

COMPARISON OF BLOOD SUGAR LEVEL REDUCTION THROUGH AEROBIC AND RESISTANCE EXERCISE IN PREDIABETIC

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ABSTRACT

Prediabetic is a situation where the person's blood sugar level is above normal but has not fully categorized as Diabetes Mellitus. The decrease of blood sugar level in prediabetes patients can be done in various methods, such as *Aerobic Exercise* and *Resistance Exercise*. This study aims to investigate the difference of the decrease blood sugar level through *Aerobic Exercise* and *Resistance Exercise* in prediabetes patients. Experimental with *pre test and post test two group design* is used in this study. It was conducted in Tonja sub-distict, North Denpasar in January until March 2020. The research sample is 24 people, where 21 is woman and 3 man which are randomly divided into 2 experimental groups. Experimental Group I was given *Aerobic Exercise* and experimental group II was given *Resistance Exercise*. *Glucometer* is used as a measurement tool in this study. Based on the result of *paired t-test*, there is a decrease in blood sugar level in Experimental Group I, which the average before intervention is $146,58 \pm 21,33$ mg/dL into $126,42 \pm 21,03$ mg/dL after intervention and obtained $p=0,001 (<0,05)$. In Experimental Group II, the blood sugar level is decreased, where the average before intervention is $142,33 \pm 16,71$ mg/dL and after intervention is $121,83 \pm 20,83$ mg/dL and $p=0,001 (<0,05)$. There is no significant difference in the decrease of blood sugar level between two groups with $p=0,948 (>0,05)$. The conclusion is both *Aerobic Exercise* and *Resistance Exercise* have a good effect in decreasing blood sugar level.

Keywords: *Aerobic Exercise; Resistance Exercise; Prediabetic; Blood Sugar*

INTRODUCTION

Trend and pattern or lifestyle always change with the times. Nowadays, the fact is many people have applied unheathly lifestyle, such as tend to have a *sedentary lifestyle*, unhealthy eating pattern, smoking habits, alcohol and drug consumption which increased degenerative disease (a disease caused by the decrease function of organ) which is life threatening. The effect of that is there has been a transition of Non-Communicable Disease and it is increasing along with some risk factors, such as increased blood pressure, blood sugar, body mass index (obesity), unhealthy eating pattern, lack of physical activity, smoking and alcohol.

The excess amount of fat in an obese person causes insulin resistance. This conditions is happened due to the decrease function of insulin hormone to reduce blood glucose level. Normally, blood glucose is stored in muscle, liver or fat cells as energy resources. However, because of insulin resistance, glucose cannot enter to the cells so that blood glucose level tends to increase but has not caused clinical diabetes which is known as prediabetes. This situation will eventually cause exhaustion in pancreas and unable to issue insulin as needed. It causes exceed and uncontrolled production of glucose in the liver, so glucose level in blood is increased and if it is left unchecked will lead to complications, such as type 2 DM (Diabetes Mellitus)¹. Prediabetic is a condition where blood sugar level of a person is above normal but has not categorized yet into the criteria of Diabetes Melitus (DM)². Blood sugar level is the amount of glucose in a blood although it is always changing.

There are efforts to control blood glucose levels, such as by intervening pharmacotherapy and/or lifestyle mofication with diet, exercise or both³. The change of lifestyle, including exercise, can significantly delay or prevent type 2 DM (Diabetes Mellitus), lose weight, improve insulin sensitivity and improve the uptake of blood glucose in skeletal muscles through *glucose transporter 4* (GLUT 4)⁴.

The series of active and passive movements, *stretching*, *strengthening*, *aerobic exercise* and *resistance exercise* are some physiotherapy management techniques.

Aerobic exercise is one of physical activities which involves big muscles group. *Low impact aerobic* is an aerobic movement which is done continually for more or less around 30-60 minutes with low movement of legs in jumping, but only variations of walking in place which is save for all ages and beginners and do not cause any knee or back injuries. Aerobic exercise that is carried out on patients with type 2 diabetes for 12 weeks (routine and programmed) is effective in controlling blood sugar levels and also decreasing blood pressure. *Resistance exercise* is all kinds of active exercise which affect static or dynamic muscles contraction restrained by outside force (manual or mechanical). Resistance exercise for 10 weeks can decrease HbA1c and blood sugar. This exercise has some purposes, such as improving muscles strength, reducing fat level and maintaining muscle mass. Based on the explanation in background, therefore this study is conducted for the difference of the decrease blood sugar level through *Aerobic Exercise* and *Resistance Exercise* in prediabetes patients.

