled trial with two intervention groups was applied. Participants (n=100; age, height, weight) with type 2 diabetes were recruited and randomly divided into two intervention groups: high-intensity interval training (HIIT) or low-intensity interval training (LIIT). HIIT and LIIT pre and post-test assessments. The study was a follow-up clinic at a regional medical Centre in Soran City\ Erbil, Iraq. They were aged between 50 and 55 years and had been diagnosed with type 2 diabetes. **Results**: HIIT and LIIT seems to have a more significant impact on blood sugar and the cardiorespiratory system. **Conclusion**: HIIT and LIIT benefit heart rate and FEV1 for type 2 diabetic patients.

Keywords: blood glucose, training intensity, cardiorespiratory fitness, type 2 diabetes.

Introduction

There is a growing awareness of the function of physical activity in improving both physical and body health. The majority of studies to date indicate that exercise can significantly enhance physiological variables such as blood sugar and cardiovascular fitness (Rosenbaum et al., 2014; Scheewe et al., 2013).

High and low-intensity interval training (HIIT, LIIT) is a type of physical activity in which brief bursts of vigorous activity are combined with rest periods or low-intensity exercise. HIIT and LIIT are infinitely changeable, with the physiological adaptations caused by this type of training governed by many variables, including the precise nature of the exercise stimulus (Hurst et al., 2019).

However, when compared to regular endurance training on a matched-work basis or when estimated energy expenditure is identical, HIIT can induce equal or even better improvements in various physiological, performance, and health-related variables for futsal players (Gibala et al., 2012).

Low-volume, HIIT is becoming a time-efficient exercise for general population health and fitness improvement. According to the researchers, HIIT increases oxygen absorption, muscle deoxygenation, and improved exercise performance compared to low-intensity continuous endurance training (Jacobs et al., 2013; McKay et al., 2009). In addition, HIIT has been shown to help increase cardiorespiratory fitness, blood sugar management, fat reduction, and blood pressure management (Byrd et al., 2019; Finn, 1996).

Several studies have noticed that interval training may pose physical and physiological hazards, eliciting an avoidant reaction and retreat. Additionally, HIIT requires participants to exercise self-discipline and self-regulation to achieve the appropriate degree of intensity (Hardcastle et al., 2014; Viana et al., 2018). Therefore, the study aims to compare between HIIT and LIIT, which affects blood glucose regulation levels. The researcher's decision to study, understand, and compare both types of interval training on the impact of blood glucose regulation levels and cardiorespiratory in type 2 diabetes was due to the knowledge that the training types are essential for the physiological variables.

Methods and procedures

Participants

One hundred patients presenting a follow-up clinic at a regional medical Centre in Soran City\ Erbil-Iraq, were referred by medical professionals and volunteered to participate in this study. They were aged 50-55 years and had been diagnosed with type 2 diabetes (blood glucose level 180ml.mol) for over a year with a specialist doctor. Patients were included if they met the global initiative for diabetes guidelines for type 2 diabetes, such as classification based on medical history, diagnosis, and physical examination (Clinical Guidelines Task Force Global Guideline for Type 2 Diabetes, 2012). Participants were only accepted into the study if they were in a clinically stable condition, had no history of infections or worsening diabetes symptoms, and had made no medication changes in the two months preceding the study's start date. The study was approved by the Institutional Review Board (IRB) of the Soran University in Iraq (date of approval on the third of November, 2021). All experimental procedures regarding testing, lower and upper torso training by devices were carefully explained to the participants, and written informed consent from participants who met the inclusion criteria was obtained before the beginning of the experiment. Table 1 shows the baseline characteristics of the study population.

Table 1. Baseline characteristics of the study population.

Variables	Mean	SD
Age, yr	53.2	6.1
Weight, kg	68.1	8.2
High, cm	175.3	11.6
Blood sugar test	185.4	12.8
FEV1, % of predicted	80.2	9.3
Heart rate at rest	80.5	9.4

Experimental design

The researchers used an experimental research design. The study was a prospective randomized controlled trial with two groups that compared the high and low interval intensity training. The study sample was recruited and randomly divided into two intervention groups (HIIT n=50, LIIT n=50). Pre- and post-test assessments were all conducted by the researchers, who had a special training certificate. Thus, the researcher is familiar with the physiology of cardiorespiratory, respiratory muscle work, and blood sugar tests.

