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"Effect of Low Intensity Resistance Training on Blood Glucose Level in Prediabetics."

Dr. Bhagyashri Sonawadekar (PT)
Assistant Professor, Department of Physiotherapy.
Tilak Maharashtra Vidyapeeth, Pune-37
Email: bhagyashreedeore16@gmail.com

Abstract
Background
Prediabetes is a condition where blood sugar levels are higher than normal but not yet high enough to be classified as diabetes. The aim of treating prediabetes is to keep blood sugar, blood pressure, and cholesterol levels within healthy ranges to prevent or delay the onset of diabetes. Physical activity is important in helping the body manage glucose and use insulin more effectively, even without changes in insulin levels. Therefore, it's not clear what level of low-intensity resistance training is most effective in improving insulin sensitivity. This study aims to find out if low-intensity resistance training can help lower blood sugar levels in people with prediabetes. The main goal of this study is to see how low-intensity resistance training affects fasting blood sugar levels in individuals with prediabetes. The process began with identifying potential participants. Those who met the study's requirements were selected. Fasting blood sugar levels were measured, and only participants with levels between 100 mg/dL and 125 mg/dL were included. A total of 30 participants met the criteria and were informed about the study. The training intensity was set between 20% to 30% of the target heart rate, calculated using the Karvonen formula. The program lasted for six weeks. All participants performed resistance training at 50% of their one-repetition maximum (1RM). Each session started with a 5-minute warm-up, followed by six exercises: leg extension, leg press, chest fly, pull-down, biceps curl, and triceps curl. Each exercise was done with 8 repetitions using dumbbells, and there was a 2-minute rest between exercises. Participants trained three times a week for six weeks. The results showed that low-intensity resistance training had a significant effect on fasting blood sugar levels in individuals with prediabetes. The study also concluded that low-intensity resistance training can improve blood sugar levels and enhance muscle strength.

Keywords
Prediabetes, fasting blood glucose level, resistance training, low intensity, target heart rate.

Introduction
Prediabetes is a condition where blood sugar levels are higher than normal but not yet at the diabetes level. Individuals with type 2 diabetes often go through a stage called prediabetes, which is marked by impaired glucose tolerance or impaired fasting glucose. Prediabetes can increase the risk of several health issues including heart disease, stroke, blindness, kidney failure, foot problems, and gum disease, which can seriously impact quality of life.

The World Health Organization (WHO) predicts that India is likely to have the highest increase in diabetes cases by 2030. The International Diabetes Federation (IDF) estimates that about 40.9 million people in India currently have diabetes, and this number is expected to increase to 69.9 million by 2025. According to the National Urban Diabetes Survey, diabetes and prediabetes prevalence rates are approximately 12.1% and 14%, respectively. Prediabetes includes diagnostic categories like impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT), which represents a range of blood sugar levels and a stage between normal glucose tolerance and full type 2 diabetes. Insulin resistance and issues with glucose sensing in the beta cells are the main causes of elevated blood sugar levels.

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The WHO defines prediabetes as having intermediate hyperglycemia, which includes IFG (fasting plasma glucose between 6.1 to 6.9 mmol/L or 110 to 125 mg/dL) and IGT (2-hour plasma glucose between 7.8 to 11.0 mmol/L or 140 to 200 mg/dL after a 75 g oral glucose load, or both conditions using an oral glucose tolerance test). Similarly, the American Diabetes Association (ADA) uses the same range for IGT but has a lower cutoff for IFG (100 to 125 mg/dL) and also uses hemoglobin A1c measurements between 5.7% and 6.4% to define prediabetes.

The treatment goals for people with prediabetes are to achieve and maintain optimal blood sugar, blood pressure, and cholesterol levels to prevent or delay the onset of diabetes. Exercise, along with diet and weight management, is essential for preventing and managing diabetes. Exercise helps in managing blood sugar, blood pressure, and cholesterol levels and also supports long-term weight maintenance. There are two main types of exercise: aerobic and resistance. Aerobic exercise uses large muscle groups for long periods, typically involving many repetitions, and is limited by the body's ability to deliver oxygen to the muscles. Resistance exercise involves moving a weight or resistance, with fewer repetitions, and is done with machines or free weights. It has been observed that aerobic exercise improves insulin action, helps the pancreas function better, and can slow the progression from prediabetes to type 2 diabetes.

