

The effect of diaphragmatic breathing exercise on Vo2max improvement in stroke patients at Yastroki Yogyakarta

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Abstract

In stroke conditions, blood flow to the brain is disrupted, causing sudden neurological dysfunction, with symptoms depending on the area of the brain affected. Due to the neurological dysfunction, cardiorespiratory fitness and diaphragmatic function decline, with VO2Max—an indicator of aerobic capacity—ranging from 11.7±3.7 mL/kg/min to 17.3±7.0 mL/kg/min, or approximately 50–60% of normal values. The aim of this study was to determine the effect of diaphragmatic breathing exercises on increasing VO2Max in stroke patients at Yastroki Yogyakarta. This study employed a quantitative experimental approach using a one-group pre-test and post-test design. Participants were selected using purposive sampling based on inclusion criteria, totaling 40 individuals. The exercise was conducted three times a week over four weeks. The instrument used was the Six-Minute Walking Test, with measurements taken before and after the intervention. The results of the hypothesis test using a paired sample t-test showed that Diaphragmatic Breathing Exercise was effective in improving VO2Max in stroke patients, with a p-value of 0.000 ($p < 0.05$). Diaphragmatic Breathing Exercise can improve VO2Max in stroke patients, indicating this exercise as an effective non-pharmacological method. The clinical implications of these findings emphasize the importance of regularly implementing this exercise to manage VO2Max and prevent cardiovascular complications in stroke patients.

Keywords: diaphragmatic breathing exercise; stroke; VO2Max

1. Introduction

Yastroki is one of the stroke communities in Indonesia, specifically located at Jl. Tambakboyo, Jetis, Wedomartani, Ngemplak District, Sleman Regency, Special Region of Yogyakarta. This foundation is actively involved in stroke prevention and post-stroke rehabilitation efforts, conducting interventions three times a week for four weeks, involving 40 participants. This community plays a crucial role in supporting the recovery process of stroke patients through a structured and sustainable approach.

Stroke is a disruption of blood flow to the brain, causing sudden neurological dysfunction, with symptoms varying depending on the affected brain area (Avula et al., 2020). The cessation of blood flow prevents oxygen supply to respiratory muscles, ultimately affecting VO2Max (Widiani, 2023). Approximately 15-30% of stroke patients experience permanent disabilities in the form of decreased cardiorespiratory function and heart rate, which impacts oxygen delivery and chest wall movement on the paralyzed side of the body (Ojo et al., 2021).

VO2Max is the primary indicator of cardiorespiratory fitness, measuring the maximum amount of oxygen that the human body can consume per minute during exercise or physical activity (Amalia, 2021). VO2Max is influenced by several factors, including age, gender, body composition, genetics, smoking, and physical activity. As an indicator of cardiorespiratory fitness and physical endurance, VO2Max serves as a marker of cardiovascular system fitness and bodily endurance capacity, typically measured through a six-minute walk test (6MWT) to evaluate an individual's functional capacity (Chang et al., 2021). Stroke patients have low cardiorespiratory fitness with VO2Max values ranging from 11.7±3.7 mL/kg/min to 17.3±7.0 mL/kg/min, or approximately 50-60% of normal values (Susilowati et al., 2020). This decline in fitness is influenced by several factors, including physiological changes associated with the aging process, such as reduced vascular elasticity, as well as other factors such as excessive body mass index, duration of stroke, smoking habits, non-active worker or informal worker status, and low levels of physical activity (Aulyra Familah et al., 2024).

According to the World Health Organization (WHO, 2022), in the last 17 years, stroke cases have increased by more than 50%, with a mortality rate of 43%, meaning that 1 in 4 people survive. Each year, approximately 700,000 people in the United States suffer from stroke, accompanied by shortness of breath and fatigue during activities, resulting in 150,000 deaths (Sumiarty et al., 2020). In Sri

Lanka, there are 60,000 patients with 4,000 deaths (Thayabaranathan et al., 2022). According to SKI data from 2023, Indonesia recorded 374,080 people experiencing a decline in cardiorespiratory function due to stroke. The prevalence of stroke in Yogyakarta is 11.4% (8,988 cases), with 9.0% of those experiencing a decline in endurance. This prevalence makes Yogyakarta's rate higher than the national average.