Measurement Procedures

Outcome Measures

1. Blood Sugar Test

Normal blood sugar levels are less than 120 mg/dL (7.8 mmol/L). After two hours, a blood sugar level of more than 200 mg/dL (11.1 mmol/L) indicates diabetes. A blood sugar level of 130 to 199 mg/dL (7.8 mmol/L to 11.0 mmol/L) indicates prediabetes. Our participants have done the measurement after effort.

2. Lung function measurements

Forced expiratory volume in one second (FEV1) was used to assess lung function. A spirometer (as used by Burt et al., 1995). After the three acceptable Forced vital capacity (FVC) manoeuvres, all values of FVC, FEV1, and the ratio of FEV1 to FVC was measured. The spirometer is a basic test that is used to diagnose airway blockage. However, the variability of spirometry measures is greater than that of most other clinical laboratory tests since the outcome is greatly dependent on the consistency of patient and technician efforts (Crapo, 1994). In addition, each subject will be tested according to the criteria of the American Thoracic Society, which recommends the use of FEV1 to diagnose the severity of airway obstruction to detect lung function (Balmes et al., 2003).

3. Heart Rate Measurement

Resting heart rate (HR) is frequently used to assess cardiorespiratory fitness. Cardiorespiratory fitness is inversely associated with resting heart rate in adults, according to cross-sectional research. Aerobic training lowered resting heart rate in untrained men and women regardless of age (41 or 41-60 years) or duration of the intervention (3, 4-6, or > 6 months). Although this link may be ascribed to increased resting cardiac vagal activity, electrophysiologic alterations intrinsic to the sinus node may also occur in many physically conditioned individuals.

A heart rate monitor (HRM) is a personal monitoring device that allows you to measure and display your heart rate in real-time and record it for later analysis. It is mostly used to collect resting heart rate data (Quintana et al., 2012).

Low and High-intensity interval training procedure

Participants attended a 1-h familiarization session where the specific training protocol was instructed and the necessary training equipment and exercise adherence diary distributed. Exercise training is performed on an outpatient basis. All sessions started with ergometer cycling. In the LIIT experimental group, the target training intensity was 50-70% HRmax, whereas in the HIIT experimental group, the target training intensity was 75-85% HRmax. The intervals in LIIT were 5 min, while 3 min. Total cycle time was 40 min, each session allowed for five "uphills", separated by four "downhills" and warming up before and cooling down afterwards. Exercise load kept as high as tolerated at all times, above the target values when possible.

Moreover, training programs used different exercises for upper and lower limb, i.e. jumping, running, jogging, arm and leg movements, flexibility exercises for thorax, neck, shoulders, arms, and legs, as well as the abdominal muscles (20 repetitions, 3 sets, at about 50-70% of 1 RM), (8 repeats, 4 sets, at about 75-85% of 1 RM) sessions. All patients scored their measurements before and after an intervention. After cycling, the session proceeded twice a week with callisthenics and relaxation and once a week with resistance training.

Statistical Analysis

Data was entered in the SPSS software, and the results were analyzed using an independent and dependent sample test (T-test).

Results and discussion

Table 2. Mean, SD, T-test, signal, and Significant of Pre and post-tests for Group 1.

Variables	Pre-test		Post-test		T-test		Significant
	Mean	SD	Mean	SD	Accountable	Signal	
Blood sugar test	183.17	11.33	145.21	8.45	4.03	0.005	S
FEV1, % of predicted	80.00	6.05	90.52	7.71	3.13	0.000	S
Heart rate at rest	83.2	6.16	73.24	5.81	3.07	0.000	S

Size of the study population (49), and significant level (0.05).

Table 2 shows there is a significant difference between the two tests, pre and post, at the error rate (5%) and the degree of freedom (49) in measuring blood sugar test, FEV1, and heart rate at rest, where the value of calculated T in all tests is (4.03, 3.13, 3.07) which is bigger than the value of T tabular (2.05) and this means there is improvement in all study tests for the group 1.

Table 3. Mean, SD, T-test, signal, and Significant of Pre and post-tests for Group 2

Variables	Pre-test		Post-test		T-test		Significant
	Mean	SD	Mean	SD	Accountable	Signal	
Blood sugar test	182.23	10.12	144.67	8.67	3.63	0.000	S
FEV1, % of predicted	82.13	6.85	89.44	7.83	3.68	0.000	S
Heart rate at rest	82.86	6.90	74.35	5.95	3.81	0.000	S

Size of the study population (49), and significant level (0.05).