Several studies have found that resistance exercise increases glucose uptake and muscle glycogen resynthesis. It is theorized that resistance exercise can improve glucose metabolism in people with prediabetes. Eriksson et al (1997) and Honkola et al (1997) showed that circuit resistance training improved long-term glycemic control (as measured by glycosylated hemoglobin). A study by Durak et al (1990) found that resistance training improved blood glucose control in individuals with type 1 diabetes. Other studies found that resistance training lowered the insulin response to glucose in normal individuals (Hurley et al., 1988; Miller et al., 1984). This suggests that resistance exercise can also be beneficial for people with prediabetes. Thus, it is still not clear what level of resistance exercise is most effective in improving insulin sensitivity.

Need Of The Study

Prediabetic cases are sedentary and along with increased blood glucose position have redundant adipose mass in visceral region within cadaverous muscle and in liver and have increased cardiovascular threat profile like hypertension.
Studies have delved the relationship between physical exertion and insulin situations unequivocally demonstrate that high situations of sedentary time, low situations of diurnal movement, and little moderate to vigorous physical exertion are associated with poor glycemic control. Insulin resistance is anabecedarian trait of both IFG and IGT, and the inverse relationship between physical exertion and insulin resistance is unstintingly proved in both healthy individualities and those withpre-diabetes. therefore, early life intervention in those withpre-diabetes may represent a window of occasion for health enhancement before the unrecoverable goods of diabetes set in.
Numerous former studies proved that, acute goods of resistance training program in type 2 diabetes and diabetes related cardiovascular complications but the demonstration on the long- term goods of resistance training in prediabetes is no way carried out.
Several studies have successfully examined the cure- response relationship between volume and intensity on insulin perceptivity and fasting blood glucose (10) but no references are available regarding low intensity resistance training to reduce the blood glucose position.
Hence the need for study is to determine the effective of low intensity resistance training on blood glucose position of Prediabetics.

Aims And Objectives

- To determine the effect of low intensity resistance training on fasting blood glucose level in Prediabetics.

Materials And Methods

Study Design

- Type of study design: Interventional study
- Setting (location of study): Various clinics
- Duration of the study: 6Months

Sample Design

- Sample size: 30
- Sample population: 30-45 years of Prediabetics patient.
- Type of sampling: Simple random sampling (by Alternate Allocation)

Inclusion criteria:

- 30-45 years age(12)
- Male and female
- Diagnosed Prediabetes within 144hours (13)
- Fasting Blood glucose level: 100-125mg/dL (6)

Exclusion criteria:

- Current Insulin therapy
- Hypertensive
- Any Neurological, Musculoskeletal and any other Endocrinological disorder.
- Exercise regularly

Materials

- Pen
- Paper
- Dumbbells
- Chair
- Foam mattress

Methodology

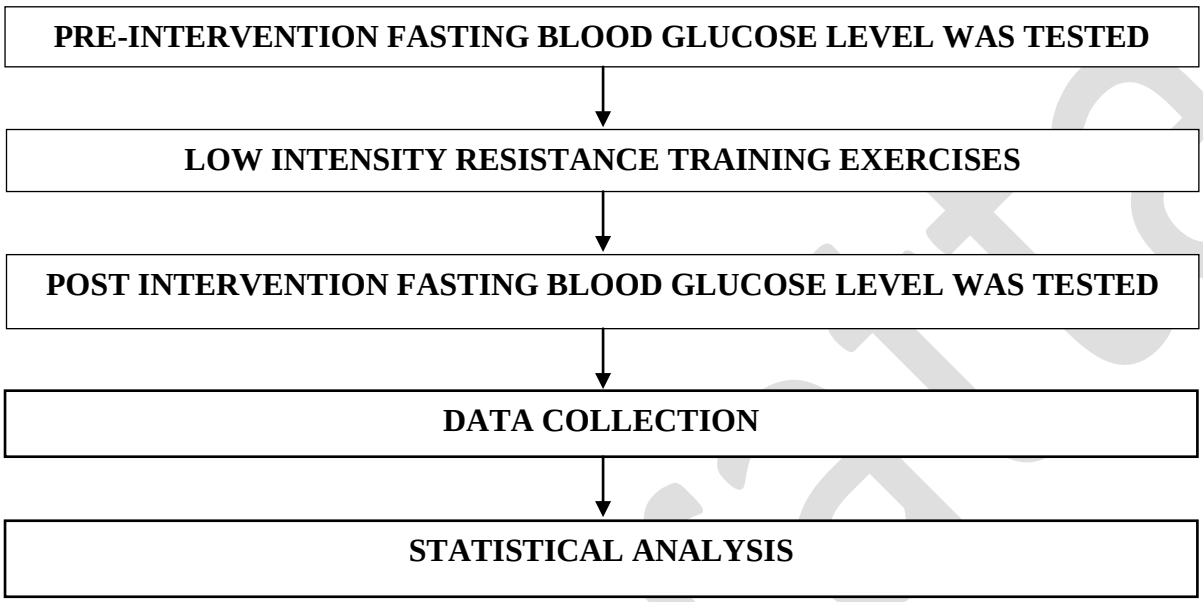
Ethical clearance was obtained from the Institutional ethical committee. Consent was obtained from the diabetic clinics where study was supposed to be carried out. Pre evaluation of the subjects was done. The pre intervened fasting blood glucose level from 100mg/dL to 125mg/dL on all the selected subject were noted. As the recruited subjects satisfied all the study criteria, they were included in the study. Accordingly, 30 subjects were recruited for the study on the basis of inclusion criteria and briefed about the same. Later, a written consent was obtained from the participant in the study. Sampling of the subjects was done by simple random sampling.
The intervention period for participants was for 6 weeks.

