

The Effect of Step Aerobic Exercise on Improving Symptoms of Moderate to Severe Asthenopia

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Abstract

Purpose:

The effect of step aerobic exercise in relieving symptoms of moderate to severe asthenopia

Methodology/approach:

Thirty-two female students of the School of Medicine and Health Sciences, Atma Jaya Catholic University, with moderate-to-severe asthenopia, participated in the study. Sixteen students were given step aerobic exercise (SAE) as an intervention (SA group), and 16 students were assigned as the control group (C). Asthenopia was provoked by reading cell phones for one hour. CVSS score 13-19 was denoted as moderate while CVSS score ≥ 20 was denoted as severe. Participants were then instructed to fill out the Computer Vision Syndrome Scale Questionnaire (CVSS). Control groups were given a three-minute break while the SA group was asked to do 3 three-minute step aerobic exercise. Step aerobics exercises were performed by going up and down stairs 20 cm high for frequency of 88 steps/minute according to metronome. Participants in both groups were instructed to fill Computer Vision Syndrome Scale Questionnaire (CVSS) after three minutes. Wilcoxon signed rank test and Mann Whitney test were applied to analyze the data due to abnormal distribution. Significance was set at $p < 0.05$

Results/findings:

Symptoms of moderate to severe asthenopia appeared after provocation (CVSS score 22.7 ± 11.1 in C group and 21.4 ± 8.0 in SA, $p = 0.67$). The CVSS score was significantly decreased in SA group after SAE (21.4 ± 8.0 vs. 5.1 ± 4.9 , $p = 0.001$) but not significant in C group (22.7 ± 11.1 vs. 21.8 ± 12.1 , $p = 0.09$). The magnitude of the decrease in CVSS scores in SA group was significantly greater than in C (-16.3 ± 5.3 vs. -0.9 ± 2.1 , $p < 0.001$).

Conclusion:

Step aerobic exercise can improve the symptoms of moderate to severe asthenopia in female students.

Limitations:

This study involved only female. Male students should be also recruited to observe the effect of gender on the response of eyes to exercise intervention. NO, as a chemical substance responsible for improvements of asthenopia, was not measured due to several limitations.

Contribution:

Sports medicine field: benefit of exercise for eye health, especially asthenopia.

ophthalmology field: finding a healthy alternative treatment for eye problems especially asthenopia

Student/employee: develop healthy behaviour to reduce and avoid the negative effects of long-term gadget use.

Keywords: *Asthenopia, nitric oxide, step exercise, female student*

1. Introduction

In today's digital age, students are frequently exposed to screens—whether on desktops, laptops, tablets, or mobile phones. Prolonged use of these devices can lead to eye fatigue, a condition known as asthenopia. This condition is characterized by visual discomfort and symptoms like dizziness, headaches, red and itchy eyes, and difficulty concentrating. The prevalence of asthenopia ranges from 12.4% to 32.2% among children under 18, and rises to 57% in adolescents aged 18 to 30. In a cross-sectional observational study conducted among 200 medical students who regularly use smartphones, laptops, and computers, it was found that 51.56% of students experienced moderate asthenopia symptoms, with 96% of participants reporting some level of discomfort. The most common symptom was headaches (56.77%), followed by eye strain (50.52%), blurred vision (40.62%), and eye redness (23.95%).(Hashemi et al., 2019, Singh et al., 2016, Xu, Y et al., 2019)

The causes of asthenopia include visual impairments like refractive errors and accommodative dysfunction, poor mental health, and environmental factors such as inadequate lighting or prolonged use of digital devices. Extended periods of screen time increase the risk of developing asthenopia, which can ultimately disrupt visual function and lead to refractive disorders.(Hashemi et al., 2019)

