



Impact of Aerobic Exercise versus Interval Resistive Exercise on Blood Coagulation and Fibrinolysis in Type 2 Diabetic women.

Faten Mohamed Mohamed Elnozhe*¹, Haitham Mahmoud Saleh², Ibrahim Abdelhakim^{3,4}, Hind Mohammed Alshareef⁵ and Magda M Rashid⁶

1. Associate Professor of Physical Therapy for Internal Medicine, Chest and Cardiology and Geriatric, Faculty of Allied Medical Science, Department of Physical Therapy, Al Aqaba University of Technology, Jordan.
2. Lecturer of Physical Therapy Department of Physical Therapy for Basic Science Faculty of Physical Therapy Deraya University.
3. Department of Physical Therapy for Pediatrics and its surgery, Faculty of Physical Therapy, Modern University for Technology & Information (MTI) Cairo, Egypt.
4. Department of Physical Therapy, National Institute for Neuromotor System. Egypt.
5. Lecture of basic science at Heliopolis University.
6. lecturer of cardiovascular, respiratory disorders and geriatrics at Heliopolis University.

Abstract:

purpose of study: This study aims to compare the effects of aerobic versus interval resistive exercises upon blood coagulation and fibrinolysis factors in women with type 2 diabetes. **Objectives and Methods:** Sixty women with type 2 diabetes, aged 45 to 65 years and with a BMI ranging from 25 to 29.9 kg/m², were recruited from El Minia Health Insurance Hospital and participated in a study for a duration of 12 weeks. The participants were divided into two groups of equivalent number: Group (A) 30 diabetic type 2 women were given a low-calorie diet in addition to a program of aerobic exercise in the form of walking on electronic treadmill for 30 min for 3 sessions per week for 12 weeks. and Group (B) 30 diabetic type 2 women were given a low-calorie diet with interval resistive exercises 3 sessions per week for 12 weeks. All participants received a comprehensive history and clinical examination, along with routine laboratory investigations, such as glycosylated hemoglobin (HbA1c). Additionally, prothrombin time, fibrinogen, tissue plasminogen activator (tPA), as well as plasminogen activator inhibitor-1 (PAI-1) were measured before the initiation of the program and after its completion (12 weeks). **Results:** The levels of HbA1c, prothrombin time, and fibrinogen were shown to be significantly lower ($p < 0.05$). Significant improvements were also observed in tissue plasminogen activator (tPA) as well as plasminogen activator inhibitor-1 (PAI-1) ($p < 0.05$). **Conclusion.** Both types of exercises significantly improves HbA1c, prothrombin time and fibrinogen levels of the blood after 12 weeks of aerobic training and interval resistive training, moreover interval resistive training is more effective in reducing HbA1c and fibrinogen levels than aerobic training.

Keywords: Blood coagulation, Diabetic type 2 women, Aerobic exercise, Interval resistive exercise.



1. Introduction

Diabetes is a significant health problem that affects more than 382 million people around the world. Diabetes mellitus type 2, which comprises 85–95% of the global diabetes cases, has a lengthy history of etiology. The main components in the development of type 2 diabetes mellitus, according to recent studies, are insulin resistance and β -cell dysfunction. In a 2018 study, Ginszt et al., (2018) The blood sugar level, also known as blood sugar concentration or blood glucose level, is the quantity of blood sugar in the circulation. All of the body's cells prefer glucose as their fuel source, and it's essential for cellular respiration. The plasma glucose concentration is the result of a delicate equilibrium between the rates of glucose uptake and outflow from the bloodstream. Circulating glucose comes from intestinal absorption from the ingestion of carbohydrate during the fed state and by the process of glycogenolysis, and gluconeogenesis in the fasting state. There are hormones involved in glucose regulation are called glucoregulatory hormones which include insulin, glucagon, amylin, glucagon-like peptide-1 (GLP-1), glucose-dependent insulinotropic peptide (GIP), epinephrine, cortisol, and growth hormone. Some of these substances are released by different parts of the body: the pancreas secretes glucagon and insulin from its β -cells, the small intestine and colon secrete GLP-1, while the upper small intestine secretes GIP. The failure of glucoregulatory or counterregulatory hormones to maintain blood sugar levels results in hypoglycemia or hyperglycemia. (Paluchamy, 2019). Obesity, high salt intake, high alcohol consumption, cigarette smoking, lack of physical activity, stress, polycythemia, nonsteroidal anti-inflammatory drugs (NSAIDs), in addition to low potassium intake are all aggravating factors (Mahmoud.et.al., 2022).

