The Effect of Aerobic Exercise on Blood and Plasma Viscosity on Cardiac Health Club Participants

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ABSTRACT

Aim: *to analyze the effect of SJS aerobic exercise on blood and plasma viscosity.*

Methods: *the study was performed on 30 subjects with an age span of 40 to 60 years. Subjects participated in SJS aerobic exercise of moderate intensity of 40 to 45 minutes duration, three times a week for 9 to 12 weeks. Five milliliters of blood were collected into K3EDTA container to assess blood and plasma viscosity prior to the program and following the completion of the SJS program. Blood and plasma viscosity was measured using Brookfield LVDV-III viscometer using rotational method principle.*

Results: *this study demonstrated a significant decrease in blood viscosity (2.94%, p = 0.03) and insignificant decrease in plasma viscosity in subjects following SJS aerobic exercise compared to prior exercise.*

Conclusion: *this study proved that SJS aerobic exercise of moderate intensity of 40 to 45 minutes duration times a week for 9 to 12 weeks gave the benefit of lowering blood viscosity, which contributes to reducing the risk of coronary heart disease.*

Key words: *aerobic exercise, blood viscocity, plasma viscocity, cardiac health club.*

INTRODUCTION

Exercise plays a significant role in primary and secondary prevention.[1,2] Primary prevention is the preventative effort aimed at those without coronary heart disease (CHD). Secondary prevention is the preventative effort to avoid relapse among those who already have CHD, and even possibly to produce improvement.[1] Opposite correlation is found between the level of physical activity in both males and females and the incidence of CHD. CHD patients participating in the exercise programs have lower mortality rates compared to those who did not participate in such a program.[3]

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A study in patients admitted to Harapan Kita National Cardiovascular Center in 1993 found that 90% of patients presented with heart attack do not exercise in their daily life, or are classified as workers with low activity.[4] The Center for Disease Control and Prevention and the American College of Sports Medicine (ACSM) recommend at least 30 minutes of moderate intensity exercise at least three times a week.[2,5,6] According to McMurray et al,[7] a person should exercise for at least 9 weeks to reduce the risk of coronary heart disease.

Several researchers have found decreases in blood and plasma viscosity following exercise.[8] The decrease in blood and plasma viscosity caused by exercise is an important mechanism in preventing cardiovascular diseases.[2] Blood and plasma viscosity is said to have opposite correlation with physical activity or exercise.[9,10,11] According to Wilmore and Costill,[13] exercise causes a slight increase of erythrocyte volume, but this finding is inconsistent. The mechanism of erythrocyte volume increase is not precisely known.[12] Although erythrocyte volume is slightly increased, the rise in plasma volume is much higher. As a result, a relative decrease of hematocryte could be found.[13] Decreased hematocryte and increased plasma volume result in a lower blood viscosity.[13,14]

The *senam jantung sehat* (SJS) exercise is aimed at both healthy participants and post heart attack persons. Exercise is performed in accordance with Yayasan Jantung Sehat's (The Indonesian Cardiac Foundation's) program, which is of moderate intensity, three times a week.[4]

The effect of SJS exercise on blood and plasma viscosity in Healthy Heart Club (*Klub Jantung Sehat* - KJS) members has never been studied before. The aim of the study is to analyze the effect of SJS aerobic exercise on blood and plasma viscosity.

METHODS

Thirty study subjects were chosen from the Healthy Heart Club members of the Indonesian Heart

Association's Klender Branch, consisting of 28 females and 2 males aged between 40-60 years. Subjects took part in SJS aerobic exercise of moderate intensity for 40 to 45 minutes duration, three times a week for 9 to 12 weeks.

Samples were collected in 2 steps. First step took place prior to the exercise program started, while second step was performed following the program was completed. Samples were collected at basal condition. The timing of sample collection was the same in the first and second steps, i.e. in the morning from at 6 to 7 AM. The sample consisted of 5 mL of venous blood collected in 3 ml and 2 ml containers, each containing K3EDTA. Blood collection into K3EDTA containers consisted of 3 ml blood for blood viscosity measurement and 2 ml for plasma viscosity measurement, centrifuged for 15 minutes 1500x g to separate plasma from packed cell. Blood and plasma viscosity measurements were conducted using the Brookfield LVDV-III viscometer with the rotational method principle.

Data Analysis

Sample measurement data for each parameter were entered into the main table. Data distribution was classified as normal or abnormal using Kolmogorov Smirnov test for each parameter. Mean values were determined in classes with normal distribution, while in classes with abnormal distribution, median value was calculated.