In asthenopia, the ciliary muscles—responsible for focusing on near objects—become strained. To alleviate symptoms, it's important to relax these muscles. One factor that can help with this is nitric oxide (NO), a molecule produced by nitric oxide synthase in endothelial cells. NO plays a key role in relaxing smooth muscles by activating guanylate cyclase, which increases levels of cyclic guanosine monophosphate (c-GMP). NO can be obtained through nitrate-rich foods and aerobic exercise. Studies have shown that aerobic exercise can elevate basal serum NO levels more than anaerobic exercise or no exercise at all. (Förstermann, U., & Sessa, W. C.,2012, Masuda, H et al.,2012, Arefirad, T.,2022)

According to the American College of Sports Medicine (ACSM), aerobic exercise is a form of physical activity that uses oxygen to produce energy in the form of adenosine triphosphate (ATP) from amino acids, carbohydrates, and fats. This type of exercise is rhythmic, continuous, and involves large muscle groups. Examples include cycling, dancing, hiking, jogging, long-distance running, swimming, and walking. Aerobic exercise has been studied for its ability to reduce asthenopia symptoms by promoting relaxation of the ciliary muscles.(Patel, H et al., 2017, Zhang, Q et al. 2024)

One specific form of aerobic exercise is step exercise, which is often used to measure and assess a person's aerobic fitness by evaluating how quickly their heart rate returns to normal after exertion. The faster the heart rate recovers, the greater the individual's aerobic fitness. Step exercise can be performed by both athletes and non-athletes, though it is not recommended for people with hypertension or angina. (Mackenzie, B.,2005)

Because step exercise has the potential to increase nitric oxide production, this study aims to investigate whether aerobic exercise can alleviate asthenopia symptoms, particularly in medical students. Asthenopia symptoms can be measured using the Computer Vision Syndrome Scale Questionnaire (CVSS-Q), which assesses 16 common symptoms of Computer Vision Syndrome (CVS)—a condition caused by prolonged near-vision tasks, such as computer use, that often leads to asthenopia. A CVSS-Q score above 6 indicates the presence of CVS. Currently, treatments for asthenopia are mostly limited to eye exercises. Therefore, this study seeks to explore whether step exercise can help improve asthenopia symptoms in medical students.(Telles, S., 2006, Adane, F. et al., 2022)

2. Literature review and hypothesis/es development

Aerobic step exercise has been shown to reduce the symptoms of moderate to severe asthenopia in female students at the Faculty of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia.(Sun, F. C. et al.,1988, Afzal, F. et al., 2019)

3. Methodology

This study employed a quasi-experimental design with a one-group pre-test and post-test approach, where both the dependent and independent variables were measured at specific intervals. The research was conducted in the lecture room at Atma Jaya Pluit, which has a theater-like layout. The space features 20 cm high steps, allowing participants to view images on their devices from a distance of 30 cm while also performing step exercise interventions.

Thirty-two female students with moderate-to-severe asthenopia, participated in the study.

The inclusion criteria for this study were female students who experienced moderate to severe asthenopia. Exclusion criteria included students who had consumed high-nitrate, high-fiber foods, such as leafy vegetables, within 8 hours before data collection, those with a history of hypertension, and individuals experiencing chest pain. Sixteen students were given step aerobic exercise (SAE) as an intervention (SA group), and 16 students were assigned as the control group (C). Asthenopia was provoked by reading cell phones for one hour. CVSS score 13-19 was denoted as moderate while CVSS score ≥ 20 was denoted as severe. Participants were then instructed to fill out the Computer Vision Syndrome Scale Questionnaire (CVSS). Control groups were given a three-minute break while the SA group was asked to do 3 three-minute step aerobic exercise

4. Results and discussion

The questionnaire was distributed online from the researcher to female students of the Faculty of Medicine, Atma Jaya Catholic University of Indonesia. In this study, 32 respondents were obtained, consisting of 16 people in the control group and 16 people who were willing to be in the intervention group and had met the inclusion and exclusion criteria. All respondents selected were female from the 2022 to 2019 intake. Based on the data that can be seen in Table 1, most respondents looked at gadgets for more than 6 hours every day.