Exercises prescription

- **Warm-up -** 5-min with six chair stands and a 1-min brisk walk around the exercise facility (14)
- **Types of exercises** (15):
    - Biceps curl,
    - Triceps curl,
    - Leg extension,
    - Leg press,
    - Chest fly,
    - Pull-down,

- **Cool-down** -5-min with flexibility and stretching exercises(14)
  Frequency: thrice a week for 6 weeks(16)
  8 repetitions of each resistance exercises (16)
  Rest interval: 2 minutes (16)
  Dumbbells were used for resistance training (16)

Procedure



Outcome Measure

Fasting blood glucose level:
The fasting blood glucose level was checked, pre and post intervention.
The fasting blood test was done, where the patient didn't consume anything except water for at least 8 hours before the test.

Data Analysis And Interpretation

The study included 30 prediabetes participants aged 30-45 years and their pre post blood glucose level was studied. All the participants underwent a pre assessment to assure a safe participation into the training. The training was carried out 3 days/week.
The data collected was statistically analyzed using Microsoft Excel sheet and Primer of Biostatistics Version 7.0

Effect of dose response alteration in resistance training on blood glucose level in Prediabetics was analyzed using appropriate parametric and non- parametric tests.
The various statistical measures such as Mean, Standard Deviation (SD) and test of significance were utilized to analyze the data. The results were concluded to be statistically significant if, $p<0.005$. The data was represented in both tabular and graphical format.

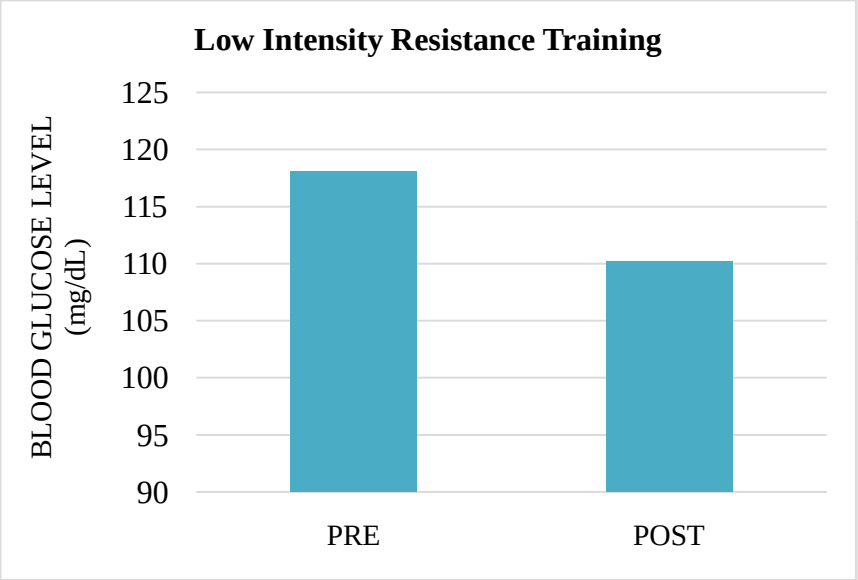
Results

Total 30 participants of age group 30-45 years were included in the study and have completed the 6 weeks of low intensity resistance training.