Based on data from the DIY Health Office in 2023, the Sleman region has the highest prevalence rate in Yogyakarta, reaching 14.6% or 5,820 cases. Researchers conducted a preliminary study in three working areas of the Minggir, Gamping 1, and Yastroki Yogyakarta Community Health Centers. There were a total of 45 stroke patients in Minggir (24 ischemic, 21 hemorrhagic), with 28 classified as superior and 17 as excellent. In Gamping 1, there were 46 patients (27 ischemic, 19 hemorrhagic), with 19 classified as superior, 16 as excellent, and 11 as good. In Yastroki, there were 50 patients (34 ischemic, 16 hemorrhagic), with 23 in the fair category, 22 in the poor category, and 5 in the very poor category.

The role of physiotherapy as an expert in human movement can be carried out through the restoration of movement and function using exercise and modalities. However, in this study, the researchers aimed to improve VO2Max in stroke patients through the administration of Diaphragmatic Breathing Exercise. This intervention showed better results as it helped lower the diaphragm position during inspiration and prolong the expiration phase, since 18–88% of breathing patterns in stroke patients become abnormal due to the loss of thoracic movement (Shetty et al., 2020). This aligns with (Yoon et al., 2022), who state that the benefits of Diaphragmatic Breathing Exercise include improved respiratory performance in terms of gas exchange efficiency, enhanced tissue oxygenation, ventilation, alveolar inflation, resolution of hypoxia, increased diaphragmatic excursion, and prevention of alveolar collapse due to decreased partial oxygen pressure. Thus, if alveolar ventilation in stroke patients is optimal, VO2Max will increase. This is because stroke patients with impaired cardiorespiratory function due to weakened diaphragmatic, intercostal, and abdominal muscles can affect VO2Max.

Diaphragmatic Breathing Exercise is a breathing technique that involves the abdominal muscles and diaphragm, thereby assisting during the inspiration process and prolonging the exhalation process (Shetty et al., 2020). According to Yoon et al. (2022), the benefits of Diaphragmatic Breathing Exercise include improving gas exchange efficiency, enhancing tissue oxygenation, and preventing alveolar collapse due to decreased partial oxygen pressure. Thus, if alveolar ventilation in stroke patients is optimal, VO2Max will increase.

The above discussion shows that stroke has extremely fatal complications. Stroke is incurable but can be controlled to prevent complications. Therefore, researchers are interested in conducting this study with the aim of developing a breakthrough for stroke control, titled “The Effect of Diaphragmatic Breathing Exercise on Increasing VO2Max in Stroke Patients.

2. Method

This study used a quantitative experimental approach with a one-group pre-test and post-test design. Respondents were selected using purposive sampling based on inclusion criteria, totaling 40 individuals. The exercise was conducted three times a week over a four-week period. The instrument used was the six-minute walking test, which was administered before and after the intervention. The research location was in Yastroki, located on Jl. Tambakboyo, Jetis, Wedomartani, Ngemplak District, Sleman Regency, Special Region of Yogyakarta. The study was conducted from May 13 to June 7, 2025. In this study, two variables were used: Diaphragmatic Breathing Exercise as the independent variable and VO2Max as the dependent variable. Inclusion criteria included stroke patients with ischemic and hemorrhagic strokes, active members of Yastroki Yogyakarta, experiencing shortness of breath and severe fatigue, and willing to participate in the study until completion by signing an informed consent form. Exclusion criteria: missing more than one session. Data analysis was conducted using descriptive statistical tests, normality tests, and hypothesis testing with a paired sample t-test. This study has been approved by the Health Research Ethics Committee of the Faculty of Health Sciences, Universitas 'Aisyiyah Yogyakarta, with certificate number 4345/KEP-UNISA/III/2025.

3. Results and Discussion

3.1 Sample Characteristics

After conducting research at Yastroki Yogyakarta on “The Effect of Diaphragmatic Breathing Exercises on Increasing VO2Max in Stroke Patients at Yastroki Yogyakarta,” the following results were obtained:

Table 1. Frequency Distribution of Age and Gender

Variables	N = 40	%
Age		
Middle Age (45-59 years)	10	25
Elderly (60-74 years)	22	55
Old (75-90 years)	8	20
Gender		
Men	12	30
Woman	28	70
Total	40	100

Based on Table 1, it is known that the characteristics of the respondents are mostly aged 60-74 years (elderly) totaling 22 people (55%), a small number aged 75-90 years (old) totaling 8 people (20%), and the rest aged 45-59 years (middle age) totaling 10 people (25%). These results indicate that the majority of respondents in this study are elderly (60–74 years old), as this age group has an increased risk of diaphragmatic dysfunction with advancing age. Among the elderly over 60 years old, especially those with a history of stroke, nearly 52% of them experience diaphragmatic dysfunction because the nerve controlling it, the phrenic nerve, is affected (Abdullahi et al., 2023). If this nerve is impaired, it will affect motor activity and the vagus nerve, which is the longest nerve in the body and controls many bodily functions (Shetty et al., 2020).