The American Heart Association reports that cardiovascular disease in older adults with type 2 diabetes accounts for 84% of deaths. Vascular endothelial dysfunction is associated with increased blood glucose levels and insulin resistance, serving as a significant factor in the pathological progression of cardiovascular disease (Muniyappa R, et al., 2008). Endothelial dysfunction is recognized as a precursor to atherosclerosis along with cardiovascular disease (CVD) (Thijssen DH, et al., 2011). During exercise, the muscles need more glucose than usual, and this increase is proportional to the amount of work being done. despite this, the hormones glucagon as well as catecholamine, which reduce insulin function, are released in response to strenuous physical activity. Continuation of an exercise program has been shown to normalize abnormal lipid metabolism in addition to increase insulin sensitivity among individuals with impaired glucose tolerance as well as type II diabetes (Abd Elwahaab et.al., 2020).

Exercise enhances cardiovascular health and optimizes endothelial function by decreasing adiposity, blood pressure, diabetes incidence, dyslipidemia, as well as inflammation, thereby increasing insulin sensitivity, glycemic control, in addition to fibrinolysis (Ergün et al., 2006). Regular physical activity is shown to significantly reduce causes of mortality. Physical activity enhances overall health. Regular exercise enhances the functions of epithelial tissue by decreasing body weight, density, the incidence of genetic disorders, and dyslipidemia (Walid B. et al., 2017). Diabetic patients can safely engage in aerobic training that involves large muscle groups at low to moderate intensity. Aerobic exercises, including running, walking, cycling, swimming, as well as rowing, are generally classified within this category of training. The international societies for diabetes suggested an aerobic exercise program of at least 150 minutes, carried out over three full days of moderate intensity (40-59% of heart rate reserve, 64-76% of maximal heart rate), with no longer than two days in a row without exercise. The American Diabetes Association



recommends that adults with type 2 diabetes engage in regular aerobic activities lasting at least 10 minutes, aiming for approximately 30 minutes per day or more, on most days of the week (Ginszt et al., 2018). There are three distinct mechanisms in which exercise can control blood sugar levels: first, by temporarily increasing insulin action; second, by temporarily stimulating glucose transport in muscles; and third, by gradually increasing the insulin signaling pathway as a consequence of regular exercise training (Sigal R et al., 2004) hypercoagulation and endothelial dysfunction. Platelet dysfunction has attained attention as a potential cause of increased cardiovascular morbidity and mortality in essential hypertension. All the above suggest the importance of platelet function in coronary artery disease and hypertension (Petidis K. et al., 2008). Short term exercise is usually associated with a significant shortening of activated partial thrombo plasmin time (APTT) and a marked increase in factor VIII (FVIII). Another study found that aerobic exercise (such as walking, cycling, jogging, or swimming) is more likely to lower HbA1c values and lipid profiles than resistive training (which includes using free weights, weight machines, body weight, or elastic resistance bands) (Van Loon J.E et al., 2014). This finding is in direct correlation with exercise intensity as well as the individuals' training status. One study found (Dewi et al., 2019). In addition, there is a strong negative relationship between HbA1c and muscle cross-sectional area post-training, and interval resistance training significantly decreased HbA1c, largely as a result of improvements in lean body mass. By enhancing glucose storage in skeletal muscle, resistance training optimizes glycemic management (Aya et al., 2017). The purpose of this study was to compare the effects on prothrombin time, fibrinogen plasminogen activator inhibitor-1 (PAI-1), as well as tissue plasminogen activator (tpA) of aerobic exercises (40-50 minutes of walking exercise three times weekly) with interval exercise in conjunction with a low-calorie diet, in addition to a low-calorie diet alone.