Table 1: Comparison of pre and post blood glucose level in low intensity resistance training group

Parameter	Pre test		Post test		Z value	p Value	Result
	Mean	SD	Mean	SD			
Blood glucose level (mg/dL)	118.1	5.808	110.2	8.049	W = 4.366	p = 0.000	Significant

Graph 1: Bar diagram showing comparison of pre and post blood glucose level in low intensity resistance training group



Inference- the above table and graph shows the comparison of pre and post blood glucose level values in low intensity training group. Blood glucose level values significantly reduced from 118.1 mg/dL to 110.2 mg/dL as p value <0.005.

Discussion

The primary findings of this research showed that low intensity resistance exercise performed and there was improvement in blood glucose level for age group of 30-45 years amongst Prediabetes participants. All the participants who performed pre intervention fasting blood glucose test showed increased blood glucose level which were improved post intervention. The differences in the blood glucose values were likely due to the specific adaptations that resulted from high intensity resistance training. The blood glucose level is comparable with previous findings involving Prediabetics as the training program resulted in significant improvements in the blood glucose levels.

In present study, significantly improved blood glucose level by difference of 8.4 mg/Dl following low intensity training for 6 weeks($p<0.005$). The most possible reason for reduced blood glucose level was that resistance training significantly improved glycemic control, increased fat free mass, reduced the requirement for diabetes medications, reduced abdominal adiposity and systolic blood pressure, and increased muscle strength and spontaneous physical activity(17)

Subjects who participated in training program made improvements on blood glucose levels from 118.1 mg/dL to 110.2 mg/dL in low intensity resistance training group($p<0.005$). This also suggests that participants respond to resistance training by improving their ability to perform at strength and endurance events.

During resistance exercises the increased glucose uptake by muscle is balanced by an equal rise in hepatic glucose production, and blood glucose levels remain unchanged. There is a decrease in insulin level, which sensitizes the liver to glucagon, thus increasing glucose production (3, 18)With prediabetes, blood glucose uptake by muscles usually increases more than hepatic production. This is also normally accompanied by a decline in plasma insulin levels, greatly reducing the risk of hypoglycemia in diabetics not using insulin or insulin secretagogues (3, 18).

The major reduction in blood glucose level was proved post-intervention by low intensity resistance training as high intensity exercise shows effect on insulin levels as well as its metabolic action in subjects due to catecholamine levels rise markedly. Catecholamines play a pivotal glucoregulatory role during exercise, their effects on insulin secretion and glucoregulatory responses have been studied during α- or β-adrenergic blockade. Increase in catecholamine causes glucose production to rise seven- to eightfold while glucose utilization is only increased three- to fourfold [(18)]. As there is a small blood glucose increase during exercise which increases further immediately at exhaustion and persists for up to 1 hour which causes plasma insulin levels rise, correcting the glucose level and restoring muscle glycogen (18)

Therefore, we have demonstrated that a 6- weeks of low intensity resistance training program 3 days per week was safe and well tolerated by Prediabetics participants. Whereas, the low intensity resistance training was effective for improvements of the blood glucose level and in muscle strength.

In summary, regular participation in a low intensity resistance training program can make an important contribution in maintaining the normal blood glucose level and the further chances of diabetes can be prevented.
The present study provides promising results in improving blood glucose level with the help of intensity resistance training program.

Limitation

Duration of low intensity resistance training per session was not included.

Conclusion

The present study provides results in improving blood glucose level with the help of low intensity resistance training program.
Hence on the basis of the results of the present study, we conclude that low intensity resistance training program was effective on fasting blood glucose level of Prediabetics.

Clinical Implication-Suggestions

Effect of low intensity resistance training causes a significant improvement in fasting blood glucose level of Prediabetics.
Thus, it is recommended that for improvement in blood glucose level within 6 weeks of low intensity resistance training should be included in the training protocol of Prediabetics.

Future Scope

1. Effect of metabolic responses following low intensity resistance exercise when variables such as the duration of exercise, mode of resistance exercise, active muscle mass, and type of subjects on blood glucose level can be done.
2. Effect of dose response alteration in resistance training on blood glucose level and endurance in Prediabetics can be carried out
3. Effect of low intensity resistance training on blood glucose level and BMI in prediabetes.

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