Table 3 shows there is a significant difference between the two tests pre and post at the error rate (5%) and the degree of freedom (49) in measuring blood sugar test, FEV1, and heart rate at rest, where the value of calculated T in all tests is (3.63, 3.68, 3.81) which is bigger than the value of T tabular (2.05) and this means there is improvement in all study tests for the group 2.

Table 4. shows the mean, SD, T-test, signal, and significance of post-tests for both groups.

Variables	Group 1		Group 2		T-test		Significant
	Mean	SD	Mean	SD	Accountable	Signal	
Blood sugar test	145.21	8.45	144.67	8.67	1.68	0.07	No S
FEV1, % of predicted	90.52	7.71	89.44	7.83	1.70	0.09	No S
Heart rate at rest	73.24	5.81	74.35	5.95	1.73	0.08	No S

Size of the study population (98), and significant level (0.01).

Table 4 shows there is no significant difference between the two groups in post-tests at the error rate (1%) and the degree of freedom (98) in measuring blood sugar test, FEV1, and heart rate at rest, where the value of calculated T in all tests is (1.68, 1.70, 173) which is bigger than the value of T tabular (1.57) and this means there is no significant between two groups in all study tests.

Endurance and strength exercise performance has been reduced with diabetes type 2 (O'Connor et al., 2012; Wilkerson et al., 2011). Furthermore, in type 2 diabetes patients, a higher resting heart rate is associated with an increased risk of cardiorespiratory problems and early mortality (Hillis et al., 2012). Furthermore, according to a recent study published in Diabetes Care, people with type 2 diabetes are 54% more likely to have pulmonary fibrosis, 22% more likely to have a chronic obstructive pulmonary disease, 8% more likely to have asthma, and nearly twice as likely to be hospitalized for pneumonia (Ottaviano et al., 2020). However, exercises with low and high-intensity interval training (aerobic and anaerobic training) can be used to treat patients with diabetes type 2.

Diabetic individuals can safely do aerobic and anaerobic training involving large muscle groups with low and high-intensity intervals. As a result, this training group commonly includes low-intensity interval training aerobic exercises such as walking, jogging, and cycling (Thent et al., 2013; Zhang et al., 2013). Anaerobic exercises that use high-intensity interval training develop muscle strength and power by adjusting resistance intensity from 75% to 90% of 1-repetition maximum (Adams, 2013).

The current study found that both groups improved on all tests (blood sugar, FEV1, per cent of predicted, and heart rate at rest). However, both high and low-intensity interval training resulted in similar gains. A new study found that high-intensity interval training can enhance blood sugar and cardiorespiratory health in type 2 diabetic patients (Francois & Little, 2015). On the other hand, other studies found that low cardiorespiratory fitness is a well-known risk factor for chronic diseases such as type 2 diabetes and a key predictor of mortality in diabetes patients (Church et al., 2004; Paffenarger & Lee, 1996; Wei et al., 2000).

According to Terada et al. (2013), HIIT also provided superior acute blood sugar reductions compared to low-intensity interval exercise, as measured by arm vein samples obtained before and after each training session throughout a 12-week training program. According to Roberts et al. (2013), HIIT boosts blood sugar levels, which leads to the recruitment of more muscle fibers and the rapid depletion of muscle glycogen stores. Thus, high and low-intensity interval training may be an effective strategy for significantly improving sugar control over the long term by stimulating a more significant increase in post-exercise muscle insulin sensitivity, which lasts for 24-48 hours after a single bout of exercise. Furthermore, high and low-intensity interval training may be an effective strategy for significantly improving sugar control over the long term. In addition, HIIT and LIIT performed over a more extended period (e.g., 12–16 weeks) may enhance lower-body muscle mass (Gillen et al., 2013) and have the added benefit of decreasing abdominal adipose tissue (Boutcher, 2011).

Heart rate and FEV1 have improved following high and low-intensity interval training; Andrade et al. (2020) confirmed that HIIT and LIIT improve heart rate and pulmonary function, whereas Parpa et al. (2009) discovered that training with HIIT and LIIT for 12 weeks leads to significant improvements in resting heart rate and fasting glucose values.

Conclusion

High-intensity interval training and low-intensity interval training both improve heart rate and FEV1 in type 2 diabetics. The type of activity chosen to treat diabetes should be suited to the patient's clinical profile. Further studies are needed to assess continued exercises on blood sugar levels in type 1 diabetes.

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