2. Materials and Methods

Sixty Diabetic type 2 women were selected from El Minia Health Insurance Hospital aged from 45 to 65 years and BMI was ranged from 25 - 29.9 kg/ m² were recruited at random from outpatient's clinic of El Minia Health Insurance Hospital in the period from July 2023 to November 2023, the participant were randomized into equivalent group each group contain 30 patients. Two groups were given a low-calorie diet, Group A got the low-calorie diet as well as the aerobic exercise program, and Group B got the low-calorie diet and the interval resistance exercise program. The incidence of diabetes for any participant should be more than 5 years ago.

All patients received a full explanation for treatment and measurement procedures as Prior to their involvement in this study, participants were requested to sign a consent form. The form was authorized by the ethical committee of scientific research at Deraya University's Faculty of Physical Therapy: The reference number is (NO.P.T/REC/230007). All patients with ischemic heart diseases, autonomic neuropathy, chest diseases, renal diseases and endocrinal disorders were excluded from this study.

Design of the study: Randomized control study.

All patients were randomized into two groups of equal numbers, as follows:

Group A 30 Diabetic type 2 women were given a low-calorie diet with a program of aerobic exercise. Group B 30 Diabetic type 2 women were given a low-calorie diet with a program of interval resistive exercises.



Evaluation procedures:

A physician and a physiotherapist administered the following tests to every individual in both groups. At the start and finish of the 12-week practical study period, the variables were recorded as:

Standard weight and height scale (Health scale made in china) was utilized to determine the body mass index (BMI) by taking the patients' height and weight. Body mass index (BMI) (kg/m²) and height (m) were computed from the patients' physical parameters using a weight and height scale. Evaluation performed according to the following formula, which is based on the defined anthropometric protocol: In kilograms divided by square meters, it is the body mass index (Elsisi et.al., 2019).

Laboratory investigations:

Estimation of Glaciated Haemoglobin (HbA1c).

1. Estimation of Blood Coagulation Factors and plasminogen activator inhibitor-1 (PAI-1) Two blood samples were collected from the subjects: one was taken from the patients' right brachial veins 24 hours before fasting, and the additional sample was collected 72 hours following the 12-week training session. Centrifuged at 3000 rpm for 10 minutes, the blood samples were then moved to EDTA-containing tubes designed for plasma preparation. It was necessary to keep the plasma at -70°C. Utilizing quantification detection, the plasma fibrinogen was assayed utilizing the coagulation method (Clauss). Each patient's plasminogen activator inhibitor-1 (PAI-1) time was recorded using a Stat fax2100 Micro Plate Reader before and after the entire 12-week trial period.

2. Physiological measurements: Vital signs, including heart rate, blood pressure, and temperature, were assessed prior to and following each session to identify any signs or symptoms that could disrupt the study's continuity and to determine maximal heart rate. The patient should avoid eating a heavy meal two hours prior to training.

Exercises prescription:

First both groups Designing nutrition plan for each subject (Low calorie diet model).

Group (A) Aerobic Exercise:

Intensity According to heart rate (60-75% of maximum heart rate) MHR=220-age.

Heart rate: Determined by palpation of radial pulse for one minute.

Duration: After a five-minute warming-up, each session lasted twenty-five to thirty minutes and ended with a five-minute cooling down.

• **Mode of exercise:** Light waking on treadmill

The training session lasted 30 minutes and involved progressively raising the treadmill speed until the participant's heart rate reached 60–75% of its maximum.

Frequency: three times per week for 12 weeks.

Group (B) Interval resistive exercises:

Composed of low intensity exercise on treadmill walking on treadmill for three sessions a week (day after day) three months according

1. Every patient is given a detailed explanation of the training stages.

2. Developing a low-calorie eating plan for each patient in the two groups. Plus, high intensity resistive exercise

The procedure consisted of 30 patients receiving interval resistive training program for three days/week (day after day) for 12 weeks. Patient walking on treadmill with gradual resistance training for the following muscles hip flexion extension/calf muscle /biceps curl muscles/triceps curl muscles



Mode of exercises: walking on treadmill or using graduated weights based on parameter of procedure

Intensity of exercise: training consisted of interval resistive training according to heart rate (60-75% of maximum heart rate) $MHR = 220 - \text{age}$. (Cad WT et al., 2008).