This is consistent with research (Oyake et al., 2019) stating that individuals over the age of 60 may experience a decrease in diaphragmatic excursion. This can lead to reduced lung ventilation efficiency, and the intercostal muscles, accessory muscles (SCM, scaleni, pectoralis major and minor, rectus abdominis, etc.) may weaken, even losing some of their contractile ability (Cahyani et al., 2020). During the exhalation process, diaphragmatic movements during breathing directly and indirectly affect the parasympathetic and sympathetic nerves (Mushtaq et al., 2023). Among the respondents, 28 were female (70%) and 12 were male (30%). From this data, it is evident that the number of women participating in this study is significantly higher than that of men. According to Rahayu (2024), stroke is more common in women because they are more susceptible to diseases such as heart disease, hypertension, and diabetes. The field results revealed that 10 respondents in this study had a history of heart disease and had undergone coronary artery bypass grafting.

In addition, the decline in estrogen levels, which normally help protect the heart after menopause, can increase the risk of stroke (Vivi et al., 2025). According to (Haiga et al., 2022), strokes are more common in women because they tend to live longer than men, increasing the risk of stroke in old age. Additionally, women often lead less physically active lifestyles and are more prone to obesity and unhealthy eating habits, which can further increase the risk of stroke. Research by (Zaid et al., 2023) shows that there are cardiovascular differences between women and men, with women having smaller and more elastic arteries, which affects blood flow. According to Rahayu (2024), women are more prone to stroke due to risk factors such as heart disease, hypertension, and diabetes. Additionally, the decrease in estrogen levels after menopause, which plays a role in cardiovascular protection, also increases the risk of stroke in women (Vivi et al., 2025). Other contributing factors include women having a less active lifestyle, being more prone to obesity, and having unhealthy eating patterns (Haiga et al., 2022). Cardiovascular structural differences include women's arteries being smaller and less elastic than men's (Zaid et al., 2023).

Table 2. Frequency Distribution Of VO2Max Results in Stroke Patients at Yastroki Yogyakarta

VO2Max	Pre Test		Post Test	
	Frequency	Percentage (%)	Frecuency	Percentage(%)
Very Poor	29	72,5	1	2,5
Poor	10	25	12	30
Fair	1	2,5	16	40
Good	0	0	11	27,5
Total	40	100	40	100

Based on Table 2, the pre-test VO2Max results show that the majority of respondents were in the very poor category, with 29 people (72.5%) showing very low VO2Max capacity before the intervention. This indicates that most patients had quite severe cardiorespiratory dysfunction. Ten participants (25%) were in the poor category, meaning their VO2Max capacity was low but not as severe as the very poor category. One participant (2.5%) was in the fair category, indicating moderate cardiorespiratory function before the intervention. No participants were in the good category, indicating that none had sufficient VO2Max capacity at the start of the study. After the 4-week intervention (post-test), there was a significant improvement, with only 1 person (2.5%) in the very poor category still showing a significant increase in VO2Max capacity. Most patients, 12 people (30%), were in the poor category, which could mean that some patients who were previously in the very poor category improved to the poor category, but further improvement is still needed. 16 individuals (40%) in the fair category showed that many patients experienced an improvement in cardiorespiratory function to a moderate level after the exercise program, and 11 individuals (27.5%) successfully reached the good category, indicating significant recovery and good improvement in cardiorespiratory capacity due to the exercise program conducted.

Maximum oxygen volume (VO2Max) is the maximum amount of oxygen that the human body can consume per minute during exercise or physical activity, thereby indicating an individual's endurance or cardiorespiratory fitness (Amalia et al., 2021). Previous research conducted by (Sinurat, 2021) indicates that VO2Max can be influenced by several factors such as age, gender, genetics, physical activity, and body composition. As a measurement tool for VO2Max, the Six Minutes Walking Test (6MWT) is used to assess cardiorespiratory fitness and physical endurance by walking for 6 minutes (Chang et al., 2021). According to Rahmasari et al. (2023), this increase in VO2Max aligns with the objective of diaphragmatic breathing exercises, which focus on strengthening the diaphragm muscles. By training these muscles, their strength increases, making them more efficient in moving air in and out of the lungs. This increases lung vital capacity, enabling greater oxygen absorption and more effective carbon dioxide excretion. As diaphragm muscle strength improves, lung ventilation becomes more effective, enhancing gas exchange in the alveoli and helping to reduce the sensation of shortness of breath (dyspnea) (Jerau et al., 2023). The reduction in dyspnea allows individuals to perform physical activities more comfortably and for longer periods of time, thereby contributing to an increase in the distance achieved during the 6MWT test (Amalia, 2021). Regular diaphragmatic breathing exercises can help stabilize blood pressure by stimulating the parasympathetic nervous system, which functions to lower heart rate and reduce vascular tension (Seo et al., 2017).