Table 1. Respondent Frequency Distribution

N = 32		
Duration of viewing gadgets per day	< 6 jam	13
	≥ 6 jam	19
Durasi melihat gadget dalam ruangan gelap per hari	<6 jam	29
	≥ 6 jam	3

The test used is the Wilcoxon Signed Rank statistical test to compare Asthenopia scores before (pre-test) and after (post-test) the intervention. In the intervention group, there was a decrease in Asthenopia scores from 21.4 to 5.1 with a p-value < 0.001 , while in the control group, there was a decrease from 22.7 to 21.8 with a p-value = 0.09. This shows that there was a significant decrease in the intervention group before and after being given aerobic exercise, "step exercise," which can be seen in Table 2.

Table. 2. Pre-test and Post-test Scores of Computer Vision Syndrome Intervention and Control Groups

	Score CVS		P-value
	Mean $\pm$ SD pre test	Mean $\pm$ SD post test	
Group intervention	21,4 $\pm$ 8,0	5,1 $\pm$ 4,9	<0,001
Group Control	22,7 $\pm$ 11,1	21,8 $\pm$ 12,1	0,09

The results indicated that the intervention group experienced a change in score of 16.3, while the control group had a change of 0.9, as shown in Table 3. The Mann-Whitney test revealed a p-value of <0.001, demonstrating a significant effect of aerobic step exercise on improving asthenopia symptoms among female students at the Faculty of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia.

Table 3. Changes in Computer Vision Syndrome Scores in Intervention and Control Groups

	Score CVS	
	Δ Score	P-value
Group intervention	-16,3 $\pm$ 5,3	<0,001
Group Control	-0,9 $\pm$ 2,1	

Aerobic exercise can increase NO production more significantly than anaerobic exercise groups or those who do not exercise at all. Taylor, J. K., 2022)

In addition to increasing NO levels, aerobic exercise also has an effect on increasing endorphins that play a role in ciliary muscle relaxation. 34 Endorphins have an effect that can relieve pain by reducing calcium absorption. 35 Beta-endorphin levels in the blood do not increase until the duration of exercise exceeds about 1 hour, with an exponential increase thereafter. 36 Meanwhile, in a study by Ozkol et al., (Ozkol, M. Z et al.,2012)..there was a significant increase in NO levels 5 minutes after aerobic exercise. This increase was significant compared to the anaerobic exercise and control groups.

During aerobic exercise, endothelial cell mechanical sensors will stimulate the production of Nitric Oxide synthase (eNOS) which will produce NO. Aerobic exercise can also increase melatonin levels. Melatonin acts as an antioxidant. By activating melatonin receptor 2, it will increase calcium levels in endothelial cells which can activate eNOS to increase the production of NO.⁴² In the control group, there was a decrease from 22.7 to 21.8 with a p value = 0.09. The results of the Wilcoxon test, with a p-value of 0.09 ($p > 0.05$), showed that the decrease in the group was not significant. This is due to the absence of intervention that can provide a relaxing effect on the eye muscles in the short term and respondents are still maintained to see the wall at close range. In addition, there was a significant difference in the delta Asthenopia score before and after the intervention using the Mann Whitney test, obtained a p value <0.001 ($p < 0.05$). This is in accordance with research by Xu Y et al., (Xu, Y., 2019) which stated that aerobic frequency is suspected as a strong predictor in fewer Asthenopia complaints.⁹ Thus, it can be accepted that there is an effect of aerobic step exercise on improving Asthenopia score symptoms in students of the Faculty of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia.

5. Conclusion

5.1. Conclusion

The change in Asthenopia scores in female students of the Faculty of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, after being given the intervention, was 16.3 for the intervention group and 0.9 for the control group. Aerobic step exercise on improving asthenopia symptoms among female students at the Faculty of Medicine and Health Sciences,

5.2. Limitation

1. There were only a few subjects with severe asthenopia.
2. The NO levels in the blood of the research samples could not be measured.

5.3. Suggestion

For further research, researchers suggest:

- Increasing the number of severe Asthenopia research subjects
- Measuring the effectiveness of aerobic step exercise on improving Asthenopia symptoms by measuring NO levels in the blood of research subjects.

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