METHOD

a. Methodology

Study Design

This research used *experimental design* approach with *pre test and post test two group design*. There were two groups which were chosen randomly, where Group I was given Aerobic Exercise and Group II was given Resistance Exercise. The scope of this research is limited geriatric physiotherapy to verify the research result of Aerobic Exercise and Resistance Exercise in decreasing blood sugar level in prediabetes patients.

Subjects Recruitment

The population in this research was the prediabetes citizen in Tonja Sub-district, North Denpasar, Bali. The sample was all population including inclusion criteria with age range 45-60 years old and blood glucose is 100-199mg/dL, normal blood pressure (120/80 mmHg), normal IMT (18,50-25,00 kg/m²) and low-medium physical activity (600-3000 METs). The exclusion criteria is the samples which have systematic with complication disease, cardiovascular disorder, scars or limb defect which affect movement disorder. The *drop out* criteria was those who experienced injuries when the exercises given and do not participate in exercise for 10 times.

Sampling Technique

Sampling techniques used in this research was *purposive sampling* is used as sampling techniques, which is a technique to decide the sample with certain consideration based on the required purpose. The sample was 24 people which were divided into two exercise groups. Group I was given *Aerobic Exercise* and Group II was given *Resistance Exercise*.

b. Material and procedure

- i. The selection of sample was obtained from the population that had meet the inclusion criteria, then agreement form (informed consent) was signed and random allocation was redone by randomizing the names of sample until it was divided into Group I and Group II. Measure blood sugar levels using a Black *Glucometer* with brand *GlucoDR*, prepare respondents to sit down, turn on the glucometer, rub the finger with an alcohol swab, put on a strip, sample blood on the finger, apply the sample to the strip, read the glucose results after 5 seconds and record the blood sugar levels when the results were seen.



Figure 1. Measuring of Blood Sugar Level

- ii. Group I was given *Aerobic Exercise* which in this study was given *low impact aerobic* to decrease blood sugar level and consists of Phase I *warm up*, Phase II *main exercise* and Phase II *cool down*. Each of the movements was done in 2 x 8 counts. In Group II was given *Resistance Exercise* by using *theraband*, which consist of movements in each region. In shoulder region, there are *shoulder flexion*, *shoulder abduction*, *lateral raise* and *overhead press* movement. In arms region, there were *elbow flexion* and *elbow kick back* movements. In chest region, there was *dynamic hug*. In upper back region, there were *shrug*, *reverse flies* and *upright row* movements. In abs and back regions, there were *lower abdominal crunch* and *side bend*. In hips region, there were *hip flexion (sitting)* and *dead lift*. In ankle region, there was *ankle plantar flexion* movement. Each movement was done in 8xrepetition in 3xset. After 1 set was over, it was continued with resting for 15 seconds. The exercise dose of two groups was given 3 times in a week for 45 minutes and led by exercise instructor.
- iii. *Pre test* was done to measure initial blood sugar level of Group I and Group II before exercise was given. Then *post test* was conducted to remeasure blood sugar level after 10 weeks of exercise in each Group I and Group II. The collected data was analysed and report was prepared related with the conducted research.
- c. Assessment
Variabel measured in this research were prediabetic patients (blood glucose is 100-199 mg/dL). Measured using an automatic glucometer.
- d. Data Analysis
After data was collected, the processing and analyzing data was done by using *IBM SPSS Statistics for Windows, Version 16.0. Armonk, NY: IBM Corporatio*.
1. Normality test by using Saphiro-Wilk test. $p > 0,05$ which means the data is normaly distributed
 2. Homogeneity test by using *Levene's test*. $p > 0,05$ which means the data is homogeneous
 3. Hypothesis test
 - a. Comparative test to two groups by using *Paired-Sample T Test* to identify the effects of exercise toward blood sugar level in before and after 10 weeks of exercise, with the significance limit of $\alpha = 0,05$
 - b. Comparative difference result test after 10 weeks of exercise in two groups used *Independent-Sample T Test*, with significance limit of $\alpha = 0,05$

RESULT

Table 1. The Characteristics of Research Subject

Subject Character (n=24)	Group I Mean (mg/dL)±SD	Group II Mean (mg/dL)±SD
Age (yeard old)	57.00 ± 6.25	56.67 ± 5.74
Blood Pressure (mmHg)	1.67 ± 0.49	1.58 ± 0.51
BMI (kg/m ²)	25.10 ± 2.92	23.87 ± 3.65
Physical activity (METs)	1710 ± 1212.3	1801.6 ± 1277.36

n = 24 each group. BMI : Body Mass Index

Table 1 shows that the characteristics of 24 samples which include the data of age, blood pressure, BMI and Physical activity.