Each session included: Five minutes warm up in form of slow walking on treadmill (aimed to prepare skeletal muscles, heart and lungs for the acute phase of the exercise training program) and five minutes cool down. Training intensity was controlled using visual analogue scale aiming to detect patient fatigue during session to stop exercise continuity.

Heart rate: Determined by radial pulse.

Duration: 40 mints of total time session (five min warm up 30 min conditioning phase and five min cool down) interval resistive exercises by weight graduated from 40-60% of 1RM.

Frequency: three times per week for 12 weeks.

After 12 weeks program, withdrawal of additional blood samples.to evaluate effect of program on HbA1c and blood coagulation.

Additional blood samples were collected at the end of the 12-week program. It was necessary to evaluate blood sugar, HBA1C, prothrombin time, fibrinogen, as well as plasminogen activator inhibitor-1 before and after the intervention.

Statistical analysis:

The mean age, weight, height, and body mass index (BMI) were compared between the two groups using descriptive statistics and a t-test. When comparing the two groups' HbA1c, prothrombin time, and fibrinogen levels, an independent t test was used. Each group's pre- and post-treatment HbA1c, prothrombin time, as well as fibrinogen were compared using an independent t test. A significant criterion of $p < 0.05$ was established for all statistical tests. The statistical package for the social sciences (SPSS) version 25 for Windows was used to conduct all statistical measures.

3. Results

Statistics were used to compare and analyze the data collected from both groups on clotting time, plasminogen activator inhibitor-1 (PAI-1), random blood sugar, as well as HBA1C.

General characteristics of both groups

There was no statistically significant difference between the two groups when comparing at the participants' general characteristics, such as their age, weight, height, as well as body mass index (BMI) ($p > 0.05$). (table 1)

Table (1): General characteristics of both groups

	Group A	Group B	MD	t- value	p-value	Sig
	$\bar{X} \pm SD$	$\bar{X} \pm SD$				
Age (years)	51.3 $\pm$ 4.94	50.31 $\pm$ 4.28	0.99	1.09	0.27	NS
Weight (kg)	80.20 $\pm$ 7.19	79.88 $\pm$ 7.52	0.32	0.24	0.73	NS
Height (cm)	168.27 $\pm$ 7.4	168.05 $\pm$ 7.67	-0.22	-0.15	0.83	NS
BMI (kg/m ²)	28.41 $\pm$ 1.23	28.21 $\pm$ 1.19	0.20	0.89	0.34	NS

$\bar{X}$: Mean SD: Standard deviation MD: Mean difference
t value: Unpaired t value p value: Probability value NS: Non significant

HBA1C

I. Between groups comparison:

Pre treatment: Before treatment, group A had a mean $\pm$ standard deviation of 9.22 ± 0.64 for HbA1c while group B had a mean of 9.14 ± 0.61 . Between the two groups, there was a mean difference of only 0.08%. Prior to treatment, there was no statistically significant difference in HbA1c levels between groups A and B ($p = 0.69$). (table 2).



Post treatment: Group B had a mean $\pm$ SD HbA1c of 6.73 ± 0.65 after treatment, while group A had a mean of 7.42 ± 0.89 . The mean difference among the two groups was 0.69 percent. Following treatment, group B's HbA1c levels decreased significantly ($p = 0.005$) as compared to group A's (table 2).

Table (2): Comparison of pre and post treatment mean values of HbA1c between group A and B:

HbA1c (%)	Pre treatment		Post treatment	
	Group A	Group B	Group A	Group B
$\bar{X} \pm SD$	9.22 ± 0.64	9.14 ± 0.61	7.42 ± 0.89	6.73 ± 0.65
MD	0.08		0.69	
t-value	0.31		2.80	
p- value	0.69		0.005	
Significance	NS		S	

$\bar{X}$: Mean

SD: Standard deviation

MD: Mean difference

t value: Unpaired t value

p value: Probability value

NS: Non significant

S: Significant

Prothrombin time

I. Between groups comparison:

Pre treatment: Group B had a mean prothrombin time of 17.74 ± 3.01 seconds before treatment, while group A had a mean time of 17.62 ± 3.11 seconds. There was a mean difference of 0.12 seconds between the two groups. The prothrombin time of groups A and B before treatment was not significantly different ($p = 0.8$). (table3).