The data collected were recorded using the Statistical Product and Service Solutions (SPSS) program (11th version). Paired t-test was utilized to determine the difference between measurements prior to and following exercise when the data were normally distributed, and Wilcoxon match-pairs sign rank test were used when the data was not normally distributed. The significance limit used a p (probability) of 0.05.

RESULTS

In within run precision test for the Brookfield LVDV-III viscometer, the CV for whole blood was 0.27% and that of plasma was 1.26%. Our study found lower levels compared to the blood and plasma viscosity CV measurements in previous studies using the same method, i.e. 2.1%[14] and 1.36%.[15]

Subjects were long-standing members of KJS Klender who had been members for 1-5 years with irregular exercise habits, who had exercised twice weekly at maximum of unobserved intensity and duration. In this study, the SJS aerobic exercise of moderate intensity was organized for 40 to 45 minutes durations each, three times a week for 9 to 12 weeks. The intensity of exercise among the study subjects was within their minimum and maximum heart rate. The exercise was programmed for 9–12 weeks with a mean KJS member attendance of 33.23 times.

Measurements prior to the SJS exercise showed a mean blood viscosity of 4.08 ± 0.30 mPa.s, while the mean blood viscosity following the program was 3.96 ± 0.18 mPa.s, showing a significant decrease ($p = 0.03$) of blood viscosity of 2.94% in 63.4% of subjects.

Measurements prior to the SJS exercise demonstrated a mean plasma viscosity of 1.64 ± 0.09 mPa.s, while the mean plasma viscosity following the exercise program was 1.61 ± 0.08 mPa.s, showing an insignificant decrease ($p = 0.156$) as much as 1.83% in 63.4% of subjects.

DISCUSSION

Blood viscosity is the intrinsic resistance of blood flow inside the bloodstream.[9,16] Blood viscosity depends on many factors, such as hematocryte, plasma viscosity, erythrocyte deformability, and erythrocyte aggregation.[9] Hematocryte is affected by the amount of erythrocytes and balance in body fluid. Erythrocyte deformability is affected by metabolic erythrocytes, changes in cytoplasms, and genetic factors. Erythrocyte aggregation is affected by cellular and plasma factors. A rise in fibrinogen level is one of the main causes of erythrocyte aggregation.[14] Among these factors, hematocryte and plasma viscosity are the main factors that determine blood viscosity.[16]

Plasma viscosity is affected by triglyceride and large molecular plasma proteins such as fibrinogen and a_2-2-macroglobulin.[8,9] Fibrinogen and globulin are able to increase the tendency of erythrocytes to aggregate and to induce the formation of rouleaux.[8] Fibrinogen is the main protein that determines plasma viscosity.[10,15]

Some of the drugs that affect viscosity are pentoxyphillin and iron(II) fumarate. Both are considered effective vasodilators to repair peripheral circulation and could raise erythrocyte deformability, thus improving blood flow.[17]

Heavy exercise could result in erythrocyte deformability, but the effect is temporary and improves in 15 to 30 minutes. On the 60th minute following heavy exercise, increase in erythrocyte aggregation and decrease in erythrocyte deformability could occur, and thus heavy exercise can be said to possibly cause death. However, this condition is not found in regular exercise, since regular exercise causes increase in erythrocyte and decrease in blood viscosity. Therefore, it would improve blood flow.[14]

Bettega et al[18] studied the effect of exercise on

plasma fibrinogen. Significant decline in plasma fibrinogen level was found following three month exercise. The decrease of fibrinogen could play a role in the decline in erythrocyte aggregation and decline in blood and plasma viscosity.[14,15]

Plasma volume loss is found during exercise, due to the shift of intravascular fluid into interstitial tissue. This condition is caused by the increase in blood pressure and hydrostatic pressure in the capillaries. Sejersted, as quoted by Lamb,[12] stated that 15 to 20% of plasma volume is lost within the first minute of exercise. The loss of plasma volume is exaggerated by secretion of sweat. This condition will cause plasma and blood viscosity to increase on initiation of exercise.[19] As a compensation, Antidiuretic Hormone (ADH) and aldosterone increase. In addition, elevation in plasma protein, particularly albumin, is also found.[19,20] The mechanism of plasma protein elevation remains unknown. This increase is thought to be related to protein distribution during exercise. Lymphatic vessels are permeable to protein, and thus lymphatic fluid contains high concentrations of protein. Muscle movements during workout will cause lymphatic flow to increase, since exercise could excite sympathetic nerves in lymphatic vessel smooth muscles.[21] As a result, lymphatic flow into circulatory system rises twofold during exercise, increasing protein level in the blood flow. The rise in plasma protein then elevates oncotic pressure, causing rise in oncotic pressure that could result in plasma volume increase.[20] This plasma volume increase is called plasma volume expansion. Plasma volume expansion is said to be the cause of blood and plasma viscosity reduction.[12,13,19,20] This condition could increase blood volume up to 8% compared to prior to exercise. Volume expansion really helps in meeting the need for circulation during every exercise.[12]