Table 2. Descriptive Data of Blood Sugar Level in Before and After Experiment

	Pre-treatment Mean (mg/dL) ±SD	Post-treatment Mean (mg/dL) ±SD	Difference
Group I	146.58 ± 21.33	126.42 ± 21.03	20.17
Group II	142.33 ± 16.71	121.83 ± 20.83	20.5

The table above shows that there is a decrease in the level of blood sugar after treatment was given. In Group I, the average of blood sugar level is decreased for 20,17%, meanwhile in Group II is 20,5%.

Table 3. Data of Normality and Homogeneity Test of Blood Sugar Level

	<i>Saphiro Wilk-Test p¹</i>		<i>Levene-Test</i>
	Group I	Group II	
Pre-treatment (mg/dL)	0.987	0.600	0.592
Post-treatment (mg/dL)	0.284	0.361	

Based on the data of normality test in Group I and Group II, it is obtained $p > 0,05$, which can be defined as normally distributed. It is also similar with homogeneity test where $p = 0,59$ ($> 0,05$) and it can be stated that the data is homogeneous.

Table 4. The Result of *t*-test of Blood Sugar Level in Before and After Research

	Pre-treatment Mean (mg/dL)±SD	Post-treatment Mean (mg/dL)±SD	<i>p value</i>	Difference
Group I	146.58 ± 21.33	126.42 ± 21.03	0.001	20.17±11.94
Group II	142.33 ± 16.71	121.83 ± 20.83	0.001	20.50±12.80

Table 4 indicates that the analysis of difference in the average of blood sugar level in before and after treatment of Group I and Group II is $p = 0,001$ ($< 0,05$). From the result, it can be stated that the treatment of *Aerobic Exercise* and *Resistance Exercise* can decrease blood sugar level in prediabetes patients. Both data are normal and homogeneous, which the data was tested by using *independent sample t-test*.

Table 5 The Result of *t*-test Blood Sugar Level in Group I and Group II

Blood Sugar Level (mg/dL)	Pre-treatment	Pre-treatment	Difference
	Rerata±SD	Rerata±SD	
Group I	146.58 ± 21.33	126.42 ± 21.03	20.17 ± 11.94
Group II	142.33 ± 16.71	121.83 ± 20.83	20.50 ± 12.80
Difference	4.25 ± 7.38	4.58 ± 11.45	
<i>p value</i>	0.592	0.597	0.948

Based on Table 5 of the significance analysis by using *t-independent* test, shows the scores of before, after and difference of both groups are $p > 0,05$, it means that between Group I and Group II are not significant after the treatment was given ($p > 0,05$).

DISCUSSION

The result in this study shows that age is risk factor in prediabetes which cannot be modified. It happens due to the decrease function of body parts, including pancreas to produce insulin hormone which causes increasing in blood sugar level. Gender is also risk factor in prediabetes which cannot be modified. The research subject in this study is more in women who are 45-60 years old experienced the decreasing in estrogen hormone because of menopause. That most of prediabetic patients in urban is women for 50%, while men is 36,7%⁵.

A relation between blood pressure and blood sugar level have become risk factors in diabetes. The linkage between insulin resistance and hyperinsulinemia is believed to increase peripheral vascular resistance and contractility of vascular smooth muscle through overresponse to norepinephrine and angiotensin II, where this condition causes the increase in blood pressure. However from the result in this study, the blood pressure still can be categorized as normal, the blood pressure of prediabetes respondents in urban is in normal category, that is 73,4% and hypertention category is 13,3%. The risk factored of prediabetes based on the interview result is that most of them is inherited from family and cholesterol as the effect of eating habit with high fat such as fried food, coconut milk and other fatty food⁵.