Post treatment: After treatment, the mean prothrombin time for group A was 15.10 ± 2.62 seconds, while for group B it was 11.98 ± 1.52 seconds. There was a mean difference of 3.12 seconds between the two groups. Compared to group A, group B's prothrombin time decreased significantly after treatment. ($p = 0.0001$). (table 3).

Table (3): Comparison of pre and post treatment mean values of prothrombin time between group A and B:

Prothrombin time (sec)	Pre treatment		Post treatment	
	Group A	Group B	Group A	Group B
$\bar{X} \pm SD$	17.62 ± 3.11	17.74 ± 3.01	15.10 ± 2.62	11.98 ± 1.52
MD	-0.12		3.12	
t-value	-0.26		5.81	
p- value	0.8		0.001	
Significance	NS		S	

$\bar{X}$: Mean

SD: Standard deviation

MD: Mean difference

t value: Unpaired t value

p value: Probability value

NS: Non significant

S: Significant

Plasminogen activator inhibitor-1(PAI-1):

Between groups comparison:

Descriptive statistics and t test for the mean PAI-1

Before treatment, the PAI-1 levels of both groups were not significantly different ($p = 0.8$). Between the pre- and post-treatment measurements, the PAI-1 of (group B) decreased significantly ($p = 0.001$). (group A) PAI-1 significantly decreased after treatment compared to before ($p = 0.001$). Results showed a significant reduction in PAI-1 between the treatment and control groups ($p = 0.001$). (table 4).



Table (4): Comparison of pre and post treatment mean values of PAI-1 between group A and B:

PAI-1 (ng/ml)	Pre treatment		Post treatment	
	Group A	Group B	Group A	Group B
$\bar{X} \pm SD$	45.83 $\pm$ 6.21	44.96 $\pm$ 7.11	42.15 $\pm$ 2.57	40.89 $\pm$ 1.4
MD	-0.87		1.26	
t-value	-0.24		5.79	
p- value	0.8		0.001	
Significance	NS		S	

$\bar{X}$: Mean

MD: Mean difference

p value: Probability value

SD: Standard deviation

t value: Unpaired t value

NS: Non significant

S: Significant

4. Discussion

The aim of the present study was to investigate the effect of aerobic exercise versus interval resistive exercise on blood coagulation in type 2 diabetic type 2 women. Group A was given a low-calorie diet and aerobic activity three times a week on an electronic treadmill for a duration of 12 weeks. Group B was given a regimen of interval resistance training in addition to a low-calorie diet (exercises using free weights with intensity (40-60%) of 1RM three time/week for 12 weeks).

Our finding show that there was significance improvement in HbA1c, prothrombin time and fibrinogen levels of the blood after 12 weeks of aerobic training (Group B) and interval resistive training (Group B), moreover interval resistive training is more effective in reducing HbA1c and fibrinogen levels than aerobic training in diabetic type 2 women.

The current study is agreed with results of (Sanz, et al., 2010) We came to the conclusion that any treatment plan for individuals with type 2 diabetes should incorporate exercise because it is an effective tool for both prevention and treatment of the disease. A 50% decline in diabetes incidence is achieved in those at high risk of acquiring type 2 diabetes, and this decline continues for several years after the monitored lifestyle intervention ends. The entire public-health system must be included in the implementation of preventative trials in the general population due to the increasing number of high-risk patients globally. Additionally, this finding is in line with certain findings of (Aguiar et al., 2014). The authors of that study found that in at-risk and prediabetic adult populations, multi-faceted lifestyle interventions involving aerobic and resistance exercise training as well as a dietary intervention, lead to modestly effective weight reduction, improved glucose tolerance, decreased fasting glucose levels, and improved dietary and exercise outcomes.

These findings lend support to the present exercise recommendations that include RT in the prevention of type 2 DM, in a study conducted by (Aya et al., 2017), it was found that regular aerobic exercise had significant effects on HbA1c levels. This type of intervention also improved glycemic management, while it had no effect on body weight. Exercising aggressively stimulates the coagulation and fibrinolytic cascades, according to another study (Jensen et al., 2008), but the timing of this effect and its therapeutic relevance remain unclear. Doctors and athletes should be aware of the hemostatic changes induced by exercise, and further work is needed to classify the possible role of these changes in sudden cardiac death. In contrast to our study.