Blood viscosity measurement prior to exercise demonstrated in a mean of 4.08 ± 0.30 mPa.s. Following the exercise program, the mean blood viscosity was 3.96 ± 0.18 mPa.s, showing a significant decrease (p=0.03) in blood viscosity (2.94%) in 63.4% of subjects.

Measurement prior to exercise demonstrated a mean plasma viscosity of 1.64 ± 0.09 mPa.s. The mean plasma viscosity following the exercise program was 1.61 ± 0.08 mPa.s, thus 1.83% insignificant decrease (p=0.156) was found in 63.4% of subjects.

Difficulties are found in comparing the decrease of viscosity between this study and other studies. According to Neuhaus and Gaehtgens,[8] the plasma viscosity among track athletes (>13 km/week) decreased 8.1% and blood viscosity decreased 8.4% compared to the non-exercising control group. Plasma and blood viscosity measurements in the Neuhaus and Gaehgents study used a rotational viscometer device.[8]

This study found a significant decrease in blood viscosity and an insignificant decrease in plasma viscosity. These findings were similar to the study by Adachi et al[22] on the effect of exercise on blood and plasma viscosity in trained subjects compared to non-exercise control group. Viscosity was measured using the Taniguchi-Ogawa viscometer. A significant decrease in blood viscosity was found in trained subjects, and no decrease was found in the control group, while no significant decrease was found in plasma viscosity. There are some hypotheses on blood viscosity reduction in trained individuals. According to Adachi et al,[22] during exercise. erythrocytes are redistributed from the lymphatic system to the circulatory system. This redistribution is influenced by the sympathetic nerve system. Among untrained individuals, the sympathetic nerve activity is unstable, causing an increase of erythrocyte release from the lymphatic system and other organs, followed by increase in hematocryte. Among trained individuals, the sympathetic nerve activity is relatively stable, causing a decrease of erythrocyte release from the lymphatic system and other organs.[22] Moreover, increased erythrocyte deformability and plasma volume expansion are found in trained individuals.[12,15,20,22] Insignificant decrease in plasma viscosity could be caused by fibrinogen, as the main factor that determines plasma viscosity.[10,15] However, fibrinogen level was not measured in this study. Plasma fibrinogen level in trained individuals is said to be decreased; however, fibrinogen is an acute phase reactant (APR) that increases during inflammatory conditions.[18] Other factors that could affect plasma viscosity is triglyceride.[10,15] This study found insignificant triglyceride reduction and triglyceride increase is found in 40% (12) subjects.

Plasma viscosity levels prior to and following aerobic exercise were higher in 10 (33.3%) subjects, and 1 (3.33%) subject did not experience any alteration. Blood viscosity levels prior to and following aerobic exercise were higher in 10 (33.3%) subjects, and 1 (3.33%) subject did not experience any alteration. Increased viscosity levels in some subjects were probably attributable to erythrocyte factors (hematocryte, erythrocyte deformability, erythrocyte aggregation) and plasma factors (fibrinogen, triglyceride). Other factors that could also contribute are insufficient fluid intake in subjects due to fasting.

This study showed similar results as previous studies conducted by some researchers, which found a decrease in blood and plasma viscosity following exercise. Blood and plasma viscosity are thought to be oppositely correlated to physical activity or exercise.[9,10,11] Decrease

in blood and plasma viscosity caused by exercise is important mechanisms to prevent coronary heart disease.[2]

This study demonstrated that SJS exercise of moderate intensity for 40 to 45 minutes three times a week gives the benefit of lowering blood viscosity, which could help reduce the risk of coronary heart disease.

CONCLUSION

SJS aerobic exercise of moderate intensity for 40 to 45 minutes three times a week for 9 to 12 weeks gives the benefit of lowering blood viscosity, which contributes to reducing the risk of coronary heart disease.

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