Obesity is related with hypertension and as a risk factor which can be changed. Unmobile lifestyle and dense energy food consumption can cause overweight and become obesity⁶. However, from the result of study, IMT is in normal category and the lowest score is 18,6 kg/m² while the highest is 29,2 kg/m² can experience prediabetes. From the study towards 30 respondents with cross sectional approach, the IMT of 8 respondents are normal, 7 respondents are over and 13 respondents are obesity. The measurement result of the relation between IMT and blood sugar level has obtained $p < 0,05$ which shows there is a connection between IMT and blood sugar level⁷.

The other risk factors which can be changed is physical activity. Regular daily exercise or physical activity can reduce insulin resistance which insulin can be well-used by cells in the body. Meanwhile, from the result of this study, there are respondents whose the score in physical activity is 140 METs/week as the lowest and 2980 METs/minggu is the highest where the high level is only in one respondent. In the study towards 59 respondents with cross sectional approach is obtained 3 respondents with low physical activities, while 53 respondents in medium and 3 respondents with high physical activities. The measurement result to the relation of physical activity and blood sugar level is $p < 0,05$ shows significant relation between physical activity and blood sugar level⁸.

The Effect of Aerobic Exercise towards Blood Sugar Level

Based on the analysis result in the data of blood sugar level in before and after the treatment in both groups by using paired sample t-test (Table 4), it is obtained all $p < 0,05$, it means that Aerobic Exercise treatment can decrease blood sugar level in prediabetes patients.

Physical activity can decrease blood sugar level, help to restrain disease progression in prediabetes patients and reduce morbidity or mortality due to type 2 DM (Diabetes Mellitus). Low impact aerobic can reduce blood sugar level in prediabetes patients⁹. Aerobic exercise is one of exercises which involves oxygen and big muscle group. This kind of exercise is done in low intensity for a long duration, so that the sources can be converted to ATP by using citric acid cycle and oxidative phosphorylation as the main metabolic. Aerobic exercise has an effect caused by insulin receptor cells experiencing resistance so that pancreatic beta cells can secrete the hormone glucagon and pancreatic beta cells are able to compensate by producing the hormone glucagon¹⁰.

The effect of aerobic towards blood sugar level which is done for 8 weeks in 3 times a week shows a significant difference ($p < 0,05$) between blood glucose of respondents in before and after participating in aerobic¹¹. Aerobic is given to prediabetes patients and its effects are impacted after practicing for 2-3 months or more where can cause better tolerance towards glucose¹².

While doing regular and planned aerobic exercise, there is a balance between the increase in the use of glucose and the production of glucose. In aerobic exercise, there is a muscles contraction which trigger the insertion of contracted GLUT-4 to muscles cells plasma membrane, so blood sugar can enter the cells even without insulin, because skeletal muscles is not dependent to insulin GLUT-4 and can react after bonding with insulin. Glucose molecules cannot go through the membrane without insulin, as the result most of tissues depend on insulin to absorb glucose from blood. GLUT-4 is very abundant in tissues that absorb a lot of blood glucose during the absorptive condition. GLUT-4 is the only glucose transporters that responds to insulin. While exercising, muscles are depend on insulin to absorb glucose because muscles contraction triggers insertion of contracted GLUT-4 to the active muscles cells plasma membrane, so when muscles are active, glucose absorption is occurred in cells even without insulin.

The Effect of Resistance Exercise towards Blood Sugar Level

Based on the analysis result of blood sugar level in before and after treatment of both groups by using paired sample t-test (Table 4), it is obtained $p < 0,05$, which means Resistance Exercise treatment can reduce the blood sugar level in prediabetes patients.

Resistance exercise is one of active exercises through the contraction of dynamic or static muscles by using outside resistance, where in this research is Theraband. There is a study conducted about the effect of exercise toward the decrease of blood glucose in type 2 DM (Diabetes Mellitus). The study is done for 4 weeks about 5x in a week of exercise with the amount of sample is 15. The sample is given resistance exercise by using RubberBand. The result with glucometer is that there is a decrease

of blood glucose for about 25,43mg/dL, it shows that resistance exercise can decrease blood sugar level¹³.

Exercise by using elasticband for 12 weeks in 3x a week exercise can decrease blood glucose, cytokine and improve physical function in elderly women with hyperglycemia¹⁴. Resistance exercise has effects toward the decrease of blood sugar level and moreover in improving diabetic neuropathy and ankle brachial in type 2 DM (Diabetes Mellitus) patients¹⁵. The resistance exercise program which is recommended is ACSM for 6-12 weeks to improve metabolic adaptation to decrease blood sugar level.