In addition to the findings of (Assadi et al, 2019), another study found that fibrinogen levels decreased significantly after ECT, CRT, and HIIT when compared to the control group. However, no significant difference was seen when comparing ECT, CRT, and HIT. There have been a few studies into how exercise training affects fibrinogen levels. HIIT and CRT



resulted in a larger reduction of fibrinogen than ECT did. It appears that the glycogen level decreased attributed to exercise intensity has been more pronounced in the CRT and HIIT groups. An important element to the extent to which fibrinogen levels are reduced is the intensity of exercise training, according to studies. (Rezaeimanesh., 2020) confirm our result as they found that Implementation of HIIT involves intermittences of intense exercise and active to moderate intensity breaks. Previous studies have shown that HIIT has led to similar metabolic adaptation compared to traditional endurance training in adults. Therefore, due to the high potential of this exercise method in fat reduction and its efficiency in terms of time interval compared to other exercise methods, this protocol was used. Whether this exercise has a positive effect on fibrinolytic, D-dimer and fibrinogen indices in diabetic subjects has not been investigated. So, this study was done to examine the impact of 8 weeks of HIIT on some fibrinolytic, D-dimer and fibrinogen factors in men with type 2 diabetes (Rezaeimanesh., 2020).

The study doesn't agree with; (Khalil et al., 2015) reported that a rise in blood fibrinolysis is mostly caused by a reduction in the major inhibitor of plasminogen activator inhibitor-1 (PAI1), which is secreted by endothelial cells of the artery wall, and an elevation in tissue-type plasminogen activator (t-PA). So, an increased risk of ischemic events may be associated with acute exercise reactions. Nonetheless, cardiovascular disease (CVD) patients and healthy persons alike may benefit from continuous aerobic exercise training by reducing coagulation potential and increasing fibrinolytic potential. Given the significance of resting fibrinolysis on the exercise-induced fibrinolytic response, it is acceptable to assume that regular aerobic exercise training may lead to beneficial adaptations that lower the risk of ischemic events during rest and physical exertion.

Also (Ivanov 2022) contradict with our study noted that samples taken before and after exercise had faster whole blood coagulation times. Strenuous activity stimulates both the coagulation and fibrinolytic cascades, although it is still unclear how the two cascades are related in time and what this means clinically. At the highest levels of exercise intensity, unfavorable hemostatic alterations may increase the risk of intravascular thrombus development and cause sudden cardiac death.

5. Conclusion:

From our finding we concluded that both type of exercises significantly improve HbA1c, prothrombin time and fibrinogen levels of the blood after 12 weeks of aerobic training and interval resistive training, moreover interval resistive training is more effective in reducing HbA1c and fibrinogen levels than aerobic training in diabetic type 2 women.

6. Acknowledgments

The authors thank all participants in this project.

7. Funding

None to report.

8. Conflict of interest

The authors declare no conflicts of interest.

9. Ethics statement

This study was approved by the ethical committee of scientific research at Deraya University's Faculty of Physical Therapy (NO.P.T/REC/230007). Written informed consent was obtained from all study participants.

References:

1. Abd Elwahaab, Hisham A. A., et al. (2021) "Effect of Dynamic Exercise of Upper Limb Versus Lower Limb on Diabetic Elderly Women." *International Journal of Cuest.fisioter.*2025.54(4):4960-4969