3.2 Normality Test

Table 3. Shapiro Wilk Test Results Before and After Treatment

Variable	Nilai p	
	Pre Test	Post Test
VO2Max	0.968	0.098

Based on Table 3, the Shapiro-Wilk test results show normality for the group before treatment with a p-value of 0.968 and after treatment with a p-value of 0.098. Since both p-values before and after treatment are greater than 0.05, it can be interpreted that the data is normally distributed, thus using the paired sample t-test hypothesis test.

3.3 Hypothesis Test

Table 4. Paired Sample T-Test Before and After Treatment

	N	Mean ± SD Pre-test	Mean ± SD Post-test	Mean ± SD Different	p
VO2Max	40	17.675±3.320	21.084±2.505	3.409±1.757	0.000

Based on Table 4, the results of the paired sample t-test yielded a p-value of 0.000. Since the significance level ($p < 0.05$) was met, it can be concluded that there is a significant difference between the VO2Max results of the respondents before and after the intervention. In other words, the administration of Diaphragmatic Breathing Exercise has been proven effective in improving VO2Max in stroke patients at Yastroki Yogyakarta. This study aligns with previous research indicating that Diaphragmatic Breathing Exercise is effective in improving VO2Max in stroke patients, as this exercise focuses on utilizing the diaphragm muscle to enhance lung ventilation. Consequently, with improved respiratory efficiency, stroke patients can engage in physical activities for longer periods, as evidenced by the increase in VO2Max results (Seo et al., 2017).

VO2Max is influenced by several factors such as age, gender, body proportion, occupation, and physical activity (Chang et al., 2021). In line with the results of a study in Yastroki, Yogyakarta, it was found that most respondents were elderly (60-74 years old) and had a higher risk of diaphragmatic dysfunction as they aged. After the age of 60, there is a decline in the diaphragm's ability to contract and expand, reducing lung ventilation efficiency (Oyake et al., 2019). In addition to the diaphragm, other respiratory muscles such as the intercostal muscles and accessory muscles also weaken, even losing some of their contractile ability (Cahyani, 2020). This explains why respiratory function declines in the elderly, especially those with a history of stroke.

Women are more susceptible to stroke due to risk factors such as heart disease, hypertension, and diabetes (Aulyra Familah et al., 2024). The decline in estrogen levels after menopause, which plays a role in cardiovascular protection, also increases the risk of stroke in women (Vivi et al., 2025). Other contributing factors include women having a less active lifestyle, being prone to obesity, and having an unhealthy diet (Haiga et al., 2022). Structural cardiovascular differences, such as women's arteries being smaller and less elastic than men's, also play a role (Zaid et al., 2023).

According to Khairatunnisa (2017), the higher the body fat percentage, the lower a person's VO2Max value. This accumulation of excess fat can lead to plaque formation on arterial walls, which then narrows the arteries (atherosclerosis) (Pakpahan, 2022). This condition increases the risk of heart disease, stroke, and diabetes, and can also raise blood pressure and damage blood vessels, thereby reducing overall cardiorespiratory function (Yudha, 2023).

According to Sarah et al. (2021), housewives often experience stress and fatigue due to family responsibilities, which can increase blood pressure and the risk of stroke compared to other workers. This is due to a lack of physical activity, unhealthy eating patterns, and limited attention to self-health and access to routine check-ups, making early detection of stroke difficult (Masriana et al., 2021). If the activities performed are still insufficient, but diaphragmatic breathing exercises are performed with regularity and appropriate intensity, they can improve motor and cardiorespiratory function, making the hypothesis related to cardiorespiratory function highly relevant to test. Because routine activities lasting 30–60 minutes per day are sufficient to stimulate brain neuroplasticity post-stroke and are safe for recovery (Daba, 2023).

4. Conclusion

The routine application of diaphragmatic breathing exercises as an effective non-pharmacological method to increase VO2Max and prevent cardiovascular complications in stroke patients.

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