The mechanism of change in blood sugar level can be due to metabolic adaptations related to the energy system used during exercise. The mechanism of change in blood sugar level caused by the use of stored glucose which is mostly obtained from muscle glycogen or glucose in the bloodstream to produce ATP. The excess glucose level in the blood, especially after the application of food (carbohydrates), the glucose through the glycogenic mechanism is stored in the liver and muscles as glycogen, a complex carbohydrate.

It is caused by the regular resistance exercise, will help insulin receptor in the cells to be more sensitive, so the negative feedback in the endocrine cells occurred in the body, that is the level of glucose in blood, will decrease in the ideal conditions (homeostasis). Resistance exercise has been proven to give significant effects toward insulin sensitivity and the function of vascular endothelial cells. In resistance exercise, there is muscles contractions which cause the increase of Ca²⁺, AMP, ROS and temporary mechanism where insulin gives a signal to insulin receptor substrate and PI 3-kinase that causes collaboration between insulin and exercise to phosphorylate AS160 and TBC1D1 in activating GLUT-4 translocation, so that the increase of GLUT-4 translocation will improve glucose uptake capacity in tissues. Inside the tissues, glucose will change into ATP (energy). The more expression of GLUT-4, so that the amount of glucose in the blood is decreased because of the decrease of blood glucose which is lifted inside the tissues¹⁵.

Aerobic Exercise and Resistance Exercise Have Similar Effects in Decreasing Blood Sugar Level

Based on the analysis result of blood sugar level between Group I and Group II (Table 5) by using independent sample t-test, the blood sugar level is $p=0,597$ ($p>0,05$). It means that there is no significant difference between Group I and Group II.

In daily, there are some factors which cannot be controlled by the researcher, one of those is food intake consumed by the sample. The pattern of food and physical activity which are controlled and well-organized can decrease blood sugar level¹⁶. The similar compositions of exercise duration between two groups is included as one of the effects of the similar decrease of blood sugar level. The treatment in Group I and Group II were given with similar intensity and time of exercises. It can be seen from the given of treatments time that were 10 weeks (3 times in a week) is an adequate time to obtain the significant decrease of blood sugar level in both groups.

Aerobic exercise (low impact) is an exercise by using aerobic metabolic because oxygen is involved during exercise. Meanwhile, anaerobic energy metabolism does not involve oxygen and resistance exercise is categorized as anaerobic exercise¹². Both aerobic and resistance exercises are using energy sources from aerobic and anaerobic metabolism, depends on the exercise intensity, the weight pressure and exercise duration. Therefore, both exercises given in this study have no difference in the result. In the principle of resistance exercise is that the exercise must be given by increasing the pressure step by step, which is based on weekly frequency, while in this study the level of exercise given is steady from the beginning until the end of treatments.

Aerobic exercise and resistance exercise have positive therapy effects in medication and control of blood sugar level in patients with T2DM and prediabetes¹⁷. Nonetheless, the combination of two types of exercise apparently has better effects in glycemic control than both types of exercise. It is related with a study conducted which 12 weeks of research has a result that there is a significant decrease in blood sugar level in aerobic exercise and resistance exercise groups, meanwhile the combination of the two kinds of exercise is able to decrease blood sugar level and efficient in improving HOMA-IR and omentin-1 serum¹⁸.

CONCLUSION

The conclusion of this study is Aerobic Exercise and Resistance Exercise can decrease the blood sugar level in prediabetic patients. Aerobic Exercise is as good as doing Resistance Exercise in decreasing blood sugar level in prediabetes patients in Tonja sub-district, North Denpasar, Bali.

CONFLICT OF INTEREST

For people with prediabetic, it is important to maintain blood sugar level so as not to cause other diseases that can be fatal to the body, so the Aerobic Exercise and Resistance Exercise should be continued and applied regularly with a purpose to control and decrease blood sugar level. The further researchers are expected to control the nutrition intake, measure the pulse and remeasure the weight of the respondents in the end of exercise to ensure the effect of exercises given. The increase of exercise pressure gradually to maximize the increase of muscles strength. This study can be used as reference and comparison of research result if the background is similar with this study.

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