- Health Sciences, vol. 5, no. S1, pp. 815-826, doi:10.53730/ijhs. v5nS1.14424.
2. Aguiar J, Morgan J, Collins E, Plotnikoff C and Robin C (2014): International Journal of Behavioral Nutrition and Physical Activity, 11: 2.
 3. Asaadi, V., Azizbeigi, K., Khosravi, N., & Haghnazari, N. (2019). The effect of exercise training on fibrinogen and viscosity of plasma: comparing endurance continuous, circuit resistance and high intensity interval trainings in young obese men. Journal of Clinical Research in Paramedical Sciences, 8(2).
 4. Aya A, Zaghlol Soheir S, Rezk-Allah Olfat Ali and Ayman ES, Elbadran Y (2017): Aerobic versus Resisted Exercise on Glycated Hemoglobin (HBA1C) in normal subjects Med. J. Cairo Univ., 85, (2): 831-840
 5. Cade WT (2008): Diabetes-related microvascular and macrovascular diseases in the physical therapy setting. Physical therapy; 88(11): 1322-1335.
 6. Dewi L (2019): Modalities of Exercise Intervention for Type 2 Diabetes Mellitus: Clinical Research in Diabetes and Endocrinology Vol 2, Issue 2, 2019.
 7. Elsisi, H. F. E. M., Mahmoud, T. H., Serry, Z. M. H., Rahmy, A. F., & Osman, N. M. M. (2019). Effect of strengthening exercise versus intermittent pneumatic compression device to calf muscle on blood flow in patients with varicose Veins. Biosci Res, 16(2), 2360-8.
 8. Ergün M, Tengiz I, Türk U et al. (2006): The effects of long-term regular exercise on endothelial functions, inflammatory and thrombotic activity in middle-aged, healthy men. Journal of sports science & medicine; 5(2): 266-276.
 9. Ginszt, A., Ginszt, M., Majcher, P & Tarkowski, Z. (2018). Effects of exercise on blood glucose levels in type 2 diabetic patients–Literature review. Polish Annals of Medicine, 25(2).
 10. Ivanov, I. (2022). Hemorheological alterations and physical activity. Applied Sciences, 12(20), 10374.
 11. Jensen L., Sloth B., Krog M.I. et al. (2008): A low-glycemic-index diet reduces plasma plasminogen activator inhibitor-1 activity, but not tissue inhibitor of proteinases-1 or plasminogen activator inhibitor-1 protein, in overweight women. The American journal of clinical nutrition; 87(1): 97-105.
 12. Khalil OA, Sherif M, Magda M, E Ghoniem, Fahmy Dalia, Fawzy MS (2015). Effect of aerobic exercises on blood coagulation and fibrinolytic system in type 2 diabetic patients. International Journal of Advanced Research, 3, (5), 64-70.
 13. Mahmoud, T. H., Ahmed, M. S., Saleh, H. M., Abdelhakim, N. M., Abd Elhameed, R. E., & Allah, M. A. G. (2022). Effect of High-intensity Aerobic Exercise Versus Moderate-intensity Aerobic Exercise on Serum Uric Acid in Hypertension. NeuroQuantology, 20(4), 552-563.
 14. Muniyappa R, Iantorno M, Quon MJ (2008). An integrated view of insulin resistance and endothelial dysfunction. Endocrinol Metab Clin North Am. 37(3):685–711.
 15. Paluchamy, T. (2019). Hypoglycemia: essential clinical guidelines. In Blood glucose levels. IntechOpen.
 16. Petidis K., Douma S., Doumas M. et al. (2008). The interaction of vasoactive substances during exercise modulates platelet aggregation in hypertension and coronary artery disease. BMC cardiovascular disorders; 8(1): 11- 22.
 17. Rezaeimanesh, D. (2020). The effects of high-intensity interval training on fibrinolytic factors, D-dimer, and fibrinogen in men with type 2 diabetes. Archives of Pharmacy Practice, 11(1-2020), 154-160.



-
18. Sanz C, Gautier JF and Hanaire H (2010). physical exercise for the prevention and treatment of type 2 diabetes. *Diabetes and Metabolism*, 36 (5): 346-51.
 19. Sigal R.J., Kenny G.P., Wasserman D.H. et al. (2004). Physical Activity/Exercise and Type 2 Diabetes. *Diabetes Care*; 27(10): 2518-2539.
 20. Thijssen DH et al. (2011). Assessment of flow-mediated dilation in humans: a methodological and physiological guideline. *Am J Physiol Heart Circ Physiol*. 300(1):H2–12.
 21. Van Loon J.E., Sonneveld M.A., Praet S.F. et al. (2014). Performance related factors are the main determinants of the von Willebrand factor in response to exhaustive physical exercise. *PloS one*; 9(3): 687-695.
 22. Walid B., Thomas V., Elise S., Georges K., Bernard G. and Pierre O., (2017): Health benefits of aerobic training programs in adult aged 70 and over: A systematic Review. *Archives of Gerontology and Geriatrics.*, vol. (69